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# The Dimensions of Intonation in Neurogenic Foreign Accent Syndrome: A Typological Perspective

**by**
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**Declaration of Author's Rights**

„Denn so wundervoll ist in der Sprache die Individualisirung innerhalb der allgemeinen Übereinstimmung, dass man ebenso richtig sagen kann, dass das ganze Menschengeschlecht nur Eine Sprache, als dass jeder Mensch eine besondere besitzt."

Wilhelm von Humboldt, 1836

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# TABLE OF CONTENTS

# LIST OF TABLES

# LIST OF FIGURES

# ABSTRACT

This study investigates the dimensions of intonation in foreign accent syndrome (FAS) using the autosegmental-metrical framework of intonational analysis (Ladd, 1996; Pierrehumbert, 1980). The main objective is to explore the nature of intonation impairment in FAS and to offer insights into the principles that underlie intonation realisation in this speech disorder.

To achieve this goal, the speech of four individuals with FAS was compared to the performances of four healthy gender-, age- and dialect-matched control speakers using a variety of scripted and unscripted text styles. The data were annotated using an adaptation of the IViE transcription system (Grabe, 2001, 2004; Grabe, Nolan & Farrar, 1998; Grabe, Post & Nolan, 2001) and analysed phonologically and phonetically in relation to the inventory, distribution, implementation as well as functional use of intonational elements, i.e. pitch accents and boundary tones.

Results showed a retained inventory of intonational elements in FAS combined with changes in the distribution, implementation and functional use of these elements. Importantly, none of the observed intonational changes directly reflected an underlying intonation deficit. Instead, they represented a combination of primary and secondary manifestations of physiological limitations affecting speech support systems as well as compensatory tactics to cope with the restrictions.

These findings provide new insights into the intonational system in FAS and contribute significantly to our understanding of the underlying nature of the intonation deficit in FAS. They have implications for the field of clinical linguistics by informing the assessment and management of intonation disorders as well as the use of theoretic-linguistic models of intonational analysis for the investigation of disordered speech.

# 1 INTRODUCTION

The analysis of speech and language disorders and their patterns of breakdown is generally acknowledged to have contributed significantly to furthering the global understanding of human speech/language processing, proving particularly valuable in identifying the steps involved in planning and production that cannot easily be observed in natural speech. However, whilst some linguistic aspects such as syntactic and semantic processing have attracted a great deal of clinical research interest, "linguists have not generally concerned themselves with the study of prosodic [and intonational] performance in clinical language" (Brewster, 1990, p.168). The reasons for the paucity of clinical research in this field are manifold, but can primarily be ascribed to the inherent complexity of prosody and intonation and difficulties in capturing and analysing these aspects. However, the last two decades have seen significant advances in the field of theoretical linguistics in terms of defining the various aspects of prosody and intonation and their relationships to each other, and establishing a widely accepted analysis system that is capable of describing and quantifying intonational phenomena. Stimulated by this recent development of new intonational theories and analysis approaches, the number of studies on intonation has increased significantly, resulting in a wealth of new insights into the complex nature of intonation. This has paved the way for systematic theory-led research into intonation in disordered speech.

One of the speech disorders to benefit from these recent developments in theoretical linguistics, and the availability of better methods of analysing intonation, is foreign accent syndrome (FAS). FAS is a largely neurologically-based speech disorder that features a variety of segmental and suprasegmental changes, resulting in the listener's perception of a foreign accent in speech. Studies investigating the speech patterns in FAS have frequently identified an underlying disturbance in speech prosody, i.e. rhythm and intonation, as a main factor contributing to the perceived foreign accent (among others Blumstein, Alexander, Ryalls, Katz & Dworetzky, 1987;

Blumstein & Kurowski, 2006; Kurowski, Blumstein & Alexander, 1996). However, despite the acknowledgement that intonational features were found to play a key role in the perception of foreign accentedness, the majority of investigations on FAS speech have concentrated on the segmental characteristics of speech. The few studies that have looked more closely into aspects of intonation have largely relied on perceptual judgements and broad acoustic measurements. As a result, these studies were able to establish the presence of an intonational problem, but did not provide the necessary detail to draw conclusions as to the exact manifestation of the intonational changes in FAS speech and their potential underlying nature. The absence of a thorough investigation of the intonation component in FAS points towards a gap in the literature between the relevance of the intonational changes in defining FAS on the one hand, and the efforts undertaken to unearth the nature of the intonational alterations on the other.

## 1.1 Purpose of the study

This thesis tries to fill the gap by systematically investigating the internal organisation of the intonational system in FAS in order to determine the level of intonation impairment, that way furthering the understanding of the principles which underlie intonation realisation in FAS. Following the research tradition of intonational phonology, four dimensions of intonation are analysed (Ladd, 1996):

- the phonological representation, i.e. the inventory of structural elements
- the distribution of structural elements
- the phonetic implementation of structural elements
- the use of structural elements to signal specific aspects of intonational function

The function of intonation that is of interest to the present study is the structuring of information in discourse, which requires the highlighting of relevant information in an utterance. This ability represents an important and highly communicative aspect of everyday speech as it directs the listener to the important part of the utterance. It is therefore of considerable clinical relevance, forming an integral part of assessment and intervention.

By describing the intonational system in FAS along these four dimensions a holistic approach to analysing intonation is taken. In addition, the present study adopts the autosegmental-metrical (AM) framework of intonational analysis, pioneering this approach in individuals with FAS. This framework, which is based on the groundbreaking work of Pierrehumbert (1980) and Beckman and Pierrehumbert (1986), can be regarded as the current predominant approach to analysing intonation. The present study is also innovative in that it investigates the intonation patterns in FAS in a variety of text styles to gauge and compare the influence of different scripted and unscripted speaking styles on the description of the four dimensions of intonation in FAS.

## 1.2 Importance of the study

This thesis has the potential to make significant contributions to our understanding of the nature of intonation in FAS speech as well as to the underpinnings of the theory of intonational phonology. Given the absence of in-depth knowledge pertaining to intonation in FAS, the primary aim of this study is to obtain fundamental information as to the realisation of intonation structures in FAS, providing a theoretical basis for subsequent research in this area. Despite the pre-clinical nature of this study, there is a potential for the data to be of clinical relevance in the long term, rendering this study of interest to practitioners and researchers alike.

Identifying the underlying factors responsible for the intonational changes in FAS speech might lead to new insights into the planning and production of intonation structures in this speech disorder. Better knowledge on the internal organisation of the intonation system in FAS speech, in turn, might inform the development of new assessment and management strategies, not only for FAS but for disordered speech in general. At the same time, analysing intonation patterns from a clinical perspective could constitute a powerful source to enhance the theoretical underpinnings of intonational phonology. To date, most of the evidence on which the concept is based is (psycho)linguistic in nature. However, looking at intonational phonology from a clinical viewpoint might provide new evidence that has the potential to further the understanding of the theoretical constructs and general mechanisms behind intonation realisation.

## 1.3 Structure of the thesis

This thesis investigates intonation in FAS, and as such it encompasses theories of intonation as well as intonation impairment, which will be accounted for separately in chapters 2 and 3. Specifically, in chapter 2, the term *intonation* is introduced as it is used in this study, discussing it in terms of its phonology, phonetics and function. Regarding the phonology of intonation, the focus is on introducing the principles of the AM approach (Ladd, 1996; Pierrehumbert), which constitutes the intonational framework within which the current data is analysed, and the annotation tools that are currently available to transcribe intonation. This is followed by a discussion of the phonetic parameters that are relevant for the description of intonation. An overview of the different functions of intonation is provided, whereby emphasis is laid on defining the notion of information structure, i.e. the pragmatic-linguistic function that is of relevance to this thesis. The chapter concludes with reviewing the potential of using recent theoretical frameworks to describe disordered intonation. Chapter 3 provides information on foreign accent syndrome (FAS), the motor speech disorder that is of interest to this study. The chapter discusses previous and current efforts to investigate intonation and presents the argument for a systematic investigation of the intonational system in FAS. The chapter concludes with stating the research aims of this study. In chapter 4, the methodological aspects of the study are detailed. This includes information on the participants of the study, the materials used to elicit the speech corpus as well as information on the procedures of data recording, data annotation and data analyses. In chapter 5, the results of a preliminary study are presented, which was conducted to validate appropriate methodologies, followed by the results of the main case studies in chapter 6. In chapter 7, the results of all case studies are discussed in the light of relevant findings from the literature to elucidate the nature of intonation in FAS. Finally, chapter 8 summarises the major findings of this thesis and discusses the contributions and implications of the current findings for theory and practice as well as recommendations for future research.

# 2 INTONATION

This chapter introduces the notion of intonation as it is used in the present study. In section 2.1, the position of intonation within the area of linguistics is defined. Following the research tradition of intonational phonology (Ladd, 1996), intonation is described in terms of phonology, phonetics and functional characteristics. In relation to phonology, the autosegmental-metrical (AM) approach of intonational analysis as well as a range of tools currently available to transcribe intonation are introduced (sections 2.2 and 2.3). Section 2.4 relates to the phonetic characteristics by outlining the acoustic parameters associated with intonation realisation, i.e. fundamental frequency (F0) and aspects of duration and intensity. The chapter continues by providing an overview of the different extralinguistic, paralinguistic and linguistic functions of intonation (2.5), whereby specific attention is paid to the linguistic function of information structuring in discourse. As part of this section a description of givenness, i.e. the information status of elements, is provided and illuminated in terms of its phonological and phonetic encoding. The final part of the chapter reviews the use of the AM approach and associated annotation systems to describe intonation in disordered speech and assesses the potential of this approach to inform investigations of disordered intonation (2.6).

## 2.1 Defining intonation: The tale from taming the 'savage around the edge of language'

When Bolinger (1964, 1978) tried to define the position of intonation within the field of linguistics he drew on two different metaphors, which undoubtedly reflect the complex situation intonation finds itself in. Bolinger characterised intonation as a "half-tamed savage" positioned "around the edge of language" in reference to the fact that the linguistic structures of intonation appear to be less clear-cut than those of other linguistic components such as syntax and morphology (Gussenhoven, 2004). Compared to the other linguistic components, intonation faces the challenge that pitch variation, expressed by varying fundamental frequency (F0), which is the primary parameter of intonation realisation in English, can convey linguistic as well as non-linguistic information. In the linguistic sense, pitch patterns are mainly purposefully varied to indicate phrases or to highlight the relevant information in an utterance. Although the inventory of pitch patterns may differ across languages, most have in common that, if pitch variation is used contrastively, it constitutes a highly structural process that aligns with the grammatical nature of intonation. At the same time, pitch patterns can reflect non-linguistic information such as a speaker's status, attitude or current state of emotion. These so-called extra- and paralinguistic aspects of language are universal as they signal similar aspects across languages (Gussenhoven, 2002a, 2004; Hirst & Di Cristo, 1998). Generally, speakers are less effective in controlling these aspects, which is why they are considered to be less structural in nature.

The very fact that intonation equally functions as an indicator of structural as well as non-structural aspects of language makes it more difficult to accept intonation as a grammatical system in its own right, or as Ladd (2008, p.3) phrased it: "Intonation sits uneasily with many ordinary linguistic assumptions." As a result, there is an ongoing debate in the literature arguing for and against the grammatical status of intonation. According to Gussenhoven (2004), intonation can certainly be ascribed a grammatical status if a clear line is drawn between the *tamed half* of intonation, i.e. the abstract representation of pitch patterns in terms of discrete categorical entities, and the *untamed* half, i.e. the phonetic implementation of these pitch patterns in terms of gradual F0 variation. In other words, intonational meaning as it is understood by Gussenhoven (2002a, 2004) is composed of a phonological representation on the one hand and its phonetic realisation on the other.

Even though this description of intonational meaning is now widely established in intonation theory, the duality of intonation leaves room for confusion as to its exact conceptual nature. Depending on the viewpoint adopted, the terminology used in the literature differs widely, posing a further challenge to defining intonation (among others Barnes, 1983; Clark, Yallop & Fletcher, 2007; Cruttenden, 1997; Crystal, 1969). Barnes (1983, p.59) accurately sums up the situation, remarking that the study of intonation does not lack descriptive terms, but “agreed-upon definitions of these terms”. His point can be succinctly illustrated with the following example: Intonation is generally agreed to reflect the phrasing of an utterance. However, the chunks the utterance is divided into have been variously termed *intonation phrase*, *intonational phrase*, *tone group*, *tone unit* or *breath group* (Grice, 2006). As a result of this terminological variation, terms have become interchangeable (Barnes, 1983; Hirst & Di Cristo, 1998), with intonation ultimately meaning “different things to different people” (Ladd, 1996, p.6). Consequently, the next step is to clarify how the term intonation is used in the present study.

### 2.1.1 Narrow and broad definition of intonation

Given the manifold ways to use the term intonation, a comprehensive discussion and critical consideration of the numerous approaches towards defining intonation, even though desirable, are beyond the scope of the present study. Instead, focus will be on introducing the notion as it is used in this thesis. A general overview of intonation can be found in Couper-Kuhlen (1986), Cruttenden (1997), Hirst and Di Cristo (1998), Ladd (1996, 2008) and Rossi (2000).

In the literature, intonation has been defined in a narrow as well as in broader sense (e.g. Botinis, Granström & Möbius, 2001; Grice & Baumann, 2007; Hirst & Di Cristo, 1998). According to the narrow description, intonation is the sequential structuring of tonal features by means of fundamental frequency variation. This narrow definition confines intonation strictly to the variation of fundamental frequency (Grice & Baumann, 2007; ‘t Hart, Collier & Cohen, 1990). In its broader sense, intonation is not only described in terms of tonal variation, but also in relation to temporal, i.e. duration, and dynamic parameters, i.e. intensity. This broader account often equates to what is termed *prosody* (Botinis et al., 2001). Despite this terminological overlap, agreement across definitions exists pertaining to the attribution of lexical features, i.e. word stress, only to the area of prosody. While intonation only refers to phonological phenomena on the post-lexical level, prosody covers events at lexical as well post-lexical level (Hirst & Di Cristo, 1998). Figure 2.1 illustrates the relation of the different terms:

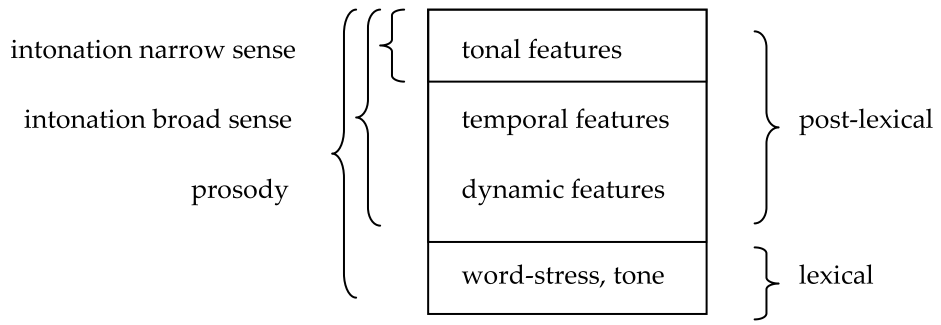


Figure 2.1: Relation between intonation in its narrow and broad sense and prosody

### 2.1.2 Ladd's definition of intonation

A widely accepted definition of intonation within the area of intonational phonology was provided by Ladd (1996). According to this definition, the term intonation refers to *suprasegmental* phonetic features, which describe *post-lexical* phenomena of spoken language in a *linguistically structured* way. Ladd's definition of intonation has been regarded favourably by the research community as it explicitly refers to the structural nature of intonation, and at the same time clearly defines the domain over which intonation operates (Rossi, 2000). Given the general acceptance of this definition, combined with the fact that this thesis employs the influential autosegmental-metrical (AM) framework for analysing intonation (Ladd, 1996; cf. section 2.2), the present study adopts the above definition of intonation. Following this view, three key characteristics are considered to be of relevance for defining intonation: *suprasegmental*, *post-lexical* and *linguistically structured*. The next sections will briefly address each of these key characteristics.

In speech production, single segments and phonemes are grouped into larger domains such as syllables, words and phrases that are generally referred to as *suprasegmentals*. The term *suprasegmental phonology* therefore relates to linguistic phenomena that are associated with larger phonological or prosodic constituents. A number of authors have suggested models that describe the hierarchical organisation of these constituents (Grice, 2006; Gussenhoven, 2002b; Hayes, 1989; Nespor & Vogel, 2007; Selkirk, 1984). Depending on the language which is analysed, the models differ slightly as to the units represented in that model. Importantly, however, the position of these units within the hierarchy of a given model remains unchanged. A typical hierarchical model of the prosodic constituents in English is provided in figure 2.2. According to the definition of intonation posited by Ladd (1996), intonation refers to phonological phenomena that occur at the level of the phonological phrase (PP), the intonation phrase (IP) as well as utterance-level (U). A more detailed description of the different constituents of the prosodic hierarchy can be found in appendix A.

Utterance (U)
|
Intonation Phrase (IP)
|
Phonological Phrase (PP)
|
Phonological Word (PW)
|
Foot (F)
|
Syllable (σ)

Figure 2.2: Typical hierarchical model representing prosodic constituents

Different phonetic parameters have been proposed to play a role in the manifestation of suprasegmentals. Adopting the traditional phonetic viewpoint, the acoustic parameters of importance to the realisation of the different prosodic constituents are fundamental frequency (F0), duration and intensity (cf. section 2.4). Tonally, higher prosodic constituents are often marked by *boundary tones*, i.e. pitch movements occurring at the edge of phrases. In terms of duration, the most reliable indicators of phrase-final boundaries are filled and silent pauses as well as final syllable lengthening (Lehiste, 1973). In phrase-initial position, anacrusis, i.e. the production of syllables with a faster speech rate and reduced articulatory accuracy, has been reported to play a role as well (Grice & Baumann, 2007; Mayer, 1997).

The second key characteristic of Ladd's (1996) definition of intonation concerns the fact that intonation conveys meanings at *sentence*- or *post-lexical* level only. Following this definition, intonation primarily functions as an indicator of meaning that relates to whole phrases and utterances such as sentence modality, speech acts and information structure (cf. section 2.5), and is thus closely connected to higher levels of linguistic representation and organisation such as syntax, semantics and pragmatics. At the same time, intonational features are not considered to signal meaning at lexical level or word level. That is, features determined in the lexicon such as tone and stress assignment (cf. figure 2.1), even though they are phonetically related to intonation, are not included in the definition of intonation proposed here.

The third key feature of the intonation definition proposed by Ladd (1996) refers to the structural nature of intonation. Ladd (1996) points out that intonation, in the sense in which he uses the term, is organised in a *linguistic* way. This means that intonation consists of a sequence of abstract categorically distinct events, i.e. pitch accents and boundary tones, that are associated with certain points in the segmental string (cf. section 2.2). The term linguistic organisation entails that paralinguistic features as well as extralinguistic features do not form part of the intonation description.

This three-part definition of intonation proposed by Ladd (1996) clearly outlines the relevance of both phonological and phonetic features in the description of the intonation component. By this definition, a comprehensive description of intonation comprises two levels. The first details the intonational structure of an utterance in terms of a small set of distinct categorical entities, i.e. pitch accents and boundary tones. At a second level, these phonological representations are translated into physical activities by means of language-specific phonetic implementation rules defining the way in which the continuous acoustic parameters vary. Consequently, the binary nature of intonation in terms of phonological representation and phonetic implementation forms an integral part of Ladd's (1996) definition of intonation, and is also reflected in the autosegmental-metrical (AM) framework of intonational analysis (cf. section 2.2). Ladd's definition of intonation differs considerably from previous approaches to describing intonation, which have either looked at intonation from a purely phonetic perspective or a purely phonological perspective. Whilst researchers favouring the former were mostly interested in determining the acoustic features of intonational phenomena (e.g. Fry, 1958; Lieberman, 1967), advocates of the latter relied on auditory impressions only to describe intonation and did not acknowledge the usefulness of investigating intonation by instrumental means (Palmer, 1922; O'Connor & Arnold, 1973). However, Ladd (1996) argues that in order to comprehensively describe intonational phenomena both phonology and phonetics have to be combined.

Although this approach towards analysing intonation is now integral to the current research landscape on intonation, its influence on research pertaining to disordered intonation is still very limited. Instead, the latter has been heavily influenced by the traditional phonetic approach which, as outlined above, aims at identifying direct physical correlates of linguistic functions. However, from an empirical point of view this approach is problematic as it only addresses the phonetic nature of the intonation component and fails to acknowledge the phonological structure of intonation. Although this is not only an issue of clinical investigations, restricting intonational analysis to the examination of continuous phonetic parameters may actually have wider implications for clinical research. Disregarding the phonological level of intonation runs the risk of misinterpreting the level of intonation breakdown and therefore potentially its precise underlying nature. For this reason, the present study adopts the autosegmental-metrical theory of intonational phonology to investigate the intonation patterns in FAS speech. The theoretical underpinnings of this intonational framework are outlined in the following section.

## 2.2 Phonology of intonation

In the late 1970s, an explicitly phonological approach towards describing intonation began to establish itself: the autosegmental-metrical (AM) theory. The term was coined by Ladd (1996)[1] and reflects the non-linear phonological theories that were instrumental in the development of the approach (e.g. Bruce, 1977; Goldsmith, 1976; Leben, 1973; Liberman, 1975; Liberman & Prince, 1977). The theory, which evolved to account for hitherto unsolved theoretical issues in phonology marked a new era in the analysis of intonation and strongly influenced present approaches and theories to describing intonation. It is based on the influential work by Liberman (1975), Bruce (1977), and most importantly Pierrehumbert (1980). In her work, Pierrehumbert presented a model of American English intonation that redefined the phonetics-phonology interface (Arvaniti, 2007; Gussenhoven, 2002b). By separating phonological representation from its phonetic implementation, Pierrehumbert paved the way for characterising intonational structure independently from the phonetic features of the tune structure. As outlined in the previous section, the duality of phonological representation and phonetic implementation describing the structure of intonation is fundamental to Ladd's concept of the AM theory: "The AM theory adopts the phonological goal of being able to characterise contours

[1] In 2008, a revised and updated version of Ladd's influential work *Intonational phonology* was published, in which many of the originally postulated theories still hold true. This thesis refers to the 1996 version of the book as the framework of the *autosegmental-metrical* theory was introduced in that version.

adequately in terms of a string of categorically distinct elements, and the phonetic goal of providing a mapping from phonological elements to continuous acoustic parameters." (Ladd, 1996, p.42).

Under the influence of Pierrehumbert and subsequent work by e.g. Beckman and Pierrehumbert (1986), the AM approach became the prevailing research paradigm in intonation research, providing an intonational account of a variety of languages. However, the AM theory not only proved to be influential in terms of the investigation of language typology and dialectal variation; it was also considered a promising start for the investigation of intonation in disordered speech (cf. section 2.6). The core ideas of the AM theory are outlined in the following sections.

The AM approach is based on four ideas that are regarded to be essential for and independent from the description of language-specific intonation systems (Ladd, 1996):

1. linearity of tonal structure
2. distinction between pitch accentuation and prominence
3. analysis of pitch accents in terms of level tones
4. local sources for global trends

**Linearity of tonal structure:** The first core assumption posited by Ladd (1996) implies that intonation contours are interpreted as a structured sequence of linguistically meaningful local events which are associated with specific points in the utterance. The pitch levels of the different localised events are linked by gradual transitions that remain phonologically unspecified. That is to say, within the AM framework the pitch levels of the discrete linguistic events are of importance, rather than the pitch movements as such. In this, the AM theory differs significantly from the British tradition of analysing intonation (Crystal, 1969; Cruttenden, 1997; Halliday, 1967a; O'Connor & Arnold, 1973). With respect to the meaningful events of the tonal sequence, two main types can be distinguished: *pitch accents* and *edge tones* or *boundary tones*. Pitch accents constitute local features that occur in the shape of simple pitch peaks or valleys or complex rising or falling pitch movements (Ladd, 1996). They are essentially prominence-cueing in nature, whereas boundary tones serve to demarcate phrasal boundaries.

**Distinction between pitch accentuation and prominence**: The prominence-cueing nature of pitch accents is further elaborated in the second core assumption of the AM approach, where the intricate relationship of pitch accentuation and prominence is directly addressed. The term pitch accent was first used by Bolinger (1958) to refer to the prominence of syllables within an utterance. In the current framework a slightly different view is put forward, with pitch patterns and prominence patterns being regarded as independent features. Whilst the former is a purely phonological feature of intonation, the latter is strongly related to the stress pattern of an utterance, which is determined by phonetic features[2].

According to this view, the stress pattern of an utterance reflects the relations between weaker and stronger constituents such as phrases, words and syllables, which are organised into a hierarchical metrical structure (Liberman, 1975). The stress pattern is realised by means of a number of phonetic cues such as duration, intensity and spectral properties, with metrically strong syllables being the ones that are phonetically salient and therefore perceived to be prominent. Importantly, prominence is defined in relative terms, i.e. the prominence of a syllable or unit is established in relation to the remaining syllables or units rather than by the absolute values of the different parameters (e.g. Ladd, 1996; Mayer, 1997).

The intonation pattern of an utterance, in turn, represents a sequence of pitch accents and boundary tones, which are associated with the text based on the prominence relations defined by the metrical stress pattern. According to rules of prosodic well-formedness, pitch accents have to be associated with prominent, i.e.

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[2] Ladd (1996) uses the term stress as the realisation of metrical relations within an utterance expressed by a combination of phonetic features. This is not to be confused with the notion of stress as an indicator of linguistic meaning (e.g. contrastive stress).

metrically strong, syllables. As a result, the presence of a pitch accent represents an indirect cue to prominence, but it is not the direct manifestation of the prominence pattern of the utterance, as initially suggested by Bolinger (1958).

**Analysis of pitch accents in terms of level tones**: Pitch accents are analysed as sequences or combinations of two types of abstract tonal values, H (High) and L (Low). These two level tones are also referred to as primitives and constitute the basic elements of the pitch contour. They roughly reflect the pitch level of the phonetic realisation of the pitch accent they represent. Even though the combination of tones can give an indication of the abstract shape of the pitch accent, the phonetic realisation of the tonal targets in terms of *alignment*, i.e. the temporal alignment of the tones relative to the text, and *scaling*, i.e. the F0 excursion, of the same type of pitch accent can differ considerably. The factors known to influence the phonetic implementation include the number of pitch accents in the utterance as well as the position of a pitch accent within that utterance. In addition, functional aspects such as the discourse structure of the utterance are also known to play a role (cf. section 2.5). By treating H and L as phonological abstractions that can phonetically be realised in different ways, the AM approach acknowledges the interaction of phonological representation and phonetic realisation.

**Local sources for global trends**: The fourth basic assumption of the AM theory concerns the influence of global trends such as declination on the overall realisation of the intonation contour. These global processes are known to interact with local features, i.e. pitch accents, that way influencing the shape they can take. Ladd (1996) assumes that global trends are mainly the result of actively controlled variation of the phonetic realisation of tonal targets. This particularly holds true for the phenomenon of downstep, i.e. the stepwise lowering of the pitch height of certain pitch accents. Semantically, downstepped pitch accents indicate greater finality or completeness than non-downstepped pitch accents (Ladd, 1996), which is why the difference between both types of pitch accents needs to be accounted for in phonological terms. As indicated, in Ladd's approach this is achieved by considering downstep to be a discrete linguistic phenomenon that is subject to a speaker's volitional control.

Despite its general popularity, the AM approach has also attracted some criticism, which mostly centres around the dominance of pitch in the analysis of intonation patterns (Baumann, 2006a; Kochanski, Grabe, Coleman & Rosner, 2005). Specifically, these authors argue that pitch has been ascribed too much importance in determining prominence patterns. Although pitch is considered to be the primary cue to prominence (e.g. Atkinson, 1978; Fry, 1955, 1958; Rietveld & Gussenhoven, 1985), post-lexical prominence should not be equated to the variation of pitch alone as this implies that prominence is essentially a function of F0. Instead, as outlined earlier, post-lexical prominence may also be cued by other means than pitch, such as length and loudness. The primacy of pitch in determining post-lexical prominence is therefore thought to weaken the role of the metrical component within the framework (Baumann, 2006a).

Regardless of this criticism, there is no doubt that based on the work of its influential precursors (Bruce, 1977; Goldsmith, 1976; Leben, 1973; Liberman, 1975; Liberman & Prince, 1977), the AM theory marked a new era of intonational research. Specifically, it constitutes a phonological approach to describing language-specific intonation systems that takes into account the phonetic realisation of the abstract phonological representations. In the following, the tools available for transcribing intonation are introduced.

## 2.3 Prosodic annotation and transcription tools

The absence of a unified system for intonation transcription was the reason for a group of scientists from different disciplines including linguistics, phonetics and engineering to join forces and devise guidelines upon which an international standard of prosodic annotation could be developed[3]. The aim of the cross-disciplinary group was to define a set of conventions based on which the essential supra-segmental features of speech could be transcribed (Beckman & Ayers-Elam, 1997; Beckman & Hirschberg, 1994; Silverman et al., 1992). The resulting transcription system - ToBI for *Tones and Break Indices* - was quickly adopted by the research community as the standard annotation system for speech prosody. In particular the explicit separation of tonal content and prosodic structure proved sufficiently flexible to be applied to other languages. Originally based on Pierrehumbert's (1980) model of American English intonation, the system was adapted to describe prosodic systems of numerous other languages such as GToBI for German (Reyelt, Grice, Benzmüller, Mayer & Batliner, 1996) and K-ToBI for Korean (Jun, 2000). As a result, the term ToBI came to signify two different aspects (Beckman, Hirschberg & Shattuck-Hufnagel, 2005). On the one hand, it is the name of the original annotation system designed to label American English prosody and intonation. This annotation system is now referred to as MAE-ToBI (Mainstream American English ToBI) to distinguish it from other variants that have subsequently been developed. On the other hand, the term ToBI now refers to a general framework for developing language-specific prosodic transcription systems. In the following section, a description of the core characteristics of the annotation system is provided. A more comprehensive account of the annotation conventions can be found in Beckman and Ayers-Elam (1997).

### 2.3.1 ToBI (Tone and Break Indices)

The ToBI annotation system is explicitly phonological in nature, providing a symbolic transcription of the distinctive elements of the pitch contour, rather than a description of the actual pitch movements. The original ToBI version comprises four independent labelling tiers, each of which serves a specific function:

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[3] Similar efforts were already made within the area of segmental transcription, leading to the development of a unified transcription system of the single sounds of the world's languages - the International Phonetic Alphabet (IPA).

1. tone tier
2. orthographic tier
3. break index tier
4. miscellaneous tier

On the *orthographic tier* the words are labelled providing anchor points for the intonation analysis. The *miscellaneous tier* captures non-tonal phenomena that are not directly related to the annotation, but might influence the prosodic analysis. This includes aspects such as voice quality, laughter, audible inhaling and exhaling, any form of dysfluency, false starts or restarts. The prosodic core transcription is carried out on the *tone tier* and the *break index tier*, where the structural phonological elements and the perceived boundary strengths of adjacent words are annotated. Based on these tiers, the categorically distinct pitch events of an intonation contour as well as the prosodic structure and its constituents are captured.

The *tone tier* is used to describe the intonation of a language in terms of pitch accents and edge tones, whereby in ToBI the latter refer to phrase accents as well as boundary tones[4]. The inventory of phonological labels is language-specific, but general labelling conventions apply. As briefly introduced in section 2.2, the tune structure is linearly described by means of high (H) and low (L) tones. Simple pitch accents, i.e. pitch accents which refer to peaks or valleys only, are marked with an H or L respectively. These tones can further be combined to describe more complex pitch patterns. A falling pitch pattern is indicated by the tone combination HL, a rising pattern by LH, a rise-fall by LHL and a fall-rise by HLH, whereby in all types of combinations the tone that is associated with the accented syllable is assigned an asterisk (e.g. H* or H*L). Pitch accents consisting of more than one tone can be

[4] In the original analysis (Pierrehumbert, 1980), the phrase accent occurs between the last pitch accent of an intonation phrase and the final boundary tone and is marked using the minus sign (i.e. H- and L-). It is a feature specific to ToBI that is not assumed by all transcription systems (cf. IViE, section 2.3.2).

linked by a plus sign (e.g. H*+L). Tones preceding the starred tone are referred to as *leading tones* (e.g. L+H*); tones following the starred tone are called *trailing tones* (H*+L). The former type of pitch accent is referred to as right-headed pitch accents, whereas the latter represents left-headed pitch accents. Downstepped high tones are marked with an exclamation mark (e.g. !H*+L).

The second type of tonal events, the boundary tones, are also described using the primitives H and L. They are labelled using the diacritic %, which is placed before or after the tone to indicate whether they describe initial boundaries of intonation phrases (e.g. %L) or final boundaries (e.g. H%).

The *break indices*, on the other hand, serve to transcribe the perceived strength of prosodic boundaries between adjoining words. Five indices are available (0 to 4) to indicate the connection strength between words. Index 0 represents a very close connection between words, whereas index 3 and 4 indicate the presence of a phrasal boundary between words. There are two types of phrase boundaries posited in the ToBI transcription system. The minor phrase boundary (index number 3) indicates an intermediate phrase (ip), whilst the major phrase boundary (index number 4) signals the hierarchically more relevant intonation phrase (IP).

The ToBI labelling system was readily accepted by researchers in the field as the transcription is flexible in terms of the tiers and labels employed. Users are encouraged to extend the core tiers and to develop their own labels. That way, it is possible to investigate language-specific aspects of prosody as well as prosodic aspects that relate to other linguistic levels such as semantics or pragmatics. In addition, ToBI acknowledged the potential difficulties of transcribing intonation and prosody from the start, allowing transcribers to leave aspects under- or even unspecified. In other words, users are provided with precise strategies to deal with labelling uncertainties.

### 2.3.2 IViE (Intonational Variation in English)

An annotation variant that emerged during the following decade is IViE, which stands for *Intonational Variety in English* (Grabe, 2001, 2004; Grabe et al., 1998, 2001)[5]. The IViE system is modelled on ToBI. Just as in ToBI, intonation is described with a limited set of structural categories using H and L tones. These categories, in turn, are associated with syllables and phrasal boundaries, enabling the analysis of accentuation and phrasing.

IViE was specifically developed by Grabe and colleagues (Grabe, 2001, 2004; Grabe et al., 1998, 2001) with the aim of prosodically annotating different dialects of British English within a single labelling system. Devising a transparent comparative transcription system that was suitable to describe standard and non-standard varieties of English was deemed necessary as dialect-specific transcription systems adapted from the original ToBI framework such as GlaToBI (Mayo, Aylett & Ladd, 1997) differed too widely in terms of e.g. the categorical inventory to enable comparisons across dialectal varieties.

The major difference between IViE and the original ToBI system concerns the number of levels employed to arrive at the transcription of the intonation contour. While in ToBI the intonational analysis is carried out on one level only, the tone tier, IViE features three separate levels to describe the prosodic component. More precisely, within IViE the process of arriving at the phonological categorisation of pitch events is made transparent by splitting up rhythmic, phonetic and phonological analysis. The use of the three tiers was motivated by the fact that British English intonation can differ in terms of the location of rhythmic

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[5] The IViE transcription system was developed as part of the IViE project, which was conducted between 1997 and 2002 to collect a directly comparable speech corpus from different dialects of British English, including different speaking styles and speaker groups. Linguistic analyses were conducted on these speech recordings using the devised transcription system, providing researchers with benchmarks of intonation variation in the dialects investigated.

prominences, the phonetic implementation of the tune structure and the inventory of the pitch accents (Grabe, 2004). Disentangling the complexity of the annotation procedure was further intended to increase the transparency of the labelling procedure.

Overall, IViE comprises five levels of annotation, of which two are orthographic and three prosodic in nature:

1. orthographic tier
2. prominence tier
3. target tier
4. phonological tier
5. comment tier

On the *orthographic tier* the utterances are transcribed at syllable level, whereas the *comment tier* provides space to note alternative transcriptions. The prosodic core transcription is carried out on the remaining three levels. The rhythmic structure is captured on the newly introduced *prominence tier*. On this level, the prominent syllables, as well as the prosodic units, are labelled. The phonetic realisation of the speech sample is transcribed on the second level - the so-called *target tier*. Here, the pitch movements that surround the rhythmically strong syllables are described. Information from this level in turn serves as input for the phonological analysis which is carried out on the *phonological tier* to establish the categorical inventory of the tune structure.

The inventory of pitch accents and boundary tones used in the IViE system is based on the British tradition of intonation analysis (Grabe, 1998; Gussenhoven, 1984). Although these accounts describe the intonation of Southern Standard British English, IViE was not designed as such to represent the intonation system of a specific British English variety. Rather, labellers can choose from a pool of labels to annotate the variety they investigate. Overall, seven mono-, bi-, or tritonal pitch accents can be distinguished within the IViE system. Unlike ToBI, however, IViE only features left-headed pitch accents:

| | |
|---|---|
| H* | high target |
| H*L | high target followed by low target |
| !H*L | downstepped high target followed by low target |
| H*LH | fall rise |
| | |
| L* | low target |
| L*H | low target followed by high target |
| L*HL | rise fall |

In addition, the IViE system proposes three types of boundary tones to label the boundaries of intonation phrases (see below). Whilst the original ToBI annotation system differentiates between intermediate and intonation phrases, IViE only assumes one phrasal level: the intonation phrase. As a result, the phrase tone postulated in ToBI becomes redundant in IViE.

| | |
|---|---|
| %H, H% | high target at boundary |
| %L, L% | low target at boundary |
| % | no pitch movement at boundary |

Having established the phonological inventory in terms of pitch accents and boundary tones that is employed in the IViE transcription system, the following section introduces the acoustic cues that were identified to have a role in the phonetic realisation of the tune structure.

## 2.4 Phonetics of intonation

The classical field of research pertaining to the phonetics of intonation concerns the investigation of the acoustic parameters duration, intensity and fundamental frequency (F0; Clark et al., 2007; Cruttenden, 1997; Crystal, 1969; Hargrove & McGarr, 1994; Ladd, 1996, 2008). The three parameters are generally acknowledged to be the primary acoustic cues to signalling the prominence patterns of utterances (among others Beckman, 1986; Fry, 1955, 1958; Lehiste, 1970). Further prosodic parameters commonly considered to be of relevance are vowel quality (Grice, 2006), voice quality and vocal tract state (Laver, 1980; Clark et al., 2007; Nolan, 1983) as well as pausing and speech tempo (Cruttenden, 1997). While duration, intensity and F0 are dynamic parameters, i.e. their phonetic manifestation within the domain of spoken language can change rapidly, voice quality and vocal tract state are considered to be static parameters whose settings remain relatively constant over time. They are, therefore, often referred to as long term voice settings (Clark et al., 2007).

Prosodic parameters operate over domains of varying sizes (Cruttenden, 1997) and depending on the size of the domain, the manifestation of the respective dynamic parameter may vary considerably. Duration, intensity and F0 can be analysed with respect to their local and global effects on intonation realisation (Botinis et al., 2001; Hirst & Di Cristo, 1998; Vaissière, 2005). Local effects are associated with small linguistic units such as words and syllables and are realised by quickly varying the dynamic parameters. Global effects, by comparison, are related to phrase and utterance level and manifest themselves in a rather slow and continual variation of the dynamic parameters.

The following sections detail the characteristics of the three dynamic parameters in question, i.e. duration, intensity and F0, in terms of their physiological, acoustic and perceptual attributes as well as their local and global features. An overview of the physiological activity and the acoustic and perceptual characteristics of the parameters is provided in table 2.1.

| physiological activity | acoustic properties | perceptual features |
|---|---|---|
| articulatory movement | duration (ms) | length (long – short) |
| air pressure, respiratory drive | intensity (dB) | loudness (loud – soft) |
| rate of vocal fold vibration | F0 (Hz) | pitch (high – low) |

Table 2.1: Physiological and acoustic and perceptual characteristics of phonetic parameters

**Duration**: Duration refers to the time interval that is needed to produce segments, and is usually measured in seconds or milliseconds (s and ms). The perceptual correlate of duration is length. Locally, duration manifests itself in the lengthening and shortening of segments and syllables, whereas global duration features are reflected in speech tempo, rhythm and pause structure of an utterance. The duration of units is influenced by biomechanical factors, such as jaw movement (Clark et al., 2007), but also by the segmental make-up of the utterance.

**Intensity**: The intensity of the speech signal is determined by the amplitude of the vocal cord vibrations. In more general terms, intensity concerns the acoustic energy that is invested to produce a sequence of sounds or syllables. The magnitude and variation of the amplitude is controlled by the subglottal air pressure coming from the lungs (Clark et al., 2007). Intensity is measured in decibel (dB), and its perceptual correlate is loudness. Local manifestations concern the rapid variation of intensity from segment to segment, whilst global features of intensity refer to the general volume of a speaker, which, due to physiological constraints, gradually decreases over the course of an utterance.

**Fundamental frequency (F0)**: F0 is generated by the vibration of the vocal folds of the larynx and is defined as the number of completed cycles of vibration per second (Clark et al., 2007). F0 is measured in Hertz (Hz). The perceptual equivalent of F0 is pitch. A perceived change in pitch height therefore reflects a change in the rate at which the vocal folds vibrate. The rate of vibration is primarily controlled by the activities of the laryngeal muscles regulating the vocal fold settings and tension of the vocal folds as well as the subglottal air pressure that sets the vocal folds in motion (Cruttenden, 1997). In addition to that, the rate of vibration is influenced by the length and mass of the vocal folds. Local variation of F0 is associated with manifestations of pitch accents and boundary tones. Globally, F0 variation reflects a speaker's pitch range (Ladd, 1996) and general trends in F0, such as declination (cf. section 2.2)[6].

To summarise, although a variation of a number of prosodic features is of relevance to quantifying intonation in English, the phonetic parameters of duration, intensity and F0 are generally considered to be the most important cues. Whilst F0 is generally ascribed the most central role in signalling prominence patterns (Atkinson, 1978; Fry, 1955, 1958; Rietveld & Gussenhoven, 1985), duration and intensity are thought to be of lesser importance (for an alternative view see Kochanski et al., 2005). At the same time, there is evidence that the three parameters can be subject to *cue trading* (Howell, 1993; Patel & Campellone, 2009; Sluijter & van Heuven, 1996; Vaissière, 2005), where in certain contexts one parameter may be traded in favour of another one. For instance, in West Germanic languages including Dutch, English and German post-focal F0 range is commonly compressed (cf. section 2.5), increasing the likelihood of duration and intensity being employed to mark prominence relations in the remainder of the sentence. As a result of these contextual influences, the generally accepted hierarchy of phonetic parameters may change. The phenomenon of cue trading is thought to be of particular relevance in disordered speech as the use of phonetic parameters may follow mechanisms that are different to those of healthy speakers. Due to the physiological constraints in disordered speech there may be a shift in the use of parameters irrespective of contextual influences. Patel and Campellone (2009), for instance, argue that

[6] Segmental effects are known to influence the realisation of the F0 contour. For instance, the somewhat misleadingly termed phenomenon of *intrinsic pitch* is known to correlate with vowel height, with close vowels being produced with a higher F0 than open vowels (Ladd & Silverman, 1984 and Ohala, 1978, as cited in Clark et al., 2007). Importantly though, these so-called microprosodic perturbations do not affect the listener's perception and interpretation of the overall pitch pattern.

individuals who experience difficulties adjusting and fine-tuning certain acoustic parameters may compensate by relying more heavily on others, over which they still have control. Accordingly, speakers exhibiting difficulties with varying F0 effectively might employ e.g. temporal parameters to a greater degree than before to compensate for the lack of sufficient F0 variation.

In the following section, the various functions of intonation are introduced, which are expressed through varying the different phonetic parameters described above.

## 2.5 Function of intonation

In speech production, intonation signals a variety of functions which can be subdivided into extralinguistic, paralinguistic and linguistic functions (e.g. Botinis et al., 2001; Couper-Kuhlen, 1986; Cruttenden, 1997; Crystal, 1969; Grice, 2006; Grice & Baumann, 2007; Hargrove & McGarr, 1994; Hirst, 1998; Hirst & Di Cristo, 1998; Nolan, 2006; Peppé, 2009). The three aspects of intonation can be arranged along a functional continuum (cf. table 2.2), reflecting the extent to which they are structural, systematic and intentional in nature (Crystal, 1969). Extralinguistic features are classified to be non-structural, non-systematic and non-intentional, whereas linguistic features, which cluster at the opposite end of the continuum, are considered to be highly structural, systematic and intentional in nature. Linguistic intonation as part of the grammatical system is thought to be under the individual speaker's volitional control. In other words, linguistic features can be purposefully varied to express their intended function. The following sections briefly introduce the different functions of intonation outlined in table 2.2. Given the focus of the present study, the main focus will be on the linguistic function of intonation and specifically on the structuring of information. The references cited above provide a more detailed description and examples of the different functions of intonation.

**FUNCTIONAL CONTINUUM** ◄——► 

| extralinguistic | paralinguistic | linguistic |
|---|---|---|
| biological features, e.g.<br>• anatomy<br>• age<br>• gender<br>• pathologies<br><br>socio-linguistic background, e.g.<br>• professional status<br>• geographic region | attitude, e.g.<br>• politeness<br>• authority<br><br>emotional state, e.g.<br>• boredom<br>• happiness<br>• surprise<br>• anxiety, fear | turn regulation<br><br>speech acts<br>• request vs. command<br><br>grammar<br>• structuring of utterances<br>• sentence modality<br><br>information structure<br>• highlighting of units |

Table 2.2: Functional continuum of intonation

*Extralinguistic intonation* mainly reflects biological attributes of individual speakers. These so-called *indexical* characteristics provide idiosyncratic information on the approximate anatomical build of a person, their age and gender, but also potential pathologies that may affect the speaker (Crystal, 1975). In addition, extralinguistic characteristics allow to infer information about a speaker's socio-linguistic background including aspects such as ethnic background, occupation and professional status as well as dialectal background and geographic provenance (Crystal, 1975; Hargrove & McGarr, 1994; Peppé, 2009). Individual speakers are identified by a combination of features such as the quality of voice, habitual pitch span, pitch level and loudness level (Peppé, 2009).

*Paralinguistic intonation* primarily indicates the *emotional* or *affective state* of a speaker such as excitement, boredom and anxiety to name but a few. At the same time, it reflects a speaker's attitude towards what is being said (O'Connor & Arnold, 1973). Paralinguistic features are therefore highly communicative and contribute significantly to the successful interaction between interlocutors. It is generally acknowledged that the degree of emotional involvement is reflected in the speaker's pitch span and level (Cruttenden, 1997; Couper-Kuhlen, 1986; Peppé, 2009). Boredom, for instance, is generally associated with a narrow pitch span, whereas excitement is signalled using a higher than usual span width. Intonational features are only one means to convey attitude and emotions, but they are considered to be a very powerful one. For example, tonal features can be varied in such a way as to contradict the segmental information of the utterance, as employed in irony and sarcasm, thereby effectively reversing the meaning of what is said.

Intonation is further involved in the marking of a variety of *linguistic functions*, which range from the signaling of turn taking relationships, speech acts and grammatical indications to the organisation of information in discourse, i.e. the marking of relevant speech units. In line with Ladd's definition of intonation (cf. section 2.1.2), only the function at the post-lexical level of intonation is considered here.

**Turn taking**: Linguistic intonation can be employed to guide and organise spoken discourse and thus the interactional exchange between two or more interlocutors above the sentence level (Botinis et al., 2001; Couper-Kuhlen, 1986). Specifically, speakers employ tonal features to regulate turn and to indicate whether they intend to keep their turn or yield the floor (Botinis et al., 2001; Hargrove & McGarr, 1994; Nolan, 2006). The former is generally indicated with rising intonation, whereas the latter is expressed by lowering intonation patterns (Cruttenden, 2006).

**Speech acts**: Intonation is further known to support the signalling of speech acts, also referred to as *illocutionary acts* or *illocutionary modes* (Grice, 2006; Grice & Baumann, 2007; Hirst & Di Cristo, 1998; Peppé, 2009). As part of this function, intonation is generally used to establish whether speakers wish to obtain information or whether they confirm or acknowledge information.

**Grammar**: In terms of grammatical function, linguistic features of intonation can be used to disambiguate between different syntactic constructions. In such cases, intonation basically assumes the role punctuation has in written language (Cruttenden, 1997; Grice, 2006; Grice & Baumann, 2007; Nolan, 2006; Peppé, 2009).

Apart from the grouping or segmentation of units, the grammatical function further involves the use of intonation in the marking of sentence modality or *sentence modes*, which is considered to be one of the most undisputed linguistic functions of intonation (Hirst & Di Cristo, 1998). It is generally maintained that different types of sentences such as interrogatives and declaratives can be characterised by different intonation patterns. Specifically, whilst a rising pitch at the end of sentences indicates a question, a falling terminal intonation pattern is attributed to a declarative statement (Cooper, Eady & Mueller, 1985; Eady & Cooper, 1986; Lieberman, 1967; Pike, 1945). However, this proposed dichotomy paints a somewhat simplified picture as not all types of questions are characterised by a final high pitch. While yes-no-questions frequently show a rising intonation pattern, wh-questions are not necessarily defined by the same rising pattern, as the question word can function as an indicator of the interrogative mode here. In addition, higher linguistic levels, i.e. syntax, semantics and pragmatics, influence the structure of questions and answers as well. Intonation patterns are therefore only one aspect of marking sentence modality (Hirst, 1998; Hirst & Di Cristo, 1998).

**Pragmatic organisation**: A further linguistic function of intonation is the structuring of information in discourse according to its communicative relevance (e.g. Botinis et al., 2001; Brown & Yule, 1983; Couper-Kuhlen, 1986; Cruttenden, 1997; Crystal, 1969; Grice, 2006; Grice & Baumann, 2007; Hargrove & McGarr, 1994; Hirst, 1998; Hirst & Di Cristo, 1998; Peppé, 2009; Zimmermann & Féry, 2009). Like sentence modality, the structuring of information contributes significantly to the interpretation of utterances and is therefore crucial to effective communication and efficient speaker-listener relations. Given the relevance of this linguistic function for the present study, the mechanisms of information structuring including its levels and encoding form the central topic of the next sections.

### 2.5.1 Information structure

Communication in general serves to share and exchange information between different interlocutors. In English, the speaker selects the information units he considers to be important or newsworthy and intentionally highlights them. That way, the listener's attention is directed to the important information of an utterance. In other words, information on utterance and discourse level is conveyed in a structured way. When interacting, interlocutors usually provide new information, which they effectively relate to information already given in discourse. At the same time, previously established facts might be re-introduced to connect them to the new information. This particular process of organising speech to optimise information transfer in discourse is often referred to as *information structuring* (Halliday, 1967b) or *information packaging* (Chafe, 1976; Vallduví, 1992). In the process of information structuring or packaging the emphasis is thereby on *how* information is conveyed from speaker to listener, and *how* the listener identifies the relevant information in an utterance, rather than the propositional content of that utterance. It is generally agreed that context and aim of discourse determine the way information is presented. In West Germanic languages, notably English, Dutch and German, information structure is mainly encoded using intonation, albeit other linguistic aspects such as syntactic structure (e.g. topicalisation) and focus particles that modify the meaning of their referents can also contribute to the structuring of information.

### 2.5.2 Levels of information structure

A vast amount of literature is available on the relevance of information structure for the interpretation of discourse, as over the years a considerable number of approaches have been suggested to describe the complex nature of discourse structuring. The common denominator of these approaches is the division of information into new and given, rendering this dichotomy central to the investigation of information structure. However, providing a clear-cut definition of the concept of information structure and the nature of new and given information proved challenging. As with any other notion related to intonation, terminologies pertaining to information structure can overlap considerably, blurring the boundaries between the different notions. Notwithstanding these premises, three levels of information structure were identified in the literature (Baumann, 2006b), which are clearly interrelated but can nevertheless be investigated separately:

- the division of an utterance into *theme* and *rheme*
- the pragmatic partitioning of an utterance into *focus* and *background*
- the marking of *information status* of referents in discourse (givenness)

According to Baumann (2006b), the first level is indicated using syntactic structure, whereas the latter two are primarily realised by means of intonation. In the following sections, the three different levels of information structure are outlined with specific attention being paid to the notion of givenness.

**Theme – Rheme**

The division of an utterance into *theme* and *rheme* basically reflects the organisation of the sentence into the sentence topic and information pertaining to that topic (Baumann, 2006b; Grice, 2006; Grice & Baumann, 2007; Halliday, 1967b). More precisely, as exemplified in (1), theme constitutes the part the utterance is about, i.e. what is talked about, whereas rheme provides information on the previously introduced theme. In English, the position of theme and rheme is structurally determined, with the thematic part commonly occurring before the rhematic part (Halliday, 1967b). The strict syntactic nature of theme and rheme is often used to create coherence in discourse, whereby information provided in the rhematic part of a clause is often resumed as theme in the following sentence. As a result, known or given information often forms the thematic aspect of a sentence, whereas new information is represented in the rhematic part of that sentence (Halliday, 1967b).

(1) The term *intonational phonology* was introduced by Bob Ladd.

[He] $_{\text{THEME}}$ [lectures in Edinburgh] $_{\text{RHEME}}$

**Focus – Background**

Another way to structurally divide an utterance is the partitioning into highlighted and non-highlighted parts based on the structure of the previous discourse and speaker intention (Grice, 2006; Grice & Baumann, 2007). The highlighted part is commonly referred to as *focus* and represents the informative and often new part of the utterance. The non-highlighted part of the utterance comprises information already mentioned, i.e. given in discourse, and is therefore part of the interlocutors' shared knowledge. This non-informative part of the utterance is generally called *background*. In (2), for instance, *last Friday* represents the new information and is therefore in focus, whilst *The phonology workshop took place* is given, hence forming the background of this utterance.

(2) When did the workshop on phonological theories take place?

[The phonological theories workshop took place] $_{\text{BACKGROUND}}$ [last Friday]$_{\text{FOCUS}}$

However, the dichotomy of focus and background indicating new and given information is of no universal character, as focused information does not necessarily have to be new (Büring, 1997; Grice, 2006; Grice & Baumann, 2007). In some contexts, focus is used to highlight the newsworthiness of elements or to clarify and contrast information rather than to indicate the actual newness of elements. This so-called contrastive focus is exemplified in (3), where *phonology* is in focus, despite being mentioned in the context.

(3) Which workshop did you attend, the one on phonology or the one on phonetics?

I attended the one on [phonology]$_{\text{FOCUS}}$

Depending on the scope of an utterance two main types of focus can be differentiated: *narrow* and *broad focus* (Ladd, 1980, 1996, 2008). Focus assigned to a single constituent is referred to as narrow focus. Here, the *focus exponent*, i.e. the element that receives a pitch accent, and the focused constituent correspond in size. By comparison, a focused constituent that is larger than the respective focus exponent is in broad focus (Jasinskaja, Mayer & Schlangen, 2004). In such cases, language-specific syntactic and pragmatic rules determine which word within the focused constituent is pitch accented. This phenomenon is known as *focus projection* (Selkirk, 1984, 1995). Broad focus is often associated with context-free questions, so called *out-of-the-blue* questions, or is employed to answer general questions, such as *What happened?*

(4) What happened?
[I missed the workshop on phonological theories last Friday] $_{\text{FOCUS}}$

Narrow focus, on the other hand, is commonly elicited using wh-questions that refer to specific constituents. In these cases, the constituent queried by the wh-element is usually in focus (cf. example 2).

**Givenness**

In the literature, the concept of information status or givenness has by and large been defined from two different perspectives. Whilst Halliday's (1967b) definition of new and given refers to the pragmatic role of a referent within the ongoing discourse, the approach developed by Chafe (1974, 1976, 1994) regards givenness as expressing the degree of cognitive activation of discourse referents.

In his pragmatic-linguistic model of information structure, which is built upon notions instituted by scholars of the Prague School, Halliday (1967b) referred to the binary distinction of informative and non-informative parts of utterances as *new* and *given*. Conceptually, his approach largely corresponds to that of focus and background outlined in the previous section. Halliday (1967b) established that new information cannot be inferred from the context by hearers, whilst given information presented by the speaker is directly recoverable from the preceding discourse context. According to this approach, the most robust context for an element to be defined as *given* is its direct mentioning in the preceding utterance.

While Halliday's (1967b) approach highlights the role of contextual knowledge in defining givenness, the position outlined by Chafe (1974, 1976, 1994) - and taken up in subsequent work by Allerton (1978), Baumann and colleagues (Baumann, 2005, 2006a, 2006b; Grice & Baumann, 2007) and Lambrecht (1994) - views the notion of givenness in light of cognitive saliency. According to Chafe (1974, 1976, 1994), there is a crucial difference between knowledge of information as such and consciousness, in that newly activated information is not necessarily newly introduced. Givenness as it is understood in this approach refers to the degree of cognitive activation of propositions or discourse referents in the hearer's mind at the moment of the utterance. More specifically, the information state of a referent, which is described as mental representation or abstract idea corresponding to entities of the external world such as events and states, is determined by the cost that is necessary to activate that referent in discourse. If the cost is low because a referent is already active in the listener's consciousness at the time of the conversation, the referent is given; if a referent is inactive prior to the mentioning, it is new (Baumann, 2005, 2006a, 2006b; Grice & Baumann, 2007). This approach interprets givenness locally (Chafe, 1994). That is, the status of new and given is attributed to specific discourse entities, i.e. the referents representing the events and states, which can be directly related to its linguistic implementation (Baumann, 2005, 2006a, 2006b). Both notions of givenness are exemplified in (5).

(5) When did the workshop on phonological theories take place?

[The workshop] $_{\text{GIVEN/ACTIVE}}$ took place [last Friday]$_{\text{NEW/INACTIVE}}$

Importantly, in the cognitive approach the strong binary definition of new and given has subsequently been amended, giving rise to the assumption of a continuum rather than a dichotomy. Depending on the approach taken, the proposed number of degrees of givenness varies considerably from one intermediate status to a nearly infinite number (Hajicova, 1993, as cited in Baumann & Grice, 2006). These intermediate levels of givenness are thought to reflect accessible information (Baumann & Grice, 2006).

Across languages a variety of linguistic measures are employed to indicate different degrees of givenness. This ranges from syntactic markers such as word order, passives and morpho-syntactic particles to intonational indicators including accentuation and de-accentuation, i.e. the presence or absence of pitch accents (Baumann, 2005, 2006a, 2006b; Grice & Baumann, 2007). Intonational indicators are considered to be the most important marker of givenness in West Germanic languages and are discussed further in the following sections.

*Phonological encoding of givenness*

There is a general consensus that in West Germanic languages the information status of referents is signalled in a binary, categorical fashion, i.e. by the presence or absence of pitch accents. More specifically, new information, i.e. inactive referents, are routinely assigned a pitch accent, whereas given information, i.e. active referents, are unaccented or de-accented (e.g. Baumann, 2006a, 2006b; Brown & Yule, 1983; Chafe, 1994; Couper-Kuhlen, 1986; Cruttenden, 2006; Grice, 2006; Grice & Baumann, 2007; Gussenhoven, 2004; Hirst & Di Cristo, 1998; Jasinskaja et al., 2004; Ladd 1980, 1996, 2008; von Heusinger, 1999). That is to say, information that is already contextually given does not receive a pitch accent, or it is removed, whereas in all-new sentence constructions a pitch accent would be expected (Ladd, 1980, 1996, 2008). However, de-accentuation as a mechanism of prominence reduction is considered a language-specific characteristic rather than a cognitive universal (Cruttenden, 2006). Whilst in Romance languages de-accentuation only constitutes one option amongst many to structure discourse, in West Germanic languages it is a strong constraint that directly influences the position of pitch accents to achieve discourse cohesion (von Heusinger, 1999).

However, the process of de-accentuation is influenced by a number of factors including structural position and grammatical role of the referent within the sentence as well as the type of data examined (Bard & Aylett, 1999; Swerts, Krahmer & Avesani, 2002; Terken & Hirschberg, 1994). If the new referent occurs in initial or medial position of the sentence, complete de-accentuation of the following sentence elements is expected; if the new referent occurs late in the sentence, the preceding given information may be accented for rhythmical reasons (Baumann, Becker, Grice & Mücke, 2007; Chen, 2007; Gussenhoven, 2002a). Terken and Hirschberg (1994) further note that the previous mentioning of an element as such is not sufficient to act as a catalyst to de-accentuation. In cases where given referents are subject to changes in structural position or grammatical role, accentuation of that referent is likely. However, this finding was disputed by Bard and Aylett (1999). Unlike Terken and Hirschberg (1994) they did not find that similarity of structural position and grammatical role influences the de-accentuation rate. In their study, which examined givenness in task-oriented dialogues, only about one sixth of repeated referents were de-accented at all. This, in turn, is in stark contrast to findings of a study conducted by Prince (1981), in which nearly all given entities uttered in a dialogue context were found to be de-accented. Overall, findings in the literature differ as to the robustness of the de-accentuation constraint, suggesting an influence of the type of text style investigated, in addition to the structural position and the grammatical role of the given entity.

Some studies on the phonological marking of information status moved beyond the generally accepted dichotomy of accentuation versus de-accentuation (Baumann, 2006a, 2006b; Baumann & Hadelich, 2003; Baumann et al., 2007; Brazil, Coulthard & Johns, 1980; Büring, 1997; Grice, 2006; Grice & Baumann, 2007; Pierrehumbert &

Hirschberg, 1990). They argue that the information status of individual discourse referents is not only denoted by the presence or absence of pitch accents, but also by the type of pitch accent used.

The most influential work pertaining to that position comes from Pierrehumbert and Hirschberg (1990). In their account of the discoursal meaning of American English intonation contours they propose that the phonological form of individual discourse referents can serve as an indicator of different degrees of givenness and consequently different activation states. Following this approach, information that is given is de-accented or marked using an L*; information that is accessible, i.e. it is already part of the hearer's belief, is indicated by an early peak[7]; and information that is new in discourse is marked by an H* pitch accent (H*L in British English; Brazil et al., 1980). Support for these findings comes from studies on information structure in German (Baumann, 2006a, 2006b; Baumann & Grice, 2006; Baumann & Hadelich, 2003). Several perception and production experiments revealed that de-accentuation was judged to be the most appropriate marker for given referents, whilst new referents were preferably marked by an H* pitch accent. Agreement between English and German was also observed pertaining to the marking of accessible referents, which were frequently assigned an early peak, i.e. H+L*. However, Baumann and colleagues also note that the use of pitch accents to mark a certain activation state varied considerably across speakers. This observation, in combination with the findings as to the vast variation in de-accenting, renders the phonological marking of givenness relative rather than absolute.

[7] According to the literature (Baumann, 2006a, 2006b; Baumann & Grice, 2006; Baumann & Hadelich, 2003; Pierrehumbert & Hirschberg, 1990), an early peak is indicated by H+L*, a right-headed pitch accent, where the second tone of the tone combination aligns with the text. It therefore does not form part of the IVIE pitch accent inventory employed in the present study.

*Phonetic encoding of givenness*

Research on the phonetic marking of givenness has primarily focused on the acoustic parameter of F0 and to a lesser extent on duration and intensity. Overall, findings showed that new referents in discourse are generally higher in pitch, longer and louder than their given counterparts. The exact phonetic manifestation is subject to positional effects.

With regard to F0, information status can be signalled by means of F0 height, F0 range as well as alignment and scaling patterns. There is general agreement that new information is indicated by high F0 levels (Chafe, 1974, 1976; Cruttenden, 2006) and a wider F0 range (Cruttenden, 2006; Féry & Kügler, 2008), reflecting the presence of pitch accents. Given information (in post-focal position), on the other hand, is marked by lowered F0 values and a compressed F0 range (Cooper et al., 1985; Eady & Cooper, 1986; Féry & Ishihara, 2009; Féry & Kügler, 2008; Hirst & Di Cristo, 1998; Ladd, 1996, 2008; O'Shaughnessy, 1979; Swerts et al., 2002; Terken & Hirschberg, 1994; Xu & Xu, 2005). F0 values are therefore thought to reflect the degree of *newness* of a referent. Overall, the higher the F0 on a discourse referent, the more important the referent is (Gussenhoven, 2002a, 2004; Ladd & Morton, 1997; Rietveld & Gussenhoven, 1985). F0 height is further known to have a role in the scaling or excursion of pitch accents. The latter is therefore also considered to be an indicator of information status, at least in German (Rabanus, 2001). In English, however, the alignment of accent peaks in relation to segments appears to have a greater impact on the perceived prominence and consequently on the status of newness of referents, with later peaks being perceived to be more prominent than early peaks (Grice & Baumann, 2007; Gussenhoven, 2002a, 2004; Kohler, 1991; Ladd & Morton, 1997).

Analyses of durational patterns and information status have revealed that new information generally increases target word duration, whereas givenness leads to a decrease in target word duration (Baumann, Grice & Steindamm, 2006; Féry &

Kügler, 2008; Kügler, 2008; Kügler & Genzel, submitted). More specifically, it was found that target words, which were labelled given, had a significantly shorter mean duration than their previously introduced new counterparts (Fowler, 1988; Fowler & Housum, 1987; Lieberman, 1963; Shields & Balota, 1991). However, Fowler and Housum (1987) also observed that the effects on duration, although overall reliable, were by no means consistent as only about three quarters of all given items examined were shorter than their new counterparts. This considerable variation was attributed to an influence of different sentence positions. The potential influence of sentence position on the length of referents was factored into the study by Kügler and Genzel (submitted), where carefully controlled data revealed a positional effect for given items. Whilst a decrease in duration was found for pre-focal given items, no such shortening could be observed for post-focal given items.

Intensity findings are in line with F0 and duration measures, where peak amplitude for target words marking new information is generally significantly higher than for those words indicating given information (Fowler & Housum, 1987; Lieberman, 1963; Shields & Balota, 1991).

### 2.5.3 Interaction of information structural levels

It is evident from the above description that the same or similar terminologies were and are still widely used in the literature to refer to the different levels of information structure, potentially confusing meaning. Focus, for instance, is generally, albeit not exclusively, assumed to mark the new information within an utterance, whereas given information is backgrounded. At the same time, the terms new and given are used to describe the cognitive information status of referents in discourse. The notion of givenness is also frequently mentioned in context with theme and rheme, as it is thought to correlate with the thematic part of an utterance. Yet, while every sentence features a thematic part, sentences do not necessarily comprise given information (Baumann, 2006a).

Despite the similar usage of terms, conceptually these levels ought to be distinguished for several reasons. First of all, the focus-background partitioning describes the structure of information on sentence or utterance level, whilst givenness as defined here relates to single sentence elements. A second key difference concerns the definition of newness on both levels. Focus can be used to indicate new information. However, elements in focus are not necessarily new as given information considered to be newsworthy by the speaker can be highlighted as well. In other words, focus can override the cognitive activation status of givenness. Thirdly, focus reflects speakers' intentions and its implementation can to some extent be purposefully influenced. Givenness as defined by Chafe (1974, 1976, 1994) and Baumann (2006a, 2006b), on the other hand, is closely tied to the cognitive effort needed to activate referents and does therefore not underlie conscious modification. Overall, information status as Chafe (1976, p.32) points out "is a status decided on by the speaker". Although the precise structuring of discourse may be defined in relative rather than absolute terms, there are certainly regularities speakers abide by when specifying new and given referents in discourse.

## 2.6 The modelling of intonation in disordered speech

The potential of the AM framework (Ladd, 1996) and associated transcription systems such as ToBI and IViE (Beckman & Ayers-Elam, 1997; Grabe, 2001, 2004; Grabe et al., 1998, 2001; Silverman et al., 1992) for the analysis of disordered intonation and prosody has been recognised by a few studies only (Arbisi-Kelm, 2006; Ball & Rahilly, 2002; Green & Tobin, 2009; Kent & Kim, 2003; Mennen, Schaeffler, Watt & Miller, 2008; O'Halpin, 2001). This small number clearly reflects the absence of current phonological approaches towards analysing disordered intonation outlined earlier in this chapter (cf. section 2.1.2). Whilst the majority of these studies acknowledged the potential, only three actually applied the AM approach of intonation analysis to disordered speech. This included the investigation of intonation patterns in stuttering (Arbisi-Kelm, 2006), Autism Spectrum Disorders (Green & Tobin, 2009) and hypokinetic dysarthria (Mennen et al., 2008). The two former studies employed the ToBI annotation system, whereas Mennen et al. (2008) used the IViE transcription system to transcribe the speech of two speakers with Parkinson's disease.

Of the studies acknowledging the potential of the autosegmental-metrical analysis of intonation (Ball & Rahilly, 2002; Kent & Kim, 2003; O'Halpin, 2001), Kent and Kim (2003) are the only ones to elaborate their position further. According to them, the advantage of this approach lies in its potential to explain deviant intonation patterns from a linguistic perspective. Previous and current research into disordered intonation and prosody is frequently based on auditory-perceptual analysis, which is complemented by acoustic-phonetic analyses. What is amiss in these investigations is the attempt to relate perceptual and instrumental findings to linguistic notions. ToBI clearly has this linking potential. Its linguistic foundation might open up new ways to describe and explain intonation patterns in disordered speech. However, more clinical studies are required to establish whether theory and practice can capitalise on the potential this linguistic approach towards analysing intonation offers.

One of the three studies that successfully applied the AM approach to analyse intonation patterns in clinical populations was Mennen et al. (2008). The authors investigated the intonation patterns of read speech in two speakers with Parkinsonian, i.e. hypokinetic, dysarthria using the IViE transcription system. Apart from the fact that Mennen et al. (2008) pioneered the use of IViE to analyse disordered intonation, there are two more reasons as to why this study is of particular interest for the present research project.

Firstly, according to Mennen et al. (2008), the structural make up of the AM approach could help to determine whether the changes observed in disordered intonation are the result of deficits on the phonological level or the result of a deficient phonetic implementation of the abstract tune structure. This information in turn allows researchers to separate intonation changes that result from deficient motor control from those involving higher linguistic or cognitive deficits.

Secondly, Mennen et al. (2008) employ a further framework suggested by Ladd (1996), which in combination with the AM approach could provide a principled and systematic account of disordered intonation. In this taxonomy, Ladd (1996, p.119)[8] posits four levels of intonation which together would comprehensively describe the intonation system of a language, a language variety or dialect:

1. Semantic level - i.e. differences in the meaning or use of the same tune
2. Systemic level - i.e. differences in the inventory of phonologically distinct tune type, irrespective of semantic differences
3. Realisational level - i.e. differences in detail in the phonetic realisation of the same tune
4. Phonotactic level - i.e. differences in tune-text association and in the permitted structure of tunes

This typological framework, which is partly based on an account by Wells (1982) to describe segmental differences of language-specific varieties, was further extended to include sociophonetic variation within a certain language variety (Fletcher, Grabe & Warren, 2005). The study by Mennen et al. (2008) provides evidence that Ladd's typology holds for clinical variation in intonation as well. Mennen et al. (2008) adopted Ladd's (1996) four dimensions, but renamed them in order to provide more transparency:

1. the inventory of structural elements - i.e. the pitch accents and boundary tones speakers have at their disposal

[8] Ladd recently (2008, p.116) re-evaluated the levels and still finds them to hold true.

2. the phonetic implementation of structural elements - i.e. the realisation of the structural categories in terms of phrasing and accentuation
3. the distribution of structural elements - i.e. the position of elements within a tune
4. the use of elements to signal intonational function - i.e. focus, sentence modality etc.

Mennen et al.'s (2008) analysis of read speech samples based on the four dimensions revealed that the two speakers with hypokinetic dysarthria had the same categorical elements at their disposal as the matched control speakers[9]. This finding indicates that the abstract phonological representations of intonation appeared to be intact in the two clinical speakers investigated (Mennen et al., 2008). However, differences between the speakers with Parkinsonian dysarthria and the matched control speakers were observed in relation to the realisation and distribution of the phonological categories. More specifically, the speakers with Parkinson's Disease produced shorter intonation phrases, fewer pitch accents per intonation phrase, and boundary tones in unexpected places. These differences combined with the retained categorical inventory suggest that the performances of the clinical speakers are likely to reflect difficulties at the motor execution level rather than difficulties in cognitive processing.

As outlined above, the study by Mennen et al. (2008) was one of the few to apply the AM approach of intonational analysis to examine disordered intonation. Most importantly, it was the first investigation of its kind to employ the IViE transcription system. The promising findings of the study clearly show the potential of the AM approach and IViE to analyse speech in clinical populations. The results further suggest that distinguishing between the levels of phonology and phonetics can contribute to identifying the level of disturbance. In conclusion, the AM approach

[9] The intonational analysis that was carried out covered inventory, realisation and distribution of structural elements. The corpus of read speech did not permit an examination of the functional level of intonation.

appears to be a valuable tool for clinical research, with IViE constituting a particularly suitable system to annotate disordered intonation of British English speakers.

With the aim of the present study in mind, the outlined potential of the AM approach in relation to the analysis of clinical data was an important factor for adopting this approach for the current investigation. In addition, IViE was specifically developed for British English intonation and the present study was conducted with participants from the British Isles. The rare nature of FAS further means that participants from different parts of the country with different dialectal backgrounds were recruited. Using IViE allowed the analysis of intonation patterns within a single transcription system, rather than working with a number of dialect-specific ToBI adaptations.

## 2.7 Summary

The main aim of this chapter was to introduce the concept of intonation in terms of its phonological, phonetic and functional aspects which form the basis for the intonational analyses of the present study. In addition, the chapter specified the argument for using current theoretical analysis frameworks and related annotation systems for the investigation of disordered intonation, whereby the potential of the autosegmental-metrical (AM) framework (Ladd, 1996) was particularly highlighted. The discussion pertaining to the analysis of clinical intonation showed that despite the advantages of theoretic-linguistic approaches for identifying the underlying nature of intonation disturbances, clinical investigations using these approaches are still sparse, thus establishing a clear need for the present type of investigation.

Having established the intonational framework within which the current study is situated, the following chapter introduces foreign accent syndrome (FAS), the speech disorder of interest to the present study, and outlines the research that has been undertaken pertaining to the intonational component in FAS.

# 3 INTONATION IN FAS

In the previous chapter, the intonational background to the study was outlined, providing information relating to the modelling of intonation in healthy and disordered speech using current analysis frameworks. This chapter introduces the motor speech disorder that is of research interest to this study: foreign accent syndrome (FAS). In the initial section of the chapter (3.1), a definition of the speech disorder is provided, including information on aetiology, accompanying speech and language disorders, as well as accent attribution. The chapter continues with a section discussing the challenges faced when investigating FAS. This is followed by a detailed acoustic and perceptual account of the segmental and suprasegmental changes observed in FAS speech (3.2), whereby specific attention is paid to the changes on intonational level. In a next step, the research relating to the intonational component in FAS is detailed, and scrutinised as to whether research efforts pertaining to intonation reflect the relevance of intonation as a major determinant of FAS (3.3). The chapter concludes with a discussion of the current explanations offered in the literature to account for the articulatory and prosodic alterations seen in FAS. As part of this section, it is also delineated how theoretic-linguistic frameworks of intonational analysis such as the AM approach (Ladd, 1996; Pierrehumbert, 1980) can contribute to the understanding of intonation realisation in FAS (3.4). Following from this, the research aims of this study are outlined.

## 3.1 Defining FAS

FAS is a rare motor speech disorder that is characterised by changes to segmental and suprasegmental speech patterns, leading to the emergence of a perceived foreign accent in speech. That is, to listeners of the same language community the speech of the individual resembles that of a non-native speaker, or alternatively, that of a native speaker from a different region of the country. In most cases, the perceived foreign accent cannot unequivocally be attributed to a specific language, which gave rise to the notion of speakers having a *generic* foreign accent. Whilst many speakers with FAS were never exposed to the language their new accent is associated with, in others an accent learned during the early years of childhood resurfaced[10]. The changes to articulatory and prosodic features are mostly subtle and speakers remain intelligible and relatively fluent (Coleman & Gurd, 2006). Until recently, FAS was generally considered to be an acquired motor speech disorder that exclusively occurs in relation to structural brain damage or psychogenic illnesses. However, a recent study by Mariën, Verhoeven, Wackenier, Engelborghs and De Deyn (2009) challenges this traditional view. In their study, the authors present two cases of FAS in which the foreign accent occurred in conjunction with developmental verbal dyspraxia and specific language impairment (SLI), advocating a redefinition of FAS to include cases with developmental speech and language impairments.

Despite this recent expansion in terms of origin, the majority of FAS cases documented in the literature concern adult patients, who present with a wide variety of neurogenic and psychogenic aetiologies. In most reported cases the emergence of the foreign accent in speech is the result of structural brain damage, predominantly vascular brain lesions affecting the anterior and parietal parts of the language-dominant hemisphere. That is, in most cases the cortical motor speech regions of the left hemisphere are affected, including the prerolandic motor cortex, the frontal motor association cortex or the striatum, albeit not exclusively (Edwards, Patel & Pople, 2005; Kurowski et al., 1996; Mariën et al., 2006, 2009). In a few cases, lesions to the right hemisphere were reported (Dankovičová et al., 2001; Miller, Lowit & O'Sullivan, 2006). Furthermore, lesions were not confined to cortical areas as FAS also occurred after brain injuries involving the sub-cortical white matter as well as the basal ganglia (Blumstein et al., 1987; Fridriksson et al., 2005; Gurd, Bessell, Bladon & Bamford, 1988). Further organic causes described in the literature

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[10] However, there is some controversy as to whether the latter cases fall under the label of foreign accent syndrome (cf. Blumstein & Kurowski, 2006).

include FAS being the result of traumatic brain injuries, (intra)cerebral haemorrhage or degenerative brain disease such as multiple sclerosis (Bakker, Apeldoorn & Metz, 2004). In the majority of these cases the foreign accent emerged after a period of muteness. The initial inability to speak often evolved through a stage of slow and laboured verbal output, often accompanied by aphasic symptoms, into more fluent speech (Ackermann, Hertrich & Ziegler, 1993). In a few case reports, FAS occurred in the absence of any identifiable structural cause (e.g. Coelho & Robb, 2001; Gurd, Coleman, Costello & Marshall, 2001; Katz, Garst & Levitt, 2008; Moonis et al., 1996; Van Borsel, Janssens & Santens, 2005). Some of these non-organic cases of FAS were suggested to have a psychogenic basis, including episodes of psychotic schizophrenia (Reeves & Norton, 2001; Reeves, Burke & Parker, 2007), bipolar disorder (Poulin, Macoir, Paquet, Fossard & Gagnon, 2007, Reeves et al., 2007), and conversion disorder (Haley, Roth, Helm-Estabrooks & Thiessen, 2010; Verhoeven, Mariën, Engelborghs, D'Haenen & De Deyn, 2005). Taken as a whole, FAS presents with a heterogeneous picture as to the aetiological origin.

The term *foreign accent syndrome* was originally coined by Whitaker (1982) and quickly established within the research community to refer to speakers presenting with an acquired change in accent after neurological brain damage. According to this traditional approach, there are four criteria typical of FAS which are required to be met for an individual with altered speech to be termed a case of foreign accent syndrome. Firstly, the individual's accent is perceived as foreign sounding to relatives, friends and him-/herself. Secondly, the speaker's present accent differs from the one he/she had before the incident. Thirdly, the personal background of the speaker does not account for the change in accent, and lastly, the change in accent is related to a neurological incident, i.e. damage of the central nervous system. Based on this strict classification, a number of case reports described in the literature would not classify as genuine cases of FAS, whereby in particular the third and fourth criterion proposed by Whitaker (1982) appear to act as exclusion criteria. According to the third criterion, the perceived foreign accent in speech is not the result of e.g. the re-emergence of a previously learnt accent as for instance described by Roth, Fink, Cherney and Hall (1997) and Seliger, Abrams and Horton (1992). These cases are rather interpreted as the return of a previously suppressed prosodic pattern that speakers had acquired or been exposed to during childhood (Jenkins, Merzenich & Recanzone, 1990, as cited in Seliger et al., 1992). The fourth criterion by Whitaker (1982) defines FAS to be of neurological origin, excluding the possibility that psychogenic aetiologies might have a role in the altered speech patterns. The assumption that FAS should be neurogenic and not psychiatric in nature was maintained by Blumstein and Kurowski (2006), even though recent case studies clearly suggest that structural damage to the brain is not necessarily a prerequisite for a speaker to acquire a foreign accent (e.g. Gurd et al., 2001; Haley et al. 2010; Van Borsel et al., 2005, Verhoeven et al., 2005).

A recently suggested taxonomy by Verhoeven and Mariën (2010) acknowledges the heterogeneous picture that presents in relation to the aetiologies of FAS and takes account of the increasing number of published psychogenic cases of FAS. Based on a careful consideration of the current literature on FAS, Verhoeven and Mariën (2010) identified three different types of FAS: neurogenic FAS, psychogenic FAS and mixed FAS.

The first type of FAS, *neurogenic FAS*, refers to cases in which the foreign accent in speech can be clearly associated with a neurological event, i.e. damage or disruption to the central nervous system, whereby an acquired and developmental type can be distinguished (cf. section 3.1., p.48). The acquired neurogenic variant of FAS corresponds to the traditional view of FAS proposed by Whitaker (1982) and Blumstein and Kurowski (2006).

In *psychogenic FAS*, the presence of a foreign accent in speech is rooted in psychological issues such as conversion disorder (Haley et al., 2010; Verhoeven et al., 2005) or schizophrenia (Reeves & Norton, 2001; Reeves, Burke & Parker, 2007).

The third type of FAS proposed in this taxonomy relates to cases in which the perceived foreign accent in speech appears to be a combination of an underlying neurogenic aetiology and psychologically motivated adaptations to deal with the change in accent. Specifically, Verhoeven and Mariën (2010) assume that the speaker with FAS adopts some features typically associated with the accent perceived by listeners in an attempt to create a personality that better matches listeners' expectations arising from the new accent (Laures-Gore, Contado Henson, Weismer & Rambow, 2006). Whilst the increasing number of publications describing FAS cases with psychogenic origin clearly warrants the incorporation of psychogenic cases of FAS into a classificatory system of FAS, the inclusion of mixed cases may benefit from a more thorough evidence basis, as the inclusion of this variant appears to be based on a single case reported by Laures-Gore et al. (2006).

Apart from the aetiological variation, wide variability can also be observed regarding the co-occurrence of FAS with other acquired speech and language disorders. FAS can present in isolation (e.g. Takayama, Sugishita, Kido, Ogawa & Akiguchi, 1993), but more frequently the change in accent is accompanied by further speech and language difficulties such as aphasia, dysarthria and apraxia of speech or a combination of any of these disorders. Aronson (1980) analysed 25 cases of FAS, which were published between 1907 and 1978, and reported that in about 68% of these cases FAS occurred in conjunction with other acquired speech and language disorders. Similar figures (63%) were reported by Coelho and Robb (2001), who assessed 16 cases of FAS published since 1982.

The analysis of FAS case reports has further revealed a relationship between the number of accompanying speech and language disorders and the persistence of the foreign sounding features. The more accompanying speech and language difficulties, the less likely it is that the foreign accent will recede over time (Coleman & Gurd, 2006). The generally high coincidence of FAS with other acquired speech and language disorders, in combination with the variety of conditions and lesion sites, has triggered debates as to the nature of FAS. These led to claims that FAS may not be a true syndrome, but a subtype or mild manifestation of dysarthria or apraxia of speech (Ackermann et al., 1993; Coelho & Robb, 2001; Kanjee, Watter, Sévigny & Humphreys, 2010; Mariën et al., 2006, 2009; Miller et al., 2006; Varley & Whiteside, 2001; Varley, Whiteside, Hammill & Cooper, 2006; Whiteside & Varley, 1998) or a listener-bound (aphasic) epiphenomenon (Ardila, Rosselli & Ardila, 1988; Carbary, Patterson & Snyder, 2000; Edwards et al., 2005; Van Borsel et al., 2005). Regarding the latter case, Edwards et al. (2005, p.90) argue that "any lesion causing subtle damage to the dominant hemisphere cortical-subcortical circuitry involved in the preparation, sequencing and execution of complex motor performance […] may give rise to FAS". For that reason, FAS rather constitutes a *medical curiosity* than a syndrome in its own right. This was disputed by Blumstein and Kurowski (2006), who argue FAS to be a true syndrome that can be defined and distinguished from apraxia of speech (AoS), dysarthria and aphasia in terms of speech characteristics, underlying mechanisms as well as neural underpinnings.

Regardless of the ongoing debate as to the precise nature of FAS, its highly intriguing characteristics have attracted a great deal of scientific attention. The fact that FAS is classified as a speech disorder, although the speech of the individuals affected are perceived as sounding foreign rather than pathological, constitutes an ongoing challenge to the understanding of the behavioural and underlying neural mechanisms of speech perception and production.

FAS is a perceptually defined disorder, and major efforts were undertaken to identify the type of accents listeners hear. However, "the precise identification of the perceived foreign accent […] has proven to be illusory" (Kurowski et al., 1996, p.2). Although some studies described the emergence of a specific accent, the majority of studies reported that listeners did not agree on hearing a specific foreign accent. At times, the attempt to map speech characteristics to specific accents even resulted in the foreign accent of the same speaker being attributed to different language families, despite them typically having different phonological and phonetic sound systems (Blumstein & Kurowski, 2006). Given this recurring multitude of perceived accents, Blumstein et al. (1987) concluded early on that FAS gives rise to a generic foreign accent, rather than any specific one - an impression that was confirmed by many subsequent studies (among others Coelho & Robb, 2001; Di Dio, Schulz & Gurd, 2006; Gurd et al., 1988; Ingram, McCormack & Kennedy, 1992; Katz et al. 2008; Kurowski et al., 1996, Mariën et al., 2009; Verhoeven & Mariën, 2002). It was consequently assumed that FAS lies in the ear of the beholder, rather than being a direct result of associated impressionistic and acoustic speech differences. In other words, listeners are thought to base their decision on which accent they hear on subjective factors such as their own personal language knowledge, their exposure to, i.e. familiarity of languages and their expectations as to what transgressions represent foreignness (Haley, 2009; Mariën et al., 2009; Miller et al., 2006). Based on these observations, Kurowski et al. (1996, p.24) conclude that "it is perhaps unfortunate that the foreign accent syndrome was named as such since it suggests in its name an explanation and characterisation of the syndrome that we now know to be untrue".

Although FAS was only formally defined in the 1980s, descriptions of people with altered accents after neurological incidents date back to the early 20$^{th}$ century. The earliest case of FAS reported in literature stems from Marie, who in 1907 noted one of his Parisian patients speaking with an Alsatian accent (Whitaker, 1982). Another early account of FAS was published by Pick in 1919, who described a Polish sounding speaker of Czech. Ever since the early descriptions of cases of FAS, researchers and clinicians likewise have been intrigued by this speech disorder. Their attempts to describe the constellations of speech characteristics and to unearth the neurological mechanisms underlying FAS are reflected in an ever growing body of research. However, despite the growing number of detailed case reports - in particular over the last three decades - the underlying nature of the alterations inherent to this speech disorder largely remained elusive.

The reasons for the absence of a clear-cut picture of the nature of FAS are manifold. One of the main challenges pertaining to the investigation of FAS is the rareness of the disorder. Recent studies estimate the number of published cases between 40 and about 60 (Haley, 2009; Haley et al., 2010; Mariën et al., 2009; Poulin et al., 2007). As a result of the rarity, a sizeable body of detailed single case studies is available. Single case study research is one of the most widely used approaches in the area of neurolinguistics and has proven valuable in cases of rare disorders such as FAS. However, case study research is not unproblematic, with the key issue being the limited ability to yield representative results that can serve as a basis for generalisations (Yin, 2009). In the case of FAS, where case studies are the only viable option, generalisations of findings or comparisons of cases are further complicated by the use of different methodologies and/or analyses. More specifically, different studies focused on different aspects of the individual's speech production. Whilst some studies concentrated on the analysis of segmental aspects, others investigated segmental as well as suprasegmental features. Pertaining to suprasegmental aspects of speech, some studies investigated the pitch movements on single words, whereas in others intonation on sentence level was examined. In addition to that, materials also differed widely across studies, with some studies investigating read speech, whereas others concentrated on spontaneous or repeated speech. The benchmark against which performances were compared was also different across studies. While in some studies the speech features were compared to that of (not always perfectly) matched control speakers, in others post-stroke data was compared to a speech sample recorded prior to the onset of FAS. The different analysis foci combined with the application of different methodologies and the investigation of different source languages make comparisons across studies next to impossible.

Another issue that poses further challenges to unearthing the underlying mechanisms of FAS is the heterogeneity of patterns seen in FAS speech. Cases reported in literature do not only differ with regard to the constellation of the segmental and suprasegmental characteristics of speech, but also in relation to the aetiology as well as the accents perceived by listeners. It is this multilayered, complex array of methodological and disorder-related issues that make the investigation of FAS so intriguing on the one hand, but so challenging on the other.

In order to ascertain the mechanisms underlying a speech disorder, it is paramount to describe the surface behaviour that characterises the speech impairment in the first place. A considerable number of case studies have dealt with describing the nature of the speech errors in FAS and the aim of the following sections is to provide an overview of the features typically associated with FAS.

## 3.2 Speech characteristics of FAS

The impression of the foreign accent in speech is considered to be brought about by a combination of segmental and suprasegmental speech alterations. Segmental speech errors including vocalic and consonantal changes are common to all FAS case reports, whereas prosodic speech alterations including stress, rhythm and intonation were observed in about 93% of published cases (Coelho & Robb, 2001). However, the constellation of affected features may vary considerably from speaker to speaker, resulting in a complex picture of speech errors that can give rise to the perception of the foreign accent in speech. The majority of case descriptions provide information on segmental as well as suprasegmental speech characteristics, whereby segmental features are usually investigated in greater detail than the prosodic features. The case reports are mostly based on impressionistic evaluations using broad and narrow phonetic transcriptions. More recent studies have further carried out instrumental-acoustic analyses to corroborate their auditory findings. In the following section, the segmental and suprasegmental changes observed in speakers with FAS are outlined.

### 3.2.1 Segmental changes of speech

Regarding segmental changes, a multitude of alterations of vocalic and consonantal characteristics have been reported, whereby changes affecting vowels dominate the picture.

*Vowel* quality changes are frequently reported in the literature and include changes in length, i.e. vowel lengthening (Blumstein et al., 1987; Carbary et al., 2000; Graff-Radford, Cooper, Colsher & Damasio, 1986; Katz et al., 2008; Mariën et al., 2006; Scott, Clegg, Rudge & Burgess, 2006; Seliger et al., 1992) and vowel shortening (Ingram et al., 1992; Moen 1990, 2006; Perkins, Ryalls, Carson & Whiteside, 2010; Pick, 1919). Another common feature concerns changes in vowel tenseness, whereby a shift towards strengthening is frequently reported (Bakker et al., 2004; Blumstein et al., 1987; Ingram et al., 1992; Katz et al., 2008; Whitaker, 1982). This can result in the colouring of schwa and the change of full vowel quality (Ardila et al., 1988; Graff-Radford et al., 1986; Gurd et al., 1988; Ingram et al., 1992; Katz et al., 2008; Miller et al., 2006; Whitaker, 1982). In addition, vowel reduction and deletion have been reported (Ingram et al., 1992; Kurowski et al., 1996; Laures-Gore et al. 2006; Miller et al., 2006).

Acoustic analyses of vowel quality have typically concerned the measuring of F1 and F2 formant frequencies (Berthier, Ruiz, Massone, Starkstein & Leiguarda, 1991; Blumstein et al., 1987; Carbary et al., 2000; Coelho & Robb, 2001; Dankovičová et al., 2001; Ingram et al., 1992; Kanjee et al., 2010; Katz et al., 2008; Kurowski et al., 1996; Laures-Gore et al., 2006; Miller et al., 2006; Moonis et al., 1996; Verhoeven & Mariën, 2010). In most of these studies, lower F1 and F2 values and/or a restricted F1 and F2 range was reported, indicating a reduction in overall vowel space. This finding suggests a more closed articulatory setting in FAS, supporting auditory impressions of vowels that are perceived as being tenser than those produced by control speakers.

*Consonantal changes* relate to alterations in manner and place of articulation as well as voicing. Changes in manner of articulation include aspects such as the stopping of fricatives or the fricative release of plosives (Ardila et al., 1988; Bakker et al., 2004; Carbary et al., 2000; Ingram et al., 1992; Katz et al., 2008; Mariën & Verhoeven, 2007; Miller et al., 2006; Scott et al., 2006; Verhoeven & Mariën, 2010). Hyper- or hypoaspiration of plosives are frequently reported as well (Dankovičová et al., 2001; Gurd et al., 1988; Ingram et al., 1992; Katz et al., 2008; Kurowski et al., 1996; Moen, 1990, 2006; Scott et al., 2006). Changes in place of articulation often involve the production of /r/, which is reported to be produced as a trill instead of the expected retroflex or uvular version (Ardila et al., 1988; Berthier et al., 1991; Mariën & Verhoeven, 2007; Verhoeven & Mariën, 2010; Whitaker, 1982). Both voicing of voiceless plosives and fricatives and devoicing of voiced plosives and fricatives is often reported (Ardila et al., 1988; Gurd et al., 1988; Ingram et al., 1992; Katz et al., 2008; Kurowski et al., 1996; Laures-Gore et al., 2006; Mariën & Verhoeven, 2007; Miller et al., 2006; Moen, 1990, 2006; Scott et al., 2006; Verhoeven & Mariën, 2010; Whitaker, 1982). In addition to the more common changes just outlined, a variety of less frequent changes could be observed in individual speakers. This included the effortful production of /h/ (Carbary et al., 2000; Gurd et al., 2001) and cluster simplifications (Ardila et al., 1988; Katz et al., 2008; Miller et al., 2006; Moen, 1990, 2006; Whitaker, 1982), but also the creation of consonant clusters by adding unexpected consonants (Miller et al., 2006).

Acoustic analyses performed in relation to consonantal features involve the measuring of voice onset time (VOT) to assess the timing relationship between the release of the closure and the onset the vocal cord vibration. Most studies measuring VOT report intact timing relations in FAS, with VOT productions being similar to that of healthy speakers (Avila, Gonzáles, Parcet & Belloch, 2004; Berthier et al., 1991; Blumstein et al., 1987; Coelho & Robb, 2001; Ingram et al., 1992; Katz et al., 2008; Kurowski et al., 1996; Miller et al., 2006; Moonis et al., 1996; Perkins et al., 2010). An exception to this pattern constitute the case studies provided by Gurd et al. (1988) and Laures-Gore et al. (2006), who found abnormal VOT patterns in their speakers. In addition to VOT measures, place and manner of consonantal articulation were examined (Blumstein et al., 1987; Katz et al., 2008; Kurowski et al., 1996; Laures-Gore et al., 2006). In terms of place of articulation the results revealed relatively normal production of alveolar stops. In comparison, manner of articulation was found to be different to that of normal speakers, with consonants that were expected to be realised as flaps being consistently produced as full stops.

### 3.2.2 Suprasegmental changes of speech

Deviant prosodic patterns are the second key characteristic of speech in FAS, with virtually all case descriptions having identified some form of prosodic alterations. Among the aspects affected on word-, phrase- and sentence-level are *stress*, *rhythm* and *intonation*. The following section provides an overview of the changes reported in relation to each of these aspects.

The perceptual evaluation of *stress* revealed infrequent misplacement of lexical stress. Whilst in some cases speakers were observed to stress the wrong syllable (Pick, 1919; Scott et al., 2006; Whitaker, 1982), in others a tendency towards equalising stress across syllables was observed (Bakker et al., 2004; Berthier et al., 1991; Blumstein et al., 1987; Mariën et al., 2006; Miller et al., 2006; Scott et al., 2006; Verhoeven & Mariën, 2002, 2004). In particular the latter phenomenon is thought to contribute to the alterations observed in relation to the rhythmic patterns in FAS speech.

*Rhythmic* alterations observed in FAS were mostly considered to be the result of changes to the syllabic structure of words. The resyllabification in turn was mainly caused by schwa-insertions and a restricted ability to reduce vowels in unstressed syllables (Ardila et al., 1988; Bakker et al., 2004; Blumstein et al., 1987; Gurd et al., 1988; Ingram et al., 1992; Katz et al., 2008; Laures-Gore et al., 2006; Miller et al., 2006; Moen, 1990, 2006; Monrad-Krohn, 1947; Scott et al., 2006; Whitaker, 1982). In some speakers the inability to manipulate vowel length was reported to lead to a shift in listeners' perception from stress-timed rhythm to a more syllable-timed rhythm (Blumstein et al., 1987; Gurd et al., 2001; Ingram et al., 1992; Mariën & Verhoeven, 2007; Miller et al., 2006; Verhoeven & Mariën, 2002, 2004, 2010). In addition, some speakers with FAS were described as having a staccato speech rhythm (Ingram et al., 1992; Moen, 1990; Verhoeven & Mariën, 2002, 2004).

A further feature commonly reported in FAS speech are inadequately long pauses at phrase boundaries or elsewhere in the utterance (Berthier et al., 1991; Graff-Radford et al., 1986; Gurd et al., 1988; Ingram et al., 1992, Laures-Gore et al., 2006; Miller et al., 2006; Verhoeven & Marien, 2010; Wendt, Bose, Scheich & Ackermann, 2007). Combined with abnormally long pauses between syllables, reflecting poor transition across word boundaries (Ardila et al., 1988; Blumstein et al., 1987; Ingram et al., 1992; Miller et al., 2006; Scott et al., 2006; Whitaker 1982), this can result in a slower than normal speaking rate (Ardila et al., 1988; Avila et al., 2004; Berthier et al., 1991; Graff-Radford et al., 1986; Gurd et al., 1988; Verhoeven & Mariën, 2004, 2010; Wendt et al., 2007). However, the slower rate does not necessarily imply that the speakers with FAS were dysfluent (Gurd et al., 1988).

The majority of reported changes relating to *intonation* concern unusual or altered pitch patterns, whereby the alterations can be allocated to one of the following two categories:

1. changes in pitch height and excursion
2. changes in global and local pitch movements

Regarding *pitch height* an overall higher mean pitch has frequently been reported (Blumstein et al., 1987; Coelho & Robb, 2001; Dankovičová et al., 2001; Gurd et al., 2001; Perkins et al., 2010; Ryalls & Whiteside, 2006). In addition, some speakers with FAS exhibited inappropriately large and sharp *pitch excursions* on prominent syllables (Avila et al., 2004; Blumstein et al., 1987; Moonis et al., 1996), in particular in sentence-final position, which resulted in the perception of exaggerated terminal falls (Ingram et al., 1992; Moen, 2006; Monrad-Krohn, 1947). The exaggerated pitch excursions were interpreted as an increased pitch range. In other cases the opposite pattern, i.e. a reduced pitch range, was reported (Berthier et al., 1991; Graff-Radford et al., 1986; Kanjee et al., 2010; Moen, Becker, Günther & Berntsen, 2007; Verhoeven & Mariën, 2010).

Changes in *global pitch movements*, i.e. sentence-level intonation, that are frequently described involve sharply rising pitch at the end of sentences where a fall would be expected (Berthier et al., 1991; Blumstein et al., 1987; Dankovičová et al., 2001; Graff-Radford et al., 1986; Katz et al., 2008; Miller et al., 2006; Monrad-Krohn, 1947; Moonis et al., 1996). Other studies have observed the opposite pattern, noting that speakers failed to raise pitch appropriately to indicate questions (Berthier et al., 1991; Graff-Radford et al., 1986; Moen, 2006). The few studies addressing the description of local pitch movements, i.e. pitch accents, found patterns to be generally well-formed (Verhoeven & Mariën, 2002, 2004, 2010; Mariën & Verhoeven, 2007).

Any of the intonational changes just described may impact on the functional effectiveness of intonation in FAS. However, despite the frequency of intonational changes in FAS speech, the functional analysis of linguistic intonation remains scarce, and if conducted, at best superficial. Carbary et al. (2000), for instance, reported that their speaker with FAS was unable to highlight words in a meaningful way. In the absence of any information as to the number of utterances investigated and the number and type of errors that occurred, the extent of the impairment of the linguistic ability cannot be gauged. The only studies addressing the linguistic function of intonation in greater detail were Graff-Radford et al. (1986) and Berthier et al. (1991). They investigated the ability to highlight specific words in a sentence and found that their speakers struggled with this task (see section 3.3.1 for more information on both studies). At times, almost every single content word received a pitch accent. In other sentences, the inverse pattern was observed, with words being unaccented where an accent was expected.

The scarcity of research into the linguistic function of intonation in FAS speech constitutes a serious research gap, as the way information is conveyed and structured plays a crucial role in communication (cf. section 2.5) and may therefore impact on the perception of these speakers. For example, the failure to scale pitch properly by e.g. exaggerating pitch contours may be interpreted by listeners as a speaker being overly excited or emotional. The reduced ability to raise or lower pitch at the end of sentences to signal questions and statements may compromise effective turn taking, as listeners may misinterpret the communicative intent of the speaker. Combined with the failure to highlight the contextually appropriate information, the structuring of information in discourse is also likely to be less effective.

The potential impact of the observed intonational deviations on the communicative effectiveness of speakers advocates the necessity to systematically investigate the form-function relationship of intonation in FAS speech. However, this is easier said than done as even detailed formal descriptions of intonation changes in FAS are still a rare sight in the current research landscape. Haley (2009) reviewed cases of FAS focusing on the prosodic characteristics associated with FAS and concluded that the intonation component is rarely discussed in more detail, rendering it "difficult to summarise concisely the nature of altered intonation contours" (p.93). This recent statement succinctly sums up the current state of the research in relation to the intonation component in FAS speech. It further highlights the need for a detailed description of intonation in general and in relation to linguistic function in particular, to do its role justice as a main feature contributing to the perception of the foreign accent.

The following section introduces some of the key studies that have described intonation in greater detail and thereby helped shape the current knowledge pertaining to intonation in FAS. The overview indicates how researchers arrived at their observations, examining which aspects of intonation were investigated and by what means.

## 3.3 Research on intonation in FAS

This section introduces some of the key studies that were conducted in relation to the intonation component in FAS speech and outlines the contribution of each study to the current knowledge pertaining to intonation in FAS. This is followed by a critical review as to whether the current research efforts relating to intonation reflect the relevance of intonation as a main contributor to the perception of the foreign accent.

### 3.3.1 Key investigations on intonation in FAS

One of the first perceptual accounts of intonation in FAS was provided by Monrad-Krohn (1947) who described the prosodic qualities of speech of a young Norwegian woman with a German sounding accent. Her spontaneous speech featured several intonational characteristics that were considered unusual for Norwegian. More precisely, pitch variations were occasionally noted to be greater than would be expected in Norwegian. In addition, pitch was frequently raised at the end of sentences instead of being lowered[11]. Another feature which was likely to contribute to the perception of a foreign accent in speech was her difficulty in properly differentiating between the two types of Norwegian pitch accents by means of pitch variation.

In this early description of FAS, Monrad-Krohn (1947) highlighted the role of prosody in communication. According to him, the *prosodic quality of speech* and their disturbances should be given as much attention as the investigation of lexicon and

[11] According to Moen (1991), terminal pitch rises are a common feature for East Norwegian. Given the absence of further information on the part of Monrad-Krohn (1947), it remains unclear why this pitch pattern was considered inappropriate.

grammar. The case of FAS he described - which turned out to become the most famous of all cases - happened to be his vehicle for advocating the necessity of investigating *dysprosody* in speech and language disorders.

About four decades after this early description of prosodic characteristics in FAS speech, a series of case studies on FAS were published that reported similar impressionistic features (Berthier et al., 1991; Blumstein et al., 1987; Graff-Radford et al., 1986; Ingram et al., 1992). Due to technological advances, some of these studies were further able to confirm perceptual findings by means of acoustic analyses.

In 1986, Graff-Radford et al. investigated the speech patterns of a 56-year library worker from Illinois who was thought to sound Nordic following a left frontal lesion. Prosodic abilities were assessed using a battery of perception and production tasks. The first of the two speech production tests examined the ability to convey different moods. Specifically, four sentences were to be read in five different emotional tones including questioning, resulting in 20 sentences to be elicited in this task. The second test assessed the speaker's linguistic ability to highlight specific words within utterances. The test materials consisted of ten short declarative sentences, e.g. *The boy took the candy*. Twenty-five questions were used to elicit accents on different words within the sentences. The speaker with FAS was instructed to answer these questions by assigning an accent to the queried word. For both tasks the overall duration of the utterances were assessed as were the F0 range and standard deviations of the peaks and valleys.

The duration measures for both tests revealed that the utterances produced by the speaker with FAS were up to one third longer than those of healthy speakers[12]. This effect, however, was thought to be a result of the frequent insertion of pauses rather than a manifestation of articulatory difficulties. The F0 measures revealed a reduced range and variability of the F0 peaks and valleys for the speaker with FAS

[12] No information was provided as to the origin of the data of the healthy speakers. That is, no information relating to number of speakers, their age and gender were available. The absence of any information should be considered when interpreting the findings.

compared to those of healthy speakers. In addition to that, the utterances that were supposed to be produced in a questioning manner displayed terminal rises that were considerably lower than those of healthy speakers. The differences in F0 realisation corresponded to difficulties in correctly identifying the intended emotion and the highlighted target word. For the latter, six out of the 25 targets were not identified to be highlighted properly. There were also a few instances of two words being emphasised within a sentence instead of one. Interestingly, in these cases the second accent was preceded by a pause. The frequent occurrence of pauses combined with the difficulties in assigning accents was interpreted by the authors as a deficit in speech planning at sentence level.

Using the same battery of prosodic tests, Berthier et al. (1991) investigated the use of intonation in four Spanish speakers with FAS from Buenos Aires who were perceived to have a Slavic or Hungarian accent. As in Graff-Radford et al. (1986), the overall duration of the utterances was assessed, as were the F0 range and standard deviations of the peaks and valleys. The verbal responses of the four clinical speakers to the expressive prosody task were rated by six undergraduate students[13]. The results of the duration measures revealed that the utterances of the clinical speakers were between 16% to 40% longer than those of the control speakers, therefore mirroring results already observed in Graff-Radford et al. (1986). The longer utterance duration times observed in Berthier et al.'s speakers (1991) were attributed to inappropriately long pauses as well as longer duration times of single segments.

The analysis of the F0 measures revealed restrictions in F0 range and variability in all four speakers. However, whilst in two speakers flat F0 contours alternated with larger F0 excursions, in particular on the terminal segments, the other speakers consistently displayed reduced F0 excursions, leading to the perception of monotonous speech output. Speakers did reasonably well expressing the different

[13] From the task description provided by Berthier et al. (1991) it is not clear whether the students also rated the task pertaining to accent placement.

emotions, but struggled with the accent placement task. For instance, content words which were supposed to be highlighted failed to be assigned a pitch accent, whereas in other instances all content words received an accent. However, the extent to which this occurred varied considerably across speakers. Whilst two speakers successfully highlighted the majority of target words (23/25 and 19/25 correct), the other two speakers mostly failed to do so (8/25 and 5/25 correct). Interestingly, according to the authors, all speakers displayed some inappropriate pausing around the target word to be highlighted. Two speakers realised pauses before the target word; one speaker exhibited inappropriate pauses after the accentuated word; whereas in the remaining speaker the highlighted element was preceded and followed by a pause. That is, both studies investigating accent assignment observed the use of pauses before and after the accentuated target word. Based on these findings, Berthier et al. (1991) argue that segmental as well as prosodic features are vital for the production of a foreign accent in speech.

As outlined above, Graff-Radford et al. (1986) and Berthier et al. (1991) were two of the few studies that investigated the functional use of intonation in greater detail. However, given that their studies focused on the pathogenesis of FAS, the interesting findings relating to linguistic intonation probably did not receive the attention they would have deserved. Importantly though, they proved that emotive intonation is by and large retained in FAS, whereas the linguistic function of intonation appears to be more prone to being affected.

In 1987, Blumstein et al. published a highly influential case study in which they extensively investigated the phonetic characteristics of speech in an effort to identify the changes that contribute to the perception of a foreign accent. To this end, the speech of a 62-year old woman from Boston described as sounding European underwent perceptual as well as acoustic analyses.

Regarding intonation, samples of spontaneous, read and repeated speech were analysed. More specifically, the spontaneous speech sample served as a baseline of the speaker's usual speech patterns; the read sentences aimed at assessing the speaker's ability to vary intonation patterns; and the repetition of the same sentences assessed the speaker's ability to produce "normal" speech patterns.

For the analysis of the speaker's spontaneous speech, the first eleven foreign sounding utterances from a semi-structured interview were taken. Of the eleven utterances examined in terms of F0, seven were found to exhibit unusual intonation patterns. This ranged from high F0 range values and large pitch excursions to inappropriately rising terminal segments. As part of the analysis of spontaneous speech, a control speaker was prompted to produce five target lexical items that were previously produced by the speaker with FAS. Four of the items were found to be realised with a different intonation pattern, whereby the rising of F0 on the terminal segment again represented the most pronounced difference.

For the examination of read and repeated speech the speaker with FAS was asked to read a set of 21 sentences including questions, declaratives as well as emphatic sentences. The same sentences were then repeated by the speaker and subsequently compared to the read sentences. This comparison revealed that five of the read sentences differed from the repeated versions in terms of F0 realisation. Once again, large local peaks on prominent syllables and rising pitch contours at the end of sentences accounted for the observed differences between the speaker with FAS and control speaker. Overall, Blumstein et al. (1987) concluded that F0 has a role in the perception of foreignness in the speaker, with read and repeated speech displaying fewer instances of abnormal intonation patterns than spontaneous speech.

In a more recent study, Verhoeven and Mariën (2002) described the pitch contours of a 53-year-old female Dutch speaker who was perceived to sound French. The case description was elaborated further in 2004 and 2010, providing information on the speaker's pre-stroke pitch patterns. The prosodic analysis of the post-stroke pitch movements was based on a two-minute sample of free conversational speech in which the speaker was asked to describe the events following the insult. Fifty-four instances of pitch movements were elicited that way and analysed following the 'Dutch' School of intonation, i.e. the IPO approach (Institute for Perception

Research, 't Hart et al., 1990). This involves the stylisation of pitch contours based on visual and auditory cues by substituting the original contours by a set of straight lines. That way, the perceptually important pitch movements of the contour were identified. In addition to the idealisation of contours, the pitch movements were labelled using a see-and-listen approach. The different transcriptions were subsequently compared. In cases of disagreement, consensus was sought.

The analysis of the intonation contours revealed that the speaker with FAS realised well-formed intonation contours, whereby four distinct intonation contours were repeatedly employed. The most frequently observed contour was the standard continuation contour in Dutch (1-B), accounting for about 65% of all realisations. This contour consists of a prominence-lending rise that is followed by a stretch of high pitch, before being reset at a syntactic boundary. The second most prevalent contour - observed in 20% of all cases - was 1-0-A, which corresponds to a prominence-lending rise followed by a fall, whereby movements are associated with two different accented syllables. In a further 11% contour 1-A was observed, which describes a prominence-lending rise followed by a fall on the very same syllable. The remaining 4% were identified as contour 1-E, which represents a prominence-lending rise, followed by a series of half falls and ending on a prominence-lending fall.

The comparison of the FAS speaker's post-stroke performances with that of her pre-stroke patterns as well as the Dutch reference data showed that the number of 1-B contours was unusually high, equalling three times the number observed in healthy speakers. By contrast, the 1-A contour was three times less frequent than expected, indicating a distributional shift in the use of pitch movements. The high incidence of the continuation contour in the speaker with FAS was interpreted by the authors as a compensatory mechanism to keep the speaking turn, that way bridging long pauses, halting speech production and segmental articulation difficulties. In the absence of any other intonation deviations, the authors concluded that the production of pitch contours was unaffected in this speaker. Based on these findings, Verhoeven and Mariën (2002, 2004, 2010) argue that deviant intonation patterns are not essentially a characteristic of FAS as postulated by previous studies. This series of studies constitutes a fundamental contribution to the growing body of research on FAS as it is the first attempt to categorise the different local pitch movements from a linguistic viewpoint, that way providing a more tangible benchmark against which to compare linguistic intonation in speakers with FAS and control speakers. The study is also unique in its effort to take into account the functional use of the contours used by the speakers with FAS. The distributional differences that were observed pertaining to the continuation contour are elucidated in terms of its potential function, rather than being interpreted a priori as a direct manifestation of an intonation impairment.

In summary, this section has introduced the studies that had a more profound influence on the current understanding of intonation in FAS. The importance of these studies lies in their novel approaches towards analysing intonation in FAS, taking a step outside the beaten research tracks by investigating linguistic aspects of intonation (Graff-Radford et al., 1986; Berthier et al., 1991) or considering the functional meaning of observed changes as Verhoeven and Mariën (2002, 2004, 2010) did. With their extensive investigations the studies further led the way towards explaining the underlying mechanisms of FAS influencing many of the studies on FAS to come. Although the studies provided a strong basis to elaborate research on intonation in FAS further, more recent studies somewhat failed to capitalise on these findings, with most of them sticking to the well-worn paths of describing intonation in general terms. The following section therefore examines the issues surrounding recent investigations pertaining to intonation in FAS speech.

### 3.3.2 Issues with investigations on intonation in FAS

Given the role of intonation as a frequent perceptual determinant of FAS and given the fact that almost every FAS case presents with dysprosodic features, it comes as a surprise that in most recent studies precise qualitative and quantitative analyses of intonation were not conducted. One reason for the scarcity of extensive intonation research, in particular in older studies, was certainly the limited access to appropriate speech analysis tools. However, with several software tools now freely available on the internet, it is surprising that more recent studies investigating intonation (e.g. Haley et al., 2010; Kanjee et al., 2010; Katz et al., 2008; Laures-Gore et al., 2006) did not make use of these resources to arrive at a more extensive intonation description in FAS speech. Rather than providing an in-depth account of intonation characteristics, the visual evaluation of global pitch contours and broad acoustic measurements prevailed. As a result, descriptions of the intonational characteristics remain unspecific and elusive (Haley, 2009).

A further issue of (not only) intonation research in FAS concerns the methodological variety employed in the different case studies, which renders a comprehensive analysis and comparison of features difficult. The growing body of research has partly recognised this problem. To enable comparisons across speakers, recent case reports such as Katz et al. (2008) and Laures-Gore et al. (2006) have used the same materials that were employed in previous studies. Although the intention behind this approach is laudable, it is not without its problems as the materials were taken from studies that were conducted about 30 years ago. Over the last three decades a sizeable number of new theoretical frameworks, within which intonation can be accounted for have been developed (cf. section 2.2). As a consequence, the use of some of the 30-year-old materials and approaches to analysing intonation does not appear appropriate anymore.

Another recurring issue in research on FAS is the relatively small set of sentences employed to investigate intonation. This is often in stark contrast with the large data sets on which segmental analyses are conducted. While Graff-Radford et al. (1986), Berthier et al. (1991) and Blumstein et al. (1987) investigated intonation patterns of about 50 sentences or utterances, more recent studies, despite having recognised the lack of extensive descriptions, appear to content themselves with examining between six to nine sentences per speaker (Katz et al., 2008; Laures-Gore et al., 2006). For instance, Katz et al. (2008) investigated sentence-level intonation in a total number of eight sentences covering four different American English intonation patterns, i.e. simple declaratives, yes-no questions, wh-questions and tag-questions.

Based on such a small set one may capture an extract of the speaker's performances, but it is clearly not enough to establish the presence of an intonation disturbance. Deriving conclusions as to the nature of intonation on a small number of sentences is also problematic in the light of the individual variation that underlies intonation realisation. Given the absence of a clearly defined one-to-one relationship between meaning and intonational realisation, variation is a common feature of healthy speech. Although one may expect certain intonation patterns in certain conditions, not realising them does not necessarily mean that the pitch pattern used is inappropriate. One aspect that cannot be assessed easily, but has a key role in intonation variation is speaker intention. For instance, depending on a speaker's intention question tags can be produced using rising and falling intonation (Levis, 1999). Unexpected intonation patterns may therefore well be the result of a speaker's intention rather than a reflection of an intonation disturbance. Moen (1991) also commented on the issue of interpreting intonation performances. Different pitch patterns may signal illocutionary acts, but may also reflect a speaker's attitude to what is being said (cf. section 2.5). According to Moen (1991), knowledge regarding the context in which an utterance is produced is therefore essential to understand whether pitch is used appropriately or not.

A further issue that comes into play in intonation realisation is task design. Most speakers use intonation rather intuitively instead of manipulating it purposefully. In other words, explicit knowledge of intonation is scarce and, as a result, repeating or producing a certain intonation pattern on cue constitutes a relatively awkward task for many speakers. For quite a few it further requires practice to master it.

Therefore, it remains open whether the repetition of certain pitch patterns realistically models the actual intonational abilities of a speaker or not.

However, given the fact that one deals with disordered speech, there may be certain expectations within the research community as to what kind of deviations are likely to occur. As a consequence, changes that could be the result of individual variation might be too readily interpreted as being deviant from the norm. In this context, Miller et al.'s (2006) observations regarding the necessity to compare performances to those of speakers from the same dialectal background are also of great importance. More specifically, the authors point out that "in previous works, it has not always been apparent whether changes claimed to be associated with the underlying speech disorder may not in fact be only instances of local variation" (Miller et al., 2006, p.402).

A final issue with recent studies is that the intonation changes that have been reported were not further illuminated in terms of their potential purpose. To date, only Verhoeven and Mariën (2002, 2004, 2010) sought to interpret pitch patterns in relation to their potential linguistic function. The prosodic analysis of their speaker with FAS revealed a higher frequency of continuation rises, which was interpreted as an active effort on the part of the speaker to keep the speaking turn. In other words, in this case of FAS the distributional differences observed in terms of intonation patterns possibly reflect compensatory mechanisms rather than an underlying intonation disturbance. Apart from Verhoeven and Mariën (2002, 2004, 2010), only Miller et al. (2006) have addressed the relevance of distinguishing between core features of the impairment and those features that are strategically employed to compensate for the central impairment. However, differentiating between both types of features has the potential to determine the factors that are indeed compromised in FAS.

The complexities of the theoretical and methodological issues relating to intonation research in FAS clearly advocate the necessity to investigate a larger set of data to obtain a more comprehensive picture of the speaker's intonation abilities. Concerning this matter, the use of current approaches and frameworks for analysing intonation would further allow research to capitalise on the recent advances within the field of intonational phonology (cf. section 2.2). The current research situation further necessitates a move beyond describing intonation in general terms, as only a detailed account of intonation that considers the potential linguistic purpose of the observed patterns will allow substantial progress to be made in uncovering the nature of intonation in FAS. Summing it up, a much more extensive investigation of intonation in FAS is called for to do intonation justice as a key feature of FAS. As indicated above, there is a huge untapped research potential in terms of the intonation component in FAS that awaits principled investigations.

A more detailed picture not only in relation to intonation but FAS in general would also be an important point of departure for exploring the potential of clinical intervention in this speaker group. Although intervention studies on FAS are scarce (Haley, 2009), the literature suggests that individuals with FAS would greatly benefit from treatment given the substantial psychosocial consequences of living with this condition (Miller et al., 2006; Miller, Taylor, Howe & Read, 2011). FAS presents a unique triangular constellation of neurological condition, speech disorder and foreign or altered accent (Miller et al., 2011). As a result, over and above the physical, emotional and speech-related communication issues brought about by the underlying neurological condition, individuals with FAS have to deal with the psychosocial impact of the changed accent on their well-being and quality of life, which may restrict the communicative participation in a variety of life situations. The change in accent is often considered the most prominent issue in the speaker's life (Miller et al., 2011), impacting not only on their own view of their selves, but also on the perception of relatives, friends and the community they live in. Speakers with FAS interviewed by Miller et al. (2011) reported that the foreign accent led to a change of identity causing feelings of distress and bereavement for the loss of self and the person they used to be. Many also struggled to come to terms with the new self, which was frequently associated with feelings of embarrassment, shame as well as loss of confidence and self respect. Reactions by others, which ranged from disbelief and puzzlement to open hostility, were also difficult to deal with, leading to changes in communicative behaviour and feelings of isolation and fear of communicating altogether.

Although the complexity of the clinical picture and the psychosocial impact of FAS on the wellbeing of affected speakers highlights the need for intervention, research on treatment and treatment efficacy in FAS has only just started (Haley, 2009). One reason for the relative absence of intervention studies lies in the ongoing identification of the speech characteristics and thus the underlying nature of FAS. Another aspect of relevance is the fact that from a health care perspective speakers with FAS, despite their foreign or altered accent, may not be considered to have pressing communication issues or concerns as their speech by and large remains intelligible and does not result in communicative breakdowns (Haley, 2009; Miller et al., 2011). However, in light of the life changing psychological and social consequences of the foreign or altered accent on individuals with FAS, clinical intervention in this group is worth pursuing.

To date, only two studies have explicitly explored the potential for clinical intervention in FAS (Haley et al., 2010; Katz, Garst, Kaplan & Frisch, 2007). Katz et al. (2007) conducted an intervention study, in which accent-reduction techniques were employed to alter the perceived foreign accent. Treatment focused on word lists containing a number of front and back vowels as well as inter-dental consonants, which were thought to contribute to the perception of the Swedish accent in this speaker. Perceptual evaluation of the speaker's performances showed highly variable results, suggesting that the structured treatment provided was not successful. A more successful intervention of a psychogenic case of FAS was reported by Haley et al. (2010). Using a combination of counselling and treatment that focused on articulation, the speaker with FAS succeeded in modifying the targeted phonemes in the structured therapy setting. However, a generalisation to conversational speech could not be observed.

In terms of the framework for the World Health Organisation International Classification of Functioning and Disability (WHO ICF), both studies would be considered to have focused on the level of articulation function, i.e. *body function* and *structures*, with the aim to influence the speaker's accent during speech production. As outlined above, Miller et al.'s study (2011) established that the foreign or altered accent was the most salient feature of the disorder, which impacted on the individuals' interaction with relatives, friends and the wider community[14]. In particular the fear of negative responses changed the overall communicative behaviour of the affected speakers, frequently leading to isolation and frustration. An intervention that aims at reducing the perceived accent by altering articulation, i.e. a treatment that addresses the body function level of the WHO's ICF, may have a positive impact on the other ICF constructs of *activity* and *participation* as well as *contextual factors,* in particular *environmental conditions* such as support and relationships as well as attitudes. Specifically, a change in the magnitude of foreign accent may increase confidence and encourage the speaker with FAS to communicate more actively again with a wider range of people. At the same time, reactions by others pertaining to the foreign accent may be more measured and hence less problematic for the speaker with FAS to deal with. Both aspects, i.e. improved communication and interpersonal relationships combined with less negative responses and attitudes by third parties, means that the speakers with FAS would be less inclined to avoid situations that require interaction with

[14] It is acknowledged that the neurological condition and associated speech and languages issues, i.e. the overall health condition, may also impact on activity- and participation-related aspects such as learning, mobility and the ability of self care. However, given the unique presence of a foreign or altered accent in the individuals with FAS and its salience in their lives, the focus of the ICF classification here is on the impact of the foreign/altered accent.

others, resulting in a more active social life that involves engaging in communication-related activities as part of the wider community.

Although the studies showed limited effectiveness in terms of the therapy outcome, it is hoped that advances in the understanding of the mechanisms that underlie the speech changes observed in FAS will lead to the development of more effective treatment strategies in this client group. Preferably, as detailed above, a holistic approach to intervention should be taken that encompasses the different ICF constructs of body function as well as activity and participation and contextual factors to modify the speech and accent in a way that positively impacts on the social well-being and acceptance of the affected speakers.

## 3.4 Potential explanations of FAS

Over the years a variety of theories and explanations have been put forward in an attempt to account for the articulatory and prosodic changes observed in FAS and to shed light on their functional origin. Given the heterogeneity of the speech deviations, a variety of theoretical frameworks and approaches have been employed. By elucidating the same behaviour from different perspectives, these approaches are generally thought to complement each other, rather than reflecting opposing views (Coelho & Robb, 2001; Moen, 2000). In the following sections, three explanations that have attracted considerable attention from the research community are outlined and evaluated as to their potential to clarify the underlying mechanism of speech errors in FAS. The three explanations view the observed speech changes from different perspectives, arguing FAS to be:

1. a result of changes to the phonetic setting
2. an underlying impairment of linguistic prosody
3. a mild form or subtype of apraxia of speech (AoS)

Specifically, the first explanation suggests that the deviations characteristic of FAS speech are brought about by altered long-term muscular settings resulting in articulatory-phonetic changes. The second explanation assumes FAS to be the result of disturbances of linguistic prosody, whereas the third approach draws on the fact that FAS shares many speech characteristics with that of AoS. In addition, Moen (1996, 2000) has suggested that recent phonological approaches and models also have the potential to elucidate the underlying nature of the observed speech alterations.

### 3.4.1 Explanation in terms of phonetic setting

Within the framework of the phonetic setting theory (Laver, 1980; Moen, 2000), it has been suggested that the speech alterations observed in FAS are partly caused by changes in the muscular tension of the speaker's vocal apparatus. More precisely, as a result of the alterations to the long-term muscular speech settings, the lingual articulation patterns, i.e. the range of the tongue movements when articulating sounds, may have changed. The articulatory alterations relating to the tongue movements in turn lead to slightly modified phonetic realisations of sound structures, whereby the articulation of vowels is particularly susceptible to qualitative changes. This is particularly important in light of the fact that abnormalities in vowel production constitute a prominent feature of FAS speech. Given that phonetic settings are known to differ between dialects and languages (Laver, 1980), the changes in the range of lingual articulation caused by changes in the muscular tension settings may result in the perception of vowels different to those of that particular language or language variety. Support for the hypothesis of tenser than normal vocal tract setting comes from several case reports that investigated vowel formant frequencies (e.g. Coelho & Robb, 2001; Ingram et al., 1992; Kurowski, et al., 1996; Moonis et al., 1996; Perkins et al., 2010; Verhoeven & Mariën, 2010). The studies reported a restricted range of vowel formant values

and/or lower F1 formants, both of which are indicative of a narrowed vocal tract setting.
According to Moen (2000), changes to phonetic settings can also be brought about by reduced speech motor control - a feature that is inherent in many neurogenic motor speech disorders. Thinking in terms of a continuum, subtle changes to phonetic settings may lead to the perception of foreign sounding speech, whereas in cases of more pronounced changes to phonetic settings, speech may be categorised as sounding pathological.

The explanation in terms of phonetic settings is very attractive as it provides a sensible account of why speakers with FAS may actually be perceived as sounding foreign. However, the hypothesis is still awaiting confirmation through detailed physiological investigations of the phonetic settings in speakers with FAS (Katz et al., 2008; Moen, 2000). In the absence of any physiological evidence, some issues pertaining to this hypothesis remain prone to debate. For instance, changes in speech motor control impacting on the muscular settings of the vocal tract, as outlined by Moen (2000), constitute characteristics that are also common to other neurogenic speech disorders such as dysarthria and AoS. These disorders, however, are not associated with the presence of a perceived foreign accent in speech. A further issue relates to the type of speech deviations that can be explained by this hypothesis. Whilst the theory may well account for the segmental changes observed in FAS, in particular the changes in vowel quality, it only offers limited explanation for the presence of prosodic deviations.

### 3.4.2 Explanation in terms of disturbance of linguistic prosody

A further theory explaining the constellation of speech deviations in FAS was suggested by Blumstein et al. (1987). According to their view, an underlying deficit relating to linguistic speech prosody is accountable for the observed changes in speech. Initially proposed in 1987, the theory was reviewed and refined over the years (Blumstein & Kurowski, 2006; Kurowski et al., 1996). As outlined earlier, it became quickly established within the FAS research community, shaping research on FAS for decades to come.

According to Blumstein and colleagues (Blumstein et al., 1987; Blumstein & Kurowski, 2006; Kurowski et al., 1996), the speech errors in FAS are primarily the result of a disturbance of linguistic prosodic features including intonation and rhythm. The few segmental changes observed in FAS are considered to be a direct consequence of the prosodic difficulties. More precisely, the authors argue that disturbances in intonation would be reflected in aberrant fundamental frequency contours, whereas rhythmic difficulties would result in deviant stress patterns and changes to the timing of syllable structures. It is the changes to the rhythmic component that are thought to affect the segmental features, in particular the quality of vowels.

Within the framework suggested, Blumstein et al. (1987) also offer an explanation as to why speakers with FAS are perceived to sound foreign rather than pathological. According to their view, speech disturbances evidenced in FAS only reflect phonological and phonetic features attested in natural languages, albeit not necessarily in the speaker's native language. By contrast, the errors occurring in other speech disorders that are closely associated with FAS such as dysarthria are thought to violate the phonological-phonetic properties common to all natural languages, thus signalling the presence of a pathological condition. A further fundamental difference between FAS and other impairments of phonological-phonetic nature is that speakers with FAS do not show the consistencies normally associated with a pathological condition. Speech errors in FAS are sporadic and inconsistent, affecting only individual speech sounds rather than phoneme classes. Listeners appear to be adept at identifying the differences between potential and distorted attributes of natural languages and seem to factor them in when having to decide whether a speaker presents with a foreign accent or a speech disorder.

Blumstein and colleagues' attempt (Blumstein et al., 1987; Blumstein & Kurowski, 2006; Kurowski et al., 1996) to explain the constellation of features in FAS speech has attracted a great deal of interest. Unlike the approach on tenser vocal tract settings (Moen, 2000), this approach succeeds in accounting for the presence of segmental as well as suprasegmental changes. In addition, Blumstein and colleagues successfully explain why the constellation of speech characteristics in FAS sounds foreign rather than pathological. However, Blumstein et al.'s (1987) approach presupposes all speakers with FAS to exhibit some form of prosodic-intonational impairment. Although intonation deviations constitute one of the key features of FAS, there are cases without obvious deviant intonation patterns (Gurd et al., 1988; Kurowski et al., 1996; Verhoeven & Mariën, 2002, 2004, 2010). This fact raises the question as to whether all of the different constellations of features described for different speakers can be accounted for within the single framework of an underlying prosodic disturbance. In a recent paper, Blumstein and Kurowski (2006) addressed this limitation by drawing parallels to other neuropsychological disorders and arguing that the different constellations of the features reflect different levels of severity of the disorder. More precisely, they argue for a common underlying syndrome in all speakers with FAS. The manifestation of this syndrome, however, varies from speaker to speaker reflected in differences in the severity of impairment across patients. Assuming this were the case, one would expect some features to be frequently affected in FAS, whereas other speech deviations would only be evident in some cases. Based on their observations the authors conclude that rhythm and timing properties are consistently compromised, whilst alterations in intonation are not universal features of FAS and therefore instantiations of more severe cases of FAS.

The issue that immediately arises with this hypothesis is how to precisely define severity in FAS in terms of mild, moderate and severe, as Blumstein and Kurowski's (2006) classification remains somewhat crude. They merely state that the presence of intonation deviations are indicative of a more severe manifestation of FAS. Based on this assumption, the majority of all cases of FAS would have to be classified as severe cases of FAS as most studies report some form of intonation impairment. However, speakers differ considerably as to the type and number of deviant intonation patterns, indicating that a finer gradation is required to define the levels of impairment in FAS. Until this has been accomplished, the account offered by Blumstein and colleagues (Blumstein et al., 1987; Blumstein & Kurowski, 2006; Kurowski et al., 1996) to explaining the absence of intonational deficits in some cases of FAS remains purely speculative.

### 3.4.3 Explanation in terms of a subtype or mild form of apraxia of speech (AoS)

Another similarly influential approach offered to account for the deviations seen in FAS speech is that FAS may be closely related to AoS (Ackermann et al., 1993; Coelho & Robb, 2001; Mariën et al., 2006, 2009; Miller et al., 2006; Varley et al., 2006; Varley & Whiteside, 2001; Whiteside & Varley, 1998). This assumption is based on the fact that FAS and AoS share a variety of deviant speech characteristics such as slow, monotonous and at times laboured speech production, inconsistency of speech sounds and cluster reduction, to name but a few. In both cases speakers have problems in coordinating and controlling laryngeal and supralaryngeal movements. Given the resemblance of the clinical pictures, a link was sought between both speech disorders. However, the proposed theories differ slightly in the way this link is established. Whilst Ackermann et al. (1993) propose FAS to be a recovery form of AoS, Varley and colleagues (Varley et al., 2006; Varley & Whiteside, 2001; Whiteside & Varley, 1998) argue that FAS is a subtype of AoS. The key argument put forward by Ackermann et al. (1993) for FAS to be a residual form of AoS is the level of severity. Despite the similarities in speech characteristics, the speech disorders clearly differ in terms of severity, with speakers with AoS at times being so severely affected that their speech becomes virtually unintelligible. This clinical behaviour is unobserved in speakers with FAS.

Varley and colleagues (Varley et al., 2006; Varley & Whiteside, 2001; Whiteside & Varley, 1998) also advocate a close relationship between both speech disorders, but they offer a slightly different explanation to account for the observed differences in severity. According to them, FAS constitutes a mild form of AoS caused by a breakdown in the cognitive planning of speech production where compensatory mechanisms are in place, as opposed to speakers with classical AoS. As a result, speakers with FAS retain a certain degree of accuracy, reflected in the less severe manifestation of the speech difficulties. Unlike Ackermann et al. (1993), Varley and colleagues (Varley et al., 2006; Varley & Whiteside, 2001; Whiteside & Varley, 1998) theoretically underpin their hypothesis by means of a psycholinguistic model, which is based on Levelt and Wheeldon's (1994) speech production model:

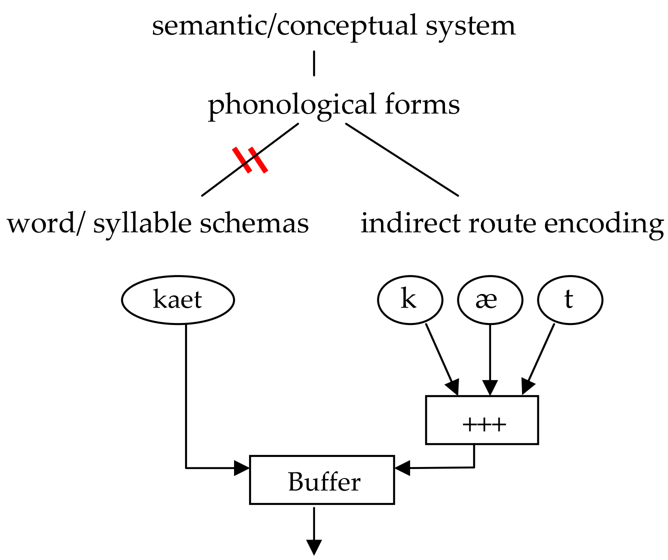


Figure 3.1: Dual route speech encoding model adapted from Varley & Whiteside (2001; The lines between phonological form and word schemas indicate assumed impairment of the direct route.)

According to this model, two phonetic encoding routes are involved in the effective production of speech patterns: A direct route via which stored syllable motor patterns for the most frequent syllables are accessed and an indirect route via which unknown or low-frequency syllables are assembled on a segment-by-segment basis

(Varley, Whiteside & Luff, 1999). The direct route is considered to be more efficient as it relies on storage, whereas the indirect route involves on-line computation requiring a higher cognitive processing demand. According to Varley and colleagues (Varley et al., 2006; Varley & Whiteside, 2001; Whiteside & Varley, 1998) both AoS and FAS manifest as a result of damage to the direct route. However, while speakers with FAS can effectively compensate for the breakdown of the direct route by exploiting the indirect phonetic encoding mechanisms, individuals with AoS fail to do so.

In addition, an anatomical link between FAS and AoS was suggested by Mariën and colleagues (Mariën et al., 2006, 2009; Mariën & Verhoeven, 2007). The authors point out that both disorders share clinical features such as slower articulation and consonantal and vocalic changes with ataxic dysarthria, a speech disorder which is commonly associated with cerebellar lesions. The consistency of clinical symptoms across the three speech disorders reflected in articulatory planning and speech timing deficits suggests that FAS, AoS and ataxic dysarthria may share some underlying patho-physiological mechanisms.

Despite the possible anatomical link, the assumption of FAS reflecting residual speech symptoms or constituting a subtype of AoS is not without its critics. More precisely, Ackermann et al.'s (1993) assumption that FAS represents a residual form of AoS was rejected by Kurowski et al. (1996). Their objection is based on the observation that the symptoms associated with FAS occur suddenly - a fact that is incompatible with the very nature of residuals. For Kurowski et al. (1996), the sudden onset of FAS constitutes evidence that FAS is a direct manifestation of an underlying impairment of neuronal mechanisms, rather than being a residue of AoS speech symptoms.

Whiteside and Varley's (1998) approach to explaining FAS by means of a psycholinguistic model reflecting cognitive neuropsychology approaches attracted a great deal of attention, not least because in doing so they ventured into uncharted scientific terrain. However, the theory which was informed by Levelt and Wheeldon's (1994) speech encoding model also triggered a series of critical comments. In general, the critical evaluations targeted the model as such and not the attempt to establish a link between FAS and AoS. Specifically, a number of issues were raised relating to the experimental evidence the model draws on, as well as the predictions it makes in relation to the expected speech patterns. Some of these issues are briefly outlined below. A more detailed account is provided in the AoS forum published in 2001 in *Aphasiology*.

Miller (2001) and Ziegler (2001) address the controversial issue of the speech error pattern predicted by the model, both raising concerns regarding the oversimplification the model presents. If the manifestations of AoS were indeed the result of an impairment of the direct speech encoding route, then words assembled using the sub-syllablic assembly route should more or less remain fluent. The verbal output of speakers with AoS would simply equal that of normal speakers producing low-frequency items. This, however, clearly does not reflect the clinical picture, where less frequent words are often more compromised than some of the highly automatised processes. Doubts as to the validity of the sub-syllabic encoding strategy in AoS were also expressed by Dogil (2006). He points out that the model may to some extent account for the dysfluent nature of AoS speech, but clearly fails to explain the frequent segmental errors and the considerable variability inherent to speech errors. What is more, the model suggests that error patterns pertaining to AoS should be unaffected by syllabic structure. This latter assumption was disproved by Aichert and Ziegler (2004; but also Staiger & Ziegler, 2008; Ziegler, Thelen, Staiger & Liephold, 2008). In a carefully designed study, the authors showed that speakers with AoS are sensitive to syllable structure. Specifically, they found that consonantal cluster errors varied depending on the position of the cluster relative to the syllable boundaries. In addition to that, they observed fewer errors in very high frequent syllables, as opposed to low frequent syllables. These findings provide evidence that speakers with AoS do have access to stored verbo-motor patterns, but face problems retrieving them. In Whiteside and Varley's dual model approach this result would hypothetically translate into a preserved direct phonetic encoding route. Miller (2001) poignantly summarises the issues surrounding the debate as follows: "The point […] is that the aetiology of motor speech disorders in general, and AoS in particular, calls for a much more extensive explanation and debate than is contained in the proposal to solve the conundrum simply through a dual-route model and a strategic compensation switch".

Returning to the hypothesis of FAS being a subtype of AoS, the critical discussion neither confirms nor disconfirms this assumption, implying that there may well be a connection between FAS and AoS. However, in view of the above findings, which proved incompatible with the assumptions of the sub-syllabic route model, it appears safe to conclude that the relationship between FAS and AoS cannot be accounted for by the model proposed by Varley and colleagues (Varley et al., 2006; Varley & Whiteside, 2001; Whiteside & Varley, 1998).

### 3.4.4 Potential of phonological theories in explaining FAS

Apart from the explanations just outlined, a fourth approach was suggested in the literature that has the potential to provide new insights into the nature of prosodic and intonational variations in FAS (Moen 1996, 2000). This approach concerns the use of recent phonological models. The particular usefulness of such models for the analysis of FAS speech was exemplified by Moen (1996), who reassessed the prosodic characteristics of Monrad-Krohn's (1947) influential case report (cf. section 3.3.1). Examining the tonal, segmental, syllabic and articulatory characteristics of speech on separate tiers, Moen (1996) showed that a disruption of the phonological units of the tonal tier would result in the realisation of deviant pitch patterns. In the case of the Norwegian speaker, this disruption led to a failure to properly distinguish between the two different types of pitch accents in Norwegian, which ultimately impacted on sentence level intonation. In other words, by using recent theory-led linguistic models, Moen (1996) succeeded in identifying the underlying cause of intonation disruption in that speaker.

Another phonological approach that has the potential to further the understanding of intonation realisation but has yet to be applied to FAS is the AM approach of intonational analysis (cf. chapter 2.2). The advantages of linguistic-theoretic approaches for the description of disordered intonation were outlined by Kent and Kim (2003; cf. section 2.6), who particularly emphasised their usefulness in explaining deviant intonation patterns from a phonological-linguistic perspective, as examining F0 modulation alone often does not suffice to fully capture the intonational properties of disordered speech. With Arbisi-Kelm (2006), Green and Tobin (2009) and Mennen et al. (2008), there are three studies that have successfully applied the AM approach to disordered intonation. Albeit still few in number, this development is encouraging as it clearly demonstrates the potential of the AM approach to provide a principled and systematic account of the intonation patterns in FAS speech. Using a recent and established theory-based linguistic model that has successfully been employed to investigate healthy and disordered intonation patterns also overcomes many of the issues raised in connection with recent studies on intonation in FAS.

## 3.5 Summary

This chapter set out to elucidate the role of intonation in defining and explaining FAS. Reviewing the literature as to the characteristics of the speech disorder, the current research efforts pertaining to intonation and the possible explanations offered to account for the observed speech changes, it was shown that, in spite of the relevance of intonation in determining FAS, extensive research in relation to the manifestation of intonational changes is scarce. This void highlights the need for a principled, systematic analysis of the intonation component in FAS that goes beyond describing intonation in broad terms. In this context, it was also argued that the comprehensive analysis should be accomplished using a larger set of data. The present study further recognised the theoretical advances in intonation research over the last decade or so for the investigation of disordered intonation, and systematically investigated the intonation patterns in FAS within the theoretical framework of the AM approach (Ladd, 1996; Pierrehumbert, 1980). In other words, an established linguistic approach to analysing intonation was employed to fill the research gap that exists regarding the detailed investigation of intonation in FAS in general and the examination of its linguistic functions in particular. The next section specifies the research aims in greater detail.

## 3.6 Research aims of the study

The main aim of this study was to provide a systematic description of the intonation patterns in speakers with FAS by means of the autosegmental-metrical (AM) framework of intonational analysis (Ladd, 1996; Pierrehumbert, 1980). In trying to address this broad objective, the following two specific aims were pursued.

The *primary aim* of this study was to comprehensively describe the different dimensions of intonation posited by Ladd (1996) and elaborated by Mennen et al. (2008), in order to establish the intonational system of FAS speech. Specifically, the intonation patterns were analysed relating to:

1. the inventory of structural elements, i.e. pitch accents and boundary tones
2. the distribution of these structural elements
3. the phonetic implementation and
4. the use of these elements to signal information status (givenness)

By comprehensively investigating the different levels of intonation in FAS speech, it was sought to identify retained and affected dimensions of intonation in FAS, thereby providing insights as to the level of intonational impairment as well as possible compensatory strategies. Based on this knowledge, conclusions could be drawn as to the underlying intonational mechanisms in FAS, that way taking the debate surrounding the underlying nature of the intonation impairment in FAS further.

In order to fulfil this aim, the performances of the speakers with FAS were compared to those of healthy dialect-, age- and gender-matched control speakers. The intonation patterns of both speaker groups were investigated using four different text styles to obtain a sizeable data set and to explore whether the manifestation of intonation and its functional realisation is influenced by the elicitation method.

The *secondary aim* of this study relates to the functional role of intonation in the marking of information status of discourse referents. Specifically, phonological as well as phonetic encoding were investigated in an effort to establish whether speakers with FAS use categorical as well as gradient means to signal new and given information. Regarding the phonetic encoding, the acoustic parameters of F0, duration and intensity were analysed to determine the extent to which speakers with FAS have control over the different phonetic cues to mark information status.

Given the absence of extensive systematic research into intonation and its linguistic function in speakers with FAS by means of phonological approaches, the present study was explorative in nature. It was therefore considered essential to pilot appropriate methodologies, before testing a larger number of participants. For this reason, a preliminary study was conducted to validate appropriate methodologies. Specifically, it aimed:

1. to select and develop test materials appropriate to investigate functional aspects of intonation, i.e. the information status of referents in discourse

2. to determine whether the materials are sensitive to adequately capture the intonation patterns in individuals with speech production difficulties

A detailed description of the methodology chosen to address these research aims is presented in the next chapter.

# 4 METHODOLOGY

This chapter covers the methodologies of the present study. The first part describes the study design (4.1), followed by information on the participants involved in this study (4.2). The section further covers ethical approval procedures and inclusion and exclusion criteria. In section 4.3, a description of the different tasks and test materials used to elicit the speech samples is provided, followed by information about recording procedures (4.4). Based on this, a detailed account of the data annotation and analyses procedures is given in sections 4.5 and 4.6. In the final section of the chapter, the data evaluation measures including intra-and inter-rater reliability are presented (4.7). In cases where the results of the preliminary study (cf. chapter 5) suggested changes to the original methodologies, the amendments undertaken relating to the main study are detailed as well.

## 4.1 Study design

Due to the rare nature of FAS, this study adopted a multiple single case studies design. The performances of four speakers with FAS and one speaker with mild dysarthria due to multiple sclerosis were directly compared to those of healthy age-, gender- and dialect-matched control speakers. The intonation patterns of the ten participants were investigated using a battery of different speech production tasks, which included scripted as well as unscripted text styles to obtain a comprehensive picture of the intonational system in FAS. To ascertain the appropriateness of the different materials and methodologies, a preliminary study was carried out. Given the strong commonalities between these results and those of the main study, the preliminary findings were subsequently incorporated in the overall evaluation on which the discussion was based.

## 4.2 Participants

Ethical approval to conduct the present study had been procured from the university research ethics committee and NHS Glasgow West. In addition, approval from local R&D departments was obtained where necessary. Relevant procedures were followed throughout. This included informing participants about the conduct of the study and gaining informed written consent for the speech to be recorded and for the collected data to be published in an anonymised way.

The clinical participants were mostly recruited through the University of Newcastle upon Tyne, where they already took part in research projects. Another speaker with FAS was further accessed through the NHS. The control participants were mainly recruited by approaching research institutions in the areas where the individuals with FAS lived, in order to match the dialectal background. Apart from Newcastle University, this included the University of Cambridge and the University of Manchester.

The recruited participants were required to meet certain criteria to be included in the study. The main inclusion criterion for the speakers with FAS was the presence of a foreign accent in speech, which was established by the experimenter as well as relevant health care professionals. Medical notes and information from health care professionals confirmed the neurogenic origin of FAS in the speakers, although the possibility of a psychogenic contribution cannot be entirely excluded. A further important inclusion criterion was that the participants were all monolingual speakers of English. In addition, the speakers with FAS were more than 12 months post onset to ensure stability of the neurological symptoms.

Apart from the inclusion criteria, several exclusion criteria were applied. People with severe cognitive impairments were not considered for the study, as participants were required to follow instructions for a considerable amount of material. Participants with any type of reading difficulties were not included either, since reading tasks made up a substantial part of the study. A further exclusion criterion concerned any form of uncorrected hearing or visual impairment as, firstly, participants had to react adequately to verbal and visual prompts, and secondly, hearing problems are known to affect self-monitoring and thus general speech production (e.g. Boothroyd, 1978; Hornsby & Ricketts, 2003; Pavlovic, Studebaker & Scherbecoe, 1986; Stelmachowicz, Pittman, Hoover, Lewis & Moeller, 2004; Studebaker, Scherbecoe, McDaniel & Gray, 1997). It was furthermore important that the participants did not suffer from depression or any other psychiatric problems since studies suggest that these can cause changes in the prosodic characteristics of speech (e.g. Alpert, Pouget & Silva, 2001; Darby & Hollien, 1977; Kraepelin, 1921; Nilsonne, 1987, 1988; Stassen, Bomben & Gunther, 1991). In addition, participants should not present with a history of speech or language difficulties.

In summary, the relevant criteria for the speakers with FAS were:

Inclusion

- presence of a neurogenic foreign accent
- monolingual speakers of English
- at least 12 months post onset

Exclusion

- severe cognitive or neurological deficits
- reading difficulties
- hearing or visual impairment
- presence of depression
- history of other speech and language difficulties

The same exclusion criteria applied to the control participants, who were matched to the clinical speakers in terms of age, gender and dialect. A more detailed description of each participant is given below.

### 4.2.1 Participants of the preliminary study

In order to assess the suitability of the materials and methodologies to capture intonation patterns in healthy and neurologically impaired speakers, one speaker with FAS (PFAS), one speaker with dysarthria as a consequence of multiple sclerosis (PMS), and two healthy age-, dialect- and gender-matched control speakers (PC1 and PC2) were recruited for the preliminary study. General information about the four participants including age and gender are presented in table 4.1. All four participants of the preliminary study were monolingual speakers of the English variety spoken around Newcastle upon Tyne. The second participant with disordered speech presented with a mild form of dysarthria due to multiple sclerosis. The rationale for choosing a speaker with mild dysarthria was to match the severity level of the speech difficulties with that of the speaker with FAS.

| participant | sex | age[1] | neurological condition |
|---|---|---|---|
| PFAS | female | 61 | left-hemispheric CVA, 2006 |
| PMS | male | 57 | MS, diagnosed in 1992 |
| PC1 | female | 60 | --- |
| PC2 | male | 54 | --- |

Table 4.1: Information about the participants of the preliminary study ([1] age at the time of the recording)

**PFAS**

PFAS was a 61-year old, right-handed woman from the Newcastle area who suffered a left-hemispheric CVA in February 2006, at the age of 60. This incident was followed by a second stroke three weeks later. At the time of testing she was 16 months post onset.

PFAS reported that the neurological examination after the first stroke revealed a moderate right hemiplegia as well as a right facial paresis. Neuropsychological assessment indicated short-term-memory deficits and acalculia. Due to the facial paresis her speech was slurred, but the change in accent was only noticed after the second stroke. The accent was classified by clinical staff and relatives to be

Jamaican, French, Italian or Eastern European. Until December 2006, she received speech therapy which focused on the pronunciation of different phonemes, particularly in consonant clusters, as well as the melodic aspects of speech. It is therefore possible that her speech characteristics had been affected by the treatment. Although the foreign accent became less pronounced over the following months, at the time of the recording her speech was still perceived as sounding foreign by the experimenter.

**PMS**

PMS was a 57-year old man from the Newcastle area, who had been diagnosed with multiple sclerosis in 1992. The first symptoms of the disorder such as vision problems and paraesthesia became noticeable about 15 years prior to diagnosis, i.e. in the late 1970s. Since then, he experienced a number of different symptoms, whereby deteriorating muscle control affecting walking and lip closure constituted the main difficulties. At the time of the investigation the participant's speech was characterised by a slow and slurred pronunciation. However, this did not compromise his intelligibility. The medical condition of MS affected his speech gradually, with the first speech problems occurring in the 1980s. Despite his difficulties, he did not seek speech intervention as he could easily be understood by other people.

**PC1**

The control participant for PFAS was a 60-year old teacher from the Newcastle upon Tyne area. She was born and raised in the area and had lived there throughout, except for a period of 10 years (from 1970 to 1980), which she spent in Leicester to study and work.

**PC2**

The control speaker for PMS was a 54-year old accounts manager from Newcastle upon Tyne. He was born and raised in Newcastle, but had lived in London between 1985 and 1997, before returning to Newcastle.

### 4.2.2 Participants of the main study

In the main study, the intonation patterns of a further three individuals with FAS (MFAS) were investigated along with their respective age-, dialect- and gender-matched control speakers (MC). General information about the participants including age, gender and dialectal background is given in table 4.2. Information about the clinical speakers' case histories is provided in the following sections along with information about the respective matched control speakers.

| participant | sex | age[1] | neurological condition | dialect |
|---|---|---|---|---|
| MFAS1 | female | 49 | left-hemispheric CVA, 2006 | Scottish, Fife |
| MFAS2 | male | 61 | brain stem infarct, 2003 | SBE, London |
| MFAS3 | male | 54 | left-hemispheric CVA, 2007 | Manchester/Salford |
| MC1 | female | 46 | --- | Scottish, Fife |
| MC2 | male | 61 | --- | SBE, London |
| MC3 | male | 53 | --- | Manchester |

Table 4.2: Information about the participants of the main study ([1] age at the time of the recording)

**MFAS1**

MFAS1 was a 50-year old, right-handed woman from Fife in Scotland who had lived in that region throughout her life. In November 2006, at the age of 47, she suffered a left-hemispheric CVA as a result of a blockage of the supplying artery. At the time of testing MFAS1 was 26 months post onset.

MFAS1 reported that, on hospital admission, a hemiplegia of the right body part was diagnosed. The subsequent neuropsychological assessment revealed severe short-term memory difficulties, dyscalculia and language difficulties. MFAS1 stayed in a stroke unit for about four weeks. During that time she received physiotherapy, occupational therapy and speech and language therapy. Concerning her speech, MFAS1 reported that after the stroke she was mute for a few days. When her speech gradually returned, people started commenting on her accent, which was not perceived as Scottish anymore, but Italian or South-African. In addition to the change in accent, her returning speech presented with aphasic symptoms. Until summer 2008, MFAS1 received continuous weekly speech and language therapy, with the management focusing on picture naming, word-picture association and spelling training. Although the foreign accent reportedly became less pronounced over the months – the therapist mentioned that MFAS1 sounds "more Fifish" – at the time of the recording, she was still perceived to sound foreign by the experimenter.

**MFAS2**

MFAS2 was a 62-year old, right-handed man from Essex. He was a native speaker of Standard British English, who had lived in the Greater London area his entire life. In October 2003, at the age of 56, MFAS2 suffered an infarction in the left brain stem. This incident was followed by a second stroke about half a year later. At the time of testing, he was five years and three months post onset.

In October 2003, MFAS2 was diagnosed with a brain stem infarction affecting walking, speech, concentration and coordination. He also presented with short-term memory problems and fatigue. The symptoms improved quickly so that two months after the incident MFAS2 was able to return to work. However, in March 2004, he suffered a second stroke, this time affecting the right hemisphere of the brain. After the second stroke, MFAS2's speech was described as very slurred to the point of being unintelligible. Once his speech improved, the change in accent was unmistakable. Schwa insertions were the most pronounced feature, which was why many people classified his new accent as being Italian. Speech and language therapy intervention concentrated on writing and spelling as well as oral motor activities to improve articulation. At the time of the recording, MFAS2's speech was still perceived as sounding foreign by the experimenter.

**MFAS3**

MFAS3 was a 54-year old, right-handed man from Manchester who had lived in the Manchester/Salford region all his life. In December 2007, at the age of 53, he suffered a left-hemispheric CVA. At the time of testing he was 15 months post onset.

In December 2007, on a trip to Italy, MFAS3 suffered a CVA in the temporo-parietal region of the left hemisphere. The stroke resulted in a hemiparesis of the right side of the body and severe speech problems. Reportedly, he was not able to generate any voice due to an insufficient air stream. After ten days he was flown back to Manchester where he stayed at the hospital for another two and a half months. During this time he received physiotherapy and occupational therapy. He also had two sessions with a speech and language therapist. After discharge, outpatient treatment continued for physiotherapy and occupational therapy. MFAS3's change in accent was first noted in Italy. He was perceived as being Italian by native speakers of English, whereas Italians thought his accent to be of Polish or Eastern European origin. A block of speech and language therapy from May until July 2008 centered around oral motor activities and breathing exercises to improve the strength of his voice. At the time of the recording, MFAS3's speech was still perceived as sounding Italian or Eastern European by the experimenter.

**MC1**

The control participant for MFAS1 was a 46-year old office worker from a small town north of Edinburgh. She was born and raised in Fife and lived there throughout her entire life.

**MC2**

The control participant for MFAS2 was a 61-year old English teacher from Cambridge. A speaker of the standard variety of British English (SBE), he was born and subsequently grew up in Northern London.

**MC3**

MC3 was a 53-year old IT manager from Manchester, where he grew up and lived all his life.

## 4.3 Materials

A crucial aspect to be considered when investigating intonation patterns is the fact that the type of elicitation can impact considerably on the way intonation is realised. More specifically, research on intonation typology in healthy speakers comparing scripted and unscripted data have yielded differences in intonational inventories, i.e. the use of pitch accents and boundary tones (e.g. Grice, Savino & Refice, 1997; Hirschberg, 2000) and also in the phonetic implementation of these structural categories including downstepping, final lowering and de-accentuation (e.g. Face, 2003; Hirschberg, Gravano, Nenkova, Sneed & Ward, 2007; Laan, 1997; Swerts, Strangert & Heldner, 1996). These findings highlight the relevance of the data elicitation method for the modelling of intonation, advocating the investigation of scripted and unscripted data in order to obtain a comprehensive picture of an intonational system. Given that the present study investigated disordered intonation, this may be of even greater importance as the neurological condition can have an impact on the way different tasks are understood and executed. For that reason, it was considered essential to assess speakers across a range of speaking styles, including scripted and unscripted speech, to gain a full picture of their intonation abilities. Therefore, each participant was asked to:

1. read short sentences
2. read a text passage
3. describe a series of four pictures
4. describe how to prepare a cup of coffee or tea (monologue)

The first two tasks were scripted in nature, i.e. controlled material was used to elicit read speech. Due to the specified sentence structure, the participants were relatively limited in their options as to how to interpret, and thus realise, the material. The remaining two tasks were unscripted in nature and aimed at eliciting semi-spontaneous speech. While the picture description or storytelling task required the participants to depict a series of four pictures, the monologue task involved describing a highly automated process from memory.

Another common method of eliciting spontaneous speech is to conduct a semi-structured interview, encouraging the participants to talk about aspects of daily life and family. This method, however, was deemed inappropriate for the current study as discussing, e.g. medical issues can involve an emotional component, increasing the likelihood of confounding the data with paralinguistic aspects of intonation. In the following sections, each of the tasks along with their materials is described in detail.

### 4.3.1 Sentence reading task

The sentence reading task was specifically designed to investigate the marking of information status (givenness) of discourse referents in different sentence positions. Target words were embedded in carrier sentences in different positions to investigate post-focal intonation patterns; i.e. de-accentuation, as an indicator of givenness. Alongside the position of the target words, the speech materials were controlled for sentence length, i.e. number of words and syllables, syllable stress patterns and sonorance of elements to facilitate pitch track analysis. In the following sections, more detailed information is provided regarding the structure of the carrier sentences, the pragmatic conditions and the paradigm used to elicit the sentences.

The carrier sentences devised for the sentence reading task featured the syntactic structure exemplified in (6). The number of lexical items as well as the syntactic structure was kept constant across all sentences to provide an equal basis for phonological and phonetic comparison.

(6)

| | | | | | | |
|---|---|---|---|---|---|---|
| | SUBJECT | VERB | | OBJECT | ADJUNCT | |
| [det | noun ]$_{Subj\text{-}NP}$ | [V] | [(det) | noun ] $_{Obj\text{-}NP}$ | [preposition | noun] $_{PP}$ |
| [The] | [gardener] | [grew] | | [roses] | [in] | [London] |

The nouns in the subject-, object- and adverbial positions were disyllabic trochees, while the verbs were monosyllabic. The sentences had an average length of nine or ten syllables per sentence and of six or seven words, respectively, thus respecting Crystal's (1969) observations regarding the length of intonation phrases and their influence on intonational realisation. Crystal (1969) analysed the length of IPs in his data set and found that the average length was five words and that 80% of the phrases were less than eight words long. Utterances that are longer than that are likely to be divided into more IPs, which could change the overall intonation pattern of the sentence. Specifically, every IP needs to be assigned at least one pitch accent (Pierrehumbert, 1980). Respecting this intonation rule might lead to the assignment of a pitch accent to an element, which in a single intonation phrase would have undergone de-accentuation.

Five baseline carrier sentences were designed following the criteria above, with the subject, object and adjunct serving as target words. That is, each of the baseline sentences contained three target words. This set of five sentences was used in four different conditions (see table 4.3). The target words in these conditions were controlled for two variables: *information status* (new vs. given) and *sentence position* (initial vs. medial vs. final). Depending on the condition, the givenness status of the target words differed. This, in turn, had an influence on the assignment of pitch accents and the de-accentuation of elements, the latter being expected of given elements in post-focal position.

| condition | initial | medial | final | |
|---|---|---|---|---|
| 1 all new | The **GARdener** | grew **ROses** | in **LONdon**. | N1 N2 N3 |
| 2 initial new | The **GARdener** | grew ROses | in LONdon. | N1 G2 G3 |
| 3 medial new | The GARdener | grew **ROses** | in LONdon. | G1 N2 G3 |
| 4 final new | The GARdener | grew ROses | in **LONdon**. | G1 G2 N3 |

Table 4.3: Test conditions and respective givenness status of referents using the sentence "The gardener grew roses in London." (N=new, G=given; number = position within the sentence, 1=initial, 2=medial, 3=final, capital letters = stressed syllable, bold = new referent)

In the baseline condition, the three target words had an all-new status, i.e. they were contextually new and hence expected to be marked by a pitch accent. The remaining conditions were designed such that one target word was new, while the other two targets were given. The position of the new target word varied systematically. In condition 2, the new target word was positioned initially (N1), leading to de-accentuation of the given target words in medial and final position (G2 and G3). In condition 3, the medial target word was new (N2), whereas the initial and final target words (G1 and G3) were given. In this condition, the de-accentuation of the target word in final position (G3) was expected. In condition 4, it was the final target word that was contextually new (N3), while G1 and G2 were given. Due to their pre-focal position, no de-accentuation of the given elements was expected. In sum, the 20 sentences yielded a total number of 60 target words per speaker, of which 30 were new and 30 were given.

A question-answer paradigm was employed to elicit the sentences. The questions varied according to the givenness structure of the different conditions. In condition 1, where all target words were new, questions were of rather general nature such as "What have you learned?" or "What happened?"; i.e. the context did not provide any information regarding the content of the answer sentences. The questions of the remaining conditions differed according to the queried constituent. In condition 2, the question (e.g. "Who grew roses in London?") provided information about the action, the object of the action as well as the place where the action took place. Merely the information regarding the person performing the action was not given. The questions for condition 3 and 4 were designed accordingly (e.g. "What did the gardener grow in London?"; "Where did the gardener grow roses?"). A complete list of all test sentences with the question and respective answer can be found in appendix B1.

### 4.3.2 Passage reading task

The reading passage used in the current study was developed by Brown and Docherty (1995) for the purposes of phonetic variation analyses across sampling tasks. It was subsequently adapted by Mennen and colleagues to investigate cross-linguistic pitch patterns (Mennen, Schaeffler & Docherty, 2007). The reading passage was written in the form of a dialogue, interspersed with short paragraphs of prose text, therefore containing a mixture of direct and indirect speech. The length of utterances within the reading passage varied, allowing the investigation of the impact of phrasing on the intonational realisation. Attention had also been paid to the sonorance of words used in the reading passage in order to facilitate pitch tracking. The reading passage can be found in appendix B2.

### 4.3.3 Picture description task

The picture description task consisted of a series of four coloured pictures which were taken from an SLI assessment battery devised by Kauschke and Siegmüller (2002). The materials were considered well-suited to investigate intonation patterns, as the story centres around a restricted number of relatively sonorant elements which feature in several pictures. The introduction and repeated reference to certain elements ensured that the number of new and given referents in the picture description was relatively balanced. The pictures of the task can be found in appendix B3.

### 4.3.4 Monologue task

The description of how to make a cup of coffee or tea had already been used successfully to elicit semi-spontaneous speech from clinical populations (Lowit, Miller & Poedjianto, 2003; Lowit, Miller, Poedjianto & McCall, 2001; Miller et al., 2007). Preparing a cup of coffee or tea is a common daily activity for many people and as such a highly automated process. In terms of intonation realisation, this had the advantage of reducing the involvement of paralinguistic aspects, which could affect pitch accent realisation. A further advantage of this task was that comparatively long utterances could be elicited from the speaker without any interruption of the speech flow. Additionally, similar to the picture description task, specific words were referred to repeatedly, allowing an investigation of the intonational patterns of new and given referents.

### 4.3.5 Changes to materials

The following section details the changes made to the materials in response to the analysis of the preliminary study (cf. chapter 5). Whilst the different text styles proved appropriate to investigate the different dimensions of intonation in FAS speech, some of the materials were amended, either to increase the amount of research data (sentence reading task) or to better fit the research purpose (reading passage). No changes were made to the materials used to elicit unscripted speech. The changes concerning the scripted speech materials were as follows.

#### 4.3.5.1 Sentence reading task

Two aspects of the set of sentences were changed to yield more reliable results. Firstly, the proper noun *Berlin* had been produced with widely varying word stress and was replaced by nouns with a more consistent stress pattern. Secondly, the number of sentences in the set was doubled to provide a more robust analysis basis. With three target words per sentence and four pragmatic conditions (cf. chapter 4.2.1), this resulted in a 120 target words for each speaker, of which 60 were new and 60 were given. A complete list of the extended set of sentences with questions and respective answers can be found in appendix B4. The basic design of the sentences in terms of syntactic structure and constituent order remained unchanged. The sentence length of the extended set varied between nine and eleven syllables per sentence, with target words being either di- or trisyllabic.

#### 4.3.5.2 Passage reading task

The reading passage eventually used in the main study was an adaptation of the well-known *Grandfather Passage* devised by Darley, Aronson and Brown (1975). A change of reading materials was necessary to enable the assessment of an equal number of new and given referents. For that purpose, the 'Grandfather Passage' was modified to incorporate 15 new discourse referents, which were taken up again in the following sentence, resulting in 15 new and 15 given referents per passage to be analysed in terms of information status. Apart from the information status, target referents were controlled for sonorance to optimise pitch track analysis. Attention was further paid to the length of utterances within the reading passage which varied, in order to investigate the impact of phrasing on the realisation of intonation. The modified reading passage, including new and given referents, can be found in appendix B5.

#### 4.3.5.3 Inclusion of screening tests

In addition to the revision of the scripted materials, screening tests were administered in the main study to investigate physiological aspects such as respiration and phonation, but also to screen for signs of AoS. The investigation of these features was motivated by the results of the preliminary study (cf. chapter 5), where PFAS showed changes to the phrasing structure, which might be related to respiratory and phonatory issues. Physiological changes affecting e.g. breathing are frequently suggested to account for prosodic changes in disordered speech (e.g. Ackermann & Ziegler, 1991; Darley, Aronson & Brown, 1969, 1975; Gurd et al., 1988; Kent & Kim, 2003; Kent, Weismer, Kent, Vorperian & Duffy, 1999; Mennen et al., 2008). In the study by Mennen et al. (2008), for instance, breath control problems were put forward as one option to explain the differences observed regarding the intonational realisation between the speakers with Parkinson's Disease (PD) and the control participants. Given that PFAS showed comparable performance patterns, it stood to reason that the mechanisms behind the intonational difficulties could be similar.

Another approach towards explaining the prosodic changes in the speech of individuals with FAS has been pursued by Whiteside and colleagues (cf. section 3.4.3; Varley et al., 2006; Varley & Whiteside, 2001; Whiteside & Varley, 1998), who suggested that FAS might be a subtype of AoS rather than the result of physiological problems related to dysarthric speech.

When devising the additional assessment tests, both lines of research were considered. Phonation and respiration were assessed to determine whether physiological aspects, similar to those in speakers with dysarthria, were involved. Further tests concentrated on the potential involvement of speech apraxic features. A detailed account of both screening tests, subtasks and respective purpose is given in the following sections.

**Respiration-phonation screening**

The tests used to assess the respiratory, phonatory and intonational abilities of the speakers were mainly taken from the standardised Frenchay Dysarthria Assessment (Enderby, 1983; Enderby & Palmer, 2008), and - where necessary - adapted for the present study. For an overview of the tests including tasks and purpose see table 4.4. The three different subcomponents were assessed on speech as well as non-speech level. Each of the tasks was demonstrated once. The participants were then asked to repeat each task twice. For the analysis, the mean across the repetitions was used. The protocol and analysis sheets developed for the assessment can be found in appendix C1 and C2.

| subcomponent | task | purpose |
|---|---|---|
| | **RESPIRATION** | |
| 1. at rest | • observation | • general impression re breathing pattern |
| 2. in speech | • count to 20 - quick<br>• count to 20 - normal | • breath groups and breaks |
| | **PHONATION** | |
| 1. duration | • sustained /a/ (MPD) | • general impression on voice quality and breath support |
| | • sustained /s/ and /z/ (MFD and s/z ratio) | • identification of respiratory vs. laryngeal issues |
| 2. loudness | • count to 5 decreasing volume<br>• count to 5 increasing volume | • general volume modulation |
| | **INTONATION** | |
| 1. pitch | • pitch glide<br>• increase pitch on /m/<br>• decrease pitch on /m/ | • general pitch modulation |
| | • production of words as question and statement | • modulation of rise and fall |

Table 4.4: Subtests of the respiration-phonation screening with tasks and purpose

The aim of assessing the *respiratory patterns* was to get a general impression of the breathing pattern at rest and during speech, whereas different maximum performance tests (MPT) were carried out to examine the *phonation* component. MPTs are considered to be a useful tool to assess the phonatory and pulmonary strength of individuals with motor speech disorders. (For an extensive discussion of the advantages and disadvantages of MPTs see Kent, Kent & Rosenbek, 1987 and Kent, 2000). In the present study, MPTs were selected with a focus to assess the temporal patterns of the speakers and to gain general information on voice quality. One of the aspects measured was maximum phonation duration (MPD). The ability to sustain a vowel sound (usually /a/) can give useful information as to the respiratory support that is available to sustain phonation. In order to identify possible laryngeal problems contributing to a phonation problem, the maximum duration of a voiced and a voiceless fricative (/z/ and /s/) was measured (maximum fricative duration, MFD) and the s/z-ratio calculated. In addition to the duration measures, the ability to modulate volume was assessed. The test of volume control included the production of a step-wise crescendo and decrescendo. The assessment of the *intonation* abilities focused on aspects of pitch modulation. Assessment on non-speech level included performing a pitch glide as well as a step-wise increase and decrease in pitch. Furthermore, participants were asked to produce a number of words either with rising intonation for questions or with falling intonation for statements.

The rating criteria were adapted from the Frenchay Dysarthria Assessment (Enderby, 1983; Enderby & Palmer, 2008), as materials for the screening were mainly taken from this assessment. The performances of the speakers were rated on a scale ranging from 1 to 4, whereby 1 was equivalent to a performance normal for age and 4 indicated considerable problems in carrying out the task. An overview of the rating criteria can be found in appendix C3. Following Enderby and Palmer (2008) the scores accomplished by each speaker for each task were then converted using a 9-point rating scale (Enderby & Palmer, 2008, p.6) to allow for comparison with standardised data.

In addition to these tests, *speech rate measures* were conducted on the reading passage, the picture description and the monologue to obtain further information on the temporal characteristics of speech production in FAS. Specifically, the following measures were calculated to assess articulatory agility and pausing behaviour:

(1) *Speaking rate* (syllables per second) was calculated dividing the total number of syllables per sample by the overall speaking time including pauses and hesitations.

(2) *Articulation rate* (syllables per second) was calculated dividing the total number of syllables per sample by the overall speaking time. In contrast to the calculation of speaking rate, hesitations and pauses were eliminated.

(3) *Pause time ratio* relative to speaking time (in %) was calculated determining the duration of both aspects and relating them to each other.

**AoS screening**

The tests selected to assess the presence of an apraxic component in the speech of the clinical participants were taken from the Apraxia Battery for Adults (ABA; Dabul, 2000). This standardised assessment tool was devised to examine all aspects associated with apraxia of speech as well as the severity of the apraxic difficulties observed.

The subtests selected for the present study focused on three different speech apraxic features: the examination of increasing word length, successive trials performance, and the inventory of articulation characteristics. The assessment of *increasing word length* aimed at determining the speaker's ability to correctly sequence sounds and syllables in words with differing length. The *repeated test trials* were chosen to measure the variability in vowel and consonant production in words over a number of trials. Furthermore, the overall *number of apraxic features* present in FAS speech was assessed. This evaluation included aspects such as voicing errors, transposition errors, schwa insertions and the overall consistency of errors. Table 4.5 summarises the subtests and the motivation to use these tasks. The protocol and analysis sheets for the screening can be found in appendices C4 and C5.

| Subtest | Task | Purpose |
|---|---|---|
| 1. Increasing word length | • reading 30 words with increasing number of syllables | • assessment of deterioration of performance score |
| 2. Repeated test trials | • threefold repetition of 10 words | • comparison of total amount of change between 1st and 3rd performance |
| 3. Inventory of articulation characteristics | • --- | • Examination of the presence of 15 features associated with apraxia of speech |

Table 4.5: Subtests of apraxia of speech screening with tasks and purpose

The analysis of the AoS screening test followed Dabul's (2000) assessment criteria. The performances of the speakers were transcribed phonetically by the experimenter and subsequently checked by a trained speech and language therapist. Based on this, the articulatory errors were assessed and the deterioration of performance scores and raw scores computed. For an overview of the cutoff scores to determine the level of impairment see Dabul (2000, p.9) and appendix C6.

As outlined above, screening tests for dysarthria and AoS were administered because findings of the preliminary study suggested an involvement of respiration-phonation issues. Furthermore, FAS has been reported in the context of AoS, and the study intended to take account of this possibility. Dabul's (2000) Apraxia Battery for Adults (ABA-2) was chosen as it represents a standardised test with normative data that was devised with the intention to screen for the presence of apraxia as well as to gauge the severity of the disorder. In addition, ABA-2 has been employed in recent publications on FAS (Kanjee et al., 2010; Katz et al., 2008; Laures-Gore et al., 2006) as well as AoS (e.g. Mauszycki, Wambaugh & Cameron, 2010).

However, one major drawback of the ABA-2 is the fact that it does not reflect the substantial progress that has been made in the clinical and theoretical understanding of AoS since its first publication in 1979. Instead it still relies on diagnostic criteria that have been identified and specified in the 1970s and 80s. Although many of these are still widely acknowledged and referred to by researchers and clinicians alike, there is growing evidence that they may represent a dated view of the diagnostic criteria essential to differentiate AoS from phonemic paraphasia.

The recent advances pertaining to the criteria relevant to diagnose AoS should be taken into account when administering the ABA-2 and interpreting its results. For instance, subtests 2 and 5, which were employed in the present study, test the ability to sequence the correct number of syllables in the right order as well as the production changes over successive trials, as both of these aspects are frequently associated with AoS. However, a study by McNeil, Odell, Miller and Hunter (1995, as cited in McNeil, Robin and Schmidt, 2008) found that individuals with phonemic paraphasia actually showed similar behavioural patterns so that the above tests cannot unequivocally differentiate between phonemic paraphasia and AoS. Subtest 6 of the ABA-2, which assesses the inventory of articulation features, proves similarly problematic. In this test - also employed in this study -, the examiner is provided with a list of 15 features characteristic of AoS, of which the presence of five establishes the diagnosis of AoS. However, Pierce (1991, as cited in McNeil et al., 2008) found that of these 15 features 12 are also frequently associated with phonemic paraphasia. McNeil et al. (2008) even argue that only two of the 15 criteria, namely abnormal prosody and schwa insertion are unique to AoS. That is, the aspects that are tested in the ABA-2, e.g. the assumption of increasing errors with increasing length of words, may be consistent with AoS, as are features such as articulatory groping, speech-initiation problems, awareness of errors and repeated attempts to correct them (Wambaugh & Shuster, 2008). However, they do not represent characteristics that are unique to AoS and are therefore not appropriate for the purposes of differential diagnosis, rendering the ABA-2 ineffective as a discriminating tool from phonemic paraphasia.

Over the last decade or so, great efforts have been undertaken to identify more adequate diagnostic descriptors of AoS that allow one to differentiate behaviours in AoS from those of phonological impairments (e.g. Mauszycki et al., 2010; McNeil et al., 2008; Miller & Wambaugh, 2011; Wambaugh, Duffy, McNeil, Robin & Rogers, 2006; Wambaugh & Shuster, 2008; Ziegler, 2008). Despite these efforts, the differential diagnosis between AoS and phonemic paraphasia remains challenging, and researchers are careful in their assertions as to which features constitute defining characteristics of AoS. The tentative list of characteristics necessary for a diagnosis of AOS include abnormal prosody, a slow speech rate with prolonged movement transitions and durations and long intra- and inter-word pauses, errors in stress assignment, sound distortions and substitutions, as well as sound errors that are relatively consistent in type and location (on repeated productions). Ziegler (2008) further considers islands of unimpaired speech to be a relevant indicator of AoS.

The recent advances pertaining to the characteristics of AoS clearly limit the significance of the ABA-2 as an adequate discriminating tool. At the same time, it has to be acknowledged that despite these advances, the differentiation between AoS and phonemic paraphasia based on current knowledge remains problematic. In the absence of a validated assessment tool that reflects current understanding of AoS, the ABA-2 remains the only standardised test that is available to researchers and clinicians.

In summary, as became clear in the above discussion, Dabul's (2000) ABA-2 may not be appropriate to unequivocally establish the true nature of the observed deviations in terms of AoS and phonemic paraphasia. Yet, in combination with the dysarthria screening it still allows to determine whether the observed performances point towards the presence of higher order problems, i.e. planning or programming, or physiological issues.

## 4.4 Recording procedure

To minimise fatigue for the clinical speakers, the recordings took place in a quiet room at their homes. The control participants were either recorded in a quiet room at home or at a nearby university. Recordings were made using a portable DAT-recorder (TASCAM DA-P1) and a condenser microphone (Beyerdynamic MPC 65 V SW), which was placed approximately 50 centimetres away from the participant.

At the beginning of the recording session, each participant was interviewed about different aspects of their life including age, education, profession and language background. The primary aim of the interview was to obtain basic information about each participant, but it was also valuable to get a first impression of the participant's speech characteristics. Additionally, the interview was intended to create a comfortable atmosphere between experimenter and participant. After the interview, the actual testing started with the tasks of the test battery being presented in a randomised order. Interview and testing for all participants was accomplished in one session and lasted between one and two hours.

### 4.4.1 Task presentation

Verbal and written instruction was provided for each of the tasks of the test battery. In addition, the participants were encouraged to ask questions to clarify aspects. Detailed instructions for each of the tasks can be found in appendix D.

The materials for the sentence reading task were presented in form of a PowerPoint presentation. This method of presentation was chosen for several reasons. Firstly, the stimulus questions could be incorporated into the presentation, minimising the influence of the experimenter's accent on the speakers' performance. The prompts of the question-answer pairs were spoken by a male and a female speaker of Standard Southern British English and recorded in quiet surroundings using the equipment mentioned above. Both speakers were instructed to speak in a natural way and with normal speech rate. Secondly, all participants were presented with the same stimulus materials, thus preventing variations in the way the questions were asked. Thirdly, the question-answer design allowed the simulation of an interaction setting approximating a natural speech setting as much as possible, but without direct influence on the experimenter's part. A joint presentation of auditory and visual prompts was chosen to ensure that the linguistic structures were processed properly (Baumann & Hadelich, 2003). In addition, it was decided to underline new referents to help elicit the intended pitch pattern. The sentences were randomised and separated by filler sentences of differing length (e.g. *What happened? Ramona saw Lina.* or *What's the weather forecast? Sunny spells will follow heavy rain.*) to prevent the participants from becoming accustomed to one particular intonation pattern or sentence structure.

For the sentence reading task the participants were seated in front of a laptop with a 15'' computer screen and it was ensured that they could comfortably reach the keyboard buttons. The PowerPoint presentation containing the stimulus material was then launched and the participants were asked to go through the slides at their own pace. The initial slides provided them with detailed test instructions, followed by practice sentences and the experiment itself. The instructions informed the participants that the sentences should be read in a natural way at a normal speech rate. The key purpose of the following practice sentences was to familiarise the participants with the question-answer-structure of the experiment and to introduce the different sentence types occurring in the experiment. Specifically, on pressing the return key, the question providing the context for the answer appeared on the upper part of the screen. This was followed by the auditory presentation of the same prompt with a 500 millisecond delay[15]. The answer to the stimulus question, which appeared on the screen once the return key was pressed, was then read out by the participants. After pressing the return key again, a new prompt appeared and the

[15] The implementation of the delay proved to be necessary to prevent simultaneous presentation of the prompt and pressing of the return key.

procedure was repeated. A number of breaks were incorporated into the PowerPoint presentation. However, the participants were free to pause at any time during the slide presentation. In case of slips of the tongue, word omissions or hesitations, the participant was asked to read the sentence again.

The reading passage was printed in large print on a separate sheet (font size 14, Times New Roman). Instructions advised the participants to carefully read through the passage once, before reading it aloud. Reading errors were not corrected to avoid disruptions to the reading flow.

For the picture description task the participants were instructed to take a look at four pictures, which were all printed on one page. They were then asked to describe everything they saw going on in these pictures. Where necessary, participants were prompted further in order to elicit a sufficient amount of speech data (about one minute of speech recording).

The monologue task required the participants to explain in detail how they would make a cup of coffee or tea, starting from thinking about making a cup until they drink it. As for the picture description task, participants were encouraged to elaborate further, if required.

### 4.4.2 Data preparation

The speech recordings were converted to audio files in .wav format using Kay Elemetrics Multispeech System, at a sampling rate of 44.1 kHz. The analysis of the speech data was conducted using *praat* speech analysis software (version 5.0.11 © Boersma & Weenink, 1992-2010). The fundamental frequency contour was checked to detect halving and doubling errors of the pitch tracker which, if necessary, were then corrected by hand. The adjusted data served as input for the subsequent intonational analysis.

## 4.5 Data annotation

The data for each participant were intonationally annotated using an adaptation of the IViE system (cf. section 1.5.2; Grabe, 2001, 2004; Grabe et al., 1998, 2001), which features five levels of annotation, of which two are orthographic and three prosodic in nature. The names in brackets indicate the tier names used in this study.

1) an orthographic tier for a word transcription on syllable level (WORDS)
2) a prominence tier indicating boundaries and prominent syllables (PROMINENCES)
3) a phonetic transcription tier describing the pitch movements around the prominent syllables (PHONETICS)
4) a phonological transcription tier showing the structural categories (PHONOLOGY)
5) a comment tier (COMMENTS)

For the present study, the five annotation levels proposed in the original IViE system were extended to include an additional tier to label the givenness status (GIVENNESS) of elements, i.e. the pragmatic function of the phonological elements. An annotation example using the tiers described above is given in figure 4.1.

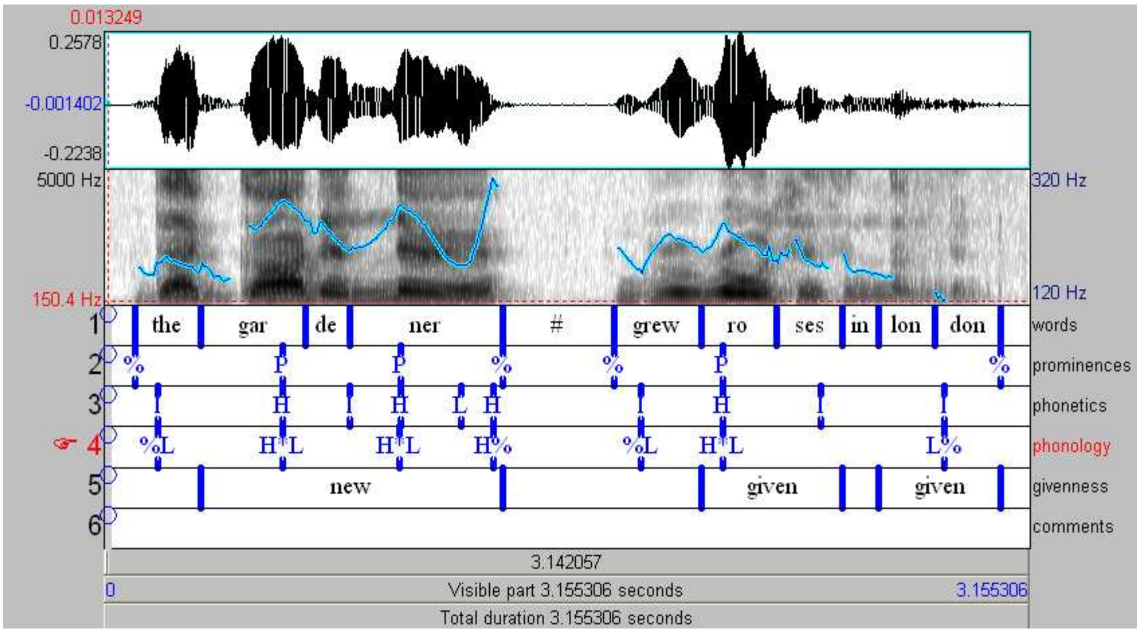


Figure 4.1: Display of the six annotation tiers for the sentence "The gardener grew roses in London." produced by speaker PFAS. Above the tiers, the oscillogram (representation of sound wave) as well as the spectrogram (representation of frequency distribution) of the sentence is displayed. The light blue line represents the pitch contour.

As outlined in section 2.3.2, prosodic transcriptions in IViE are made on three separate tiers (here: prominences, phonetics and phonology) to increase the level of transparency and replicability of the phonological transcription. The following section describes the labelling procedure used in the present study in greater detail.

In a first step, the location of rhythmically strong syllables was identified on the *prominence* tier. In terms of prominence, no difference was made between stressed or accented syllables. The prominent syllable was marked by a P which was roughly aligned with the middle of the prominent syllable. In addition to the labelling of the prominent syllables, rhythmic boundaries were transcribed as well. Here, IViE follows ToDI (Gussenhoven, Rietveld & Terken, 1999) in that there is only one major prosodic phrasing type to be marked by boundary tones, the intonational phrase (IP). According to the ToDI transcription system (ToDI 2nd edition online courseware; Gussenhoven, Rietveld, Kerkhoff & Terken, 2003), IP-boundaries can be marked by (brief) pauses, a melodic feature, or the lengthening of pre-boundary syllables. The presence of any of these phrasing features, or any combination of these, justifies the setting of an IP-boundary, which was marked using the percentage sign (%). In addition, hesitations and pauses were marked using the hash mark (#).

In a second step, the IViE labelling guide suggests a syllable-by-syllable *phonetic* transcription of the pitch movements surrounding the prominent syllables and IP-boundaries that have been identified on the prominence tier in the previous step. The phonetic labels used to describe the pitch levels of accented syllables were the capital letters H, M, L (i.e. High, Middle and Low), whereas the pitch levels of surrounding (unstressed and unaccented) syllables were indicated by small letters (h, m, l). The pitch levels were transcribed relative to each other rather than relative to an absolute value. Labels were aligned in the middle of the vowel of the syllable. Adjacent capital letters, i.e. adjacent stressed and or accented syllables, were separated by a rectangular bracket ([).

The final prosodic transcription step concerned the phonological labelling of the pitch accents and boundary tones. These formal phonological representations were labelled on the *phonology* tier.

For the phonological analysis of the intonation patterns, the pitch accent and boundary tone labels of the IViE system were used. As outlined in section 2.3.2, seven pitch accents and three types of boundary tones can be distinguished within the IViE system, which are repeated here for convenience (cf. table 4.6). The labels H* and L* describe high or low pitch accents, respectively. The label H*L refers to falling pitch accents, whereas L*H describes rising pitch accents. The falling pitch accent further exists as a downstepped version (!H*L). H*LH and L*HL are used to label fall-rise or rise-fall pitch accents. In addition, the IViE system proposes three types of boundary tones to label phrase boundaries. These are %H or H% indicating a high boundary, %L or L% indicating a low boundary and % which is used to mark a level boundary in final position where no pitch movement occurs at the boundary.

| Pitch accent labels | | Boundary tone labels | |
|---|---|---|---|
| H* | high pitch accent | %L, L% | low boundary tone |
| H*L | falling pitch accent | %H, H% | high boundary tone |
| !H*L | downstepped pitch accent | % | level boundary tone |
| H*LH | fall-rise pitch accent | | |
| L* | low pitch accent | | |
| L*H | rising pitch accent | | |
| L*HL | rise-fall pitch accent | | |

Table 4.6: Pitch accent and boundary tone labels of the IViE system

The data annotation of the different text styles for the current study was based on similar procedures and followed the IViE labelling guidelines described above (Grabe, 2001, 2004; Grabe et al., 1998, 2001). *Praat* scripts were used to create the different tiers for all four text styles and to identify the highest and the lowest pitch points of the target words in the sentence set. The data were then segmented on syllable (sentence set) or word level (remaining text styles) including pauses and hesitations using a see-listen-labelling approach. That is, visual and auditory cues were used to determine the respective boundaries. Following the identification of the salient syllables (P) and phrase boundaries (%) on the prominence tier, the pitch patterns around the identified prominences and boundaries were described on the phonetics tier. Based on phonetic information and auditory impression, the type of pitch accent and boundary tone was established, i.e. visual and auditory cues were used to formally classify the pitch accents and boundary tones, which were then labelled on the phonology tier. This was followed by the labelling of the information structural level, i.e. the information status of referents.

## 4.6 Data analysis

The intonation patterns were analysed using the autosegmental-metrical framework of intonational analysis (Ladd, 1996; Pierrehumbert, 1980). To arrive at a comprehensive picture of the intonational system in FAS speech, the four different levels of intonation, i.e. inventory, distribution, phonetic implementation and function of intonation (cf. chapter 2.6) were systematically described. The functional aspect of interest to this study was the marking of information status (givenness) of discourse referents.

Apart from the dimensional analysis, phonetic parameter analyses were conducted. Measurements of *duration*, *intensity* and *fundamental frequency* were carried out in the sentence set data to investigate the use of these phonetic cues in the marking of new and given referents and to identify similarities and differences in the use of these cues between speaker groups. More detailed information about the different analyses and the relevant statistical testing procedures is provided in the following sections.

### 4.6.1 Analysis of dimensions of intonation

Table 4.7 summarises the different dimensions of intonation and the respective measures taken for each text style. The inventorial analysis aimed at describing and establishing the intonational variety in terms of pitch accents and boundary tones the individuals with FAS have at their disposal. As part of this analysis Levenshtein distance was measured. Levenshtein distance is a measurement tool employed to determine the linguistic distances between dialects or dialect groups based on phonetic transcriptions (Heeringa, Johnson & Gooskens, 2009). In the present study it is employed to quantify the differences between the participants' inventories. This is achieved by comparing the different types of pitch accents and boundary tones speakers have at their disposal. Levenshtein distance will be expressed in a value ranging from 0 to 7 for pitch accents and 0 to 3 for boundary tones, whereby 0 implies complete overlap, i.e. no difference between speakers' inventories, and a result of 7 or 3, respectively, maximum difference between inventories. The analysis of the distributional patterns concerned the frequency of use of the structural elements that form part of the inventory[16], whereas the analysis of the phonetic realisation of the inventory relates to the way the structural elements were implemented in terms of accentuation and phrasing. This further included the analysis of the pausing patterns. Relevant measures for this level of intonation included the number of syllables, the number of pitch accents and the number of intonation phrases. Based on these measures, the pitch-accent syllable ratio and the mean length of IPs were calculated. Functionally, the intonation patterns were analysed in relation to the pitch accent to indicate the information status of elements, whereby a binary approach, i.e. new vs. given, towards defining information status was adopted (cf. section 2.5.2). The main reason for adopting the dichotomy of *new* versus *given* is the fact that the intermediate level of givenness as posited by Baumann (2006a, 2006b; Baumann & Grice, 2006; Baumann & Hadelich, 2003) and Pierrehumbert and Hirschberg (1990) is marked using right-headed pitch accents. These types of pitch accents, however, do not form part of the IViE label inventory that was employed in this study.

| **Dimensions of Intonation** | **Measures taken** |
|---|---|
| Inventory | • type of pitch accents used<br>• type of boundary tones used |
| Distribution | • frequency of use of pitch accents<br>• frequency of use of boundary tones |
| Phonetic implementation | • pitch accent-syllable-ratio, i.e. the average distance between pitch accents<br>• phrasing - mean length of IPs (in words or syllables)<br>• pausing pattern |
| Function | • use of pitch accents to mark new and given referents in discourse |

Table 4.7: The different dimensions of intonation and the respective measures taken

[16] This study adopts the definition of distribution by Mennen et al. (2008), where the term refers to the frequency of occurrence of structural categories rather than the environments in which the elements occur.

### 4.6.2 Analysis of phonetic parameters

In this study, the phonetic parameters *duration*, *intensity* and *fundamental frequency* were investigated in the set of sentences (c.f. section 4.3.1) in order to obtain detailed information on the speakers' ability to phonetically mark information status. This was assessed by analysing the following two aspects:

- the difference between new and given referents
- the magnitude of difference between new and given referents

These analyses, concerning all three parameters, were complemented by two examinations that specifically related to F0 variation:

- pitch range in terms of level and span
- post-focal F0 lowering

Before outlining each analysis including the purpose, the measures as well as the statistical examination procedures, which were conducted using SPSS (version 17.0), the process of capturing the phonetic parameters is described.

In order to capture the phonetic parameters, two new transcription tiers were added to the existing ones (cf. section 4.5). In one tier, the intervals for the duration and intensity measures were labelled, whereas in the second tier the labels required for F0 analyses were inserted. A *praat* script was then employed to extract the length of the marked intervals (tier 1), the peak intensity on these intervals and the Hz values on specified points (tier 2). The intervals relevant to the *duration* and *intensity* measures were the stressed syllables of the target words. For duration, the length of the accented syllable of the target words was measured (in ms); for intensity the peak decibel (dB) value on the accented syllables was captured. For the analysis of *fundamental frequency*, the F0 maxima on the accented syllable of the target words were captured. In addition to that, the F0 value at the beginning of each sentence as well as the final low were measured for the pitch range analyses. Overall, five F0 points were measured in each sentence (cf. figure 4.2), while care was taken to identify the appropriate F0 points[17]:

- Bi – Boundary initial (position)
- H1 – F0 peak on target word 1
- H2 – F0 peak on target word 2
- H3 – F0 peak on target word 3
- FL – final low

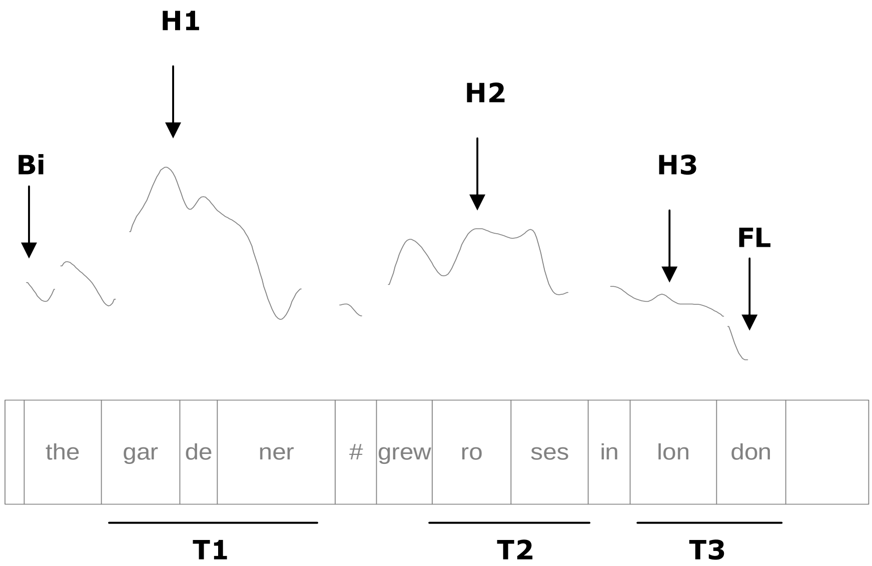


Figure 4.2: The five measurement points used for the fundamental frequency analyses (T1 = target word 1, T2 = target word 2, T3 = target word 3)

#### 4.6.2.1 Difference between new and given referents

The aim of this analysis was to establish whether speakers with FAS employ the different acoustic parameters to differentiate between new and given referents in discourse. Given the differences in gender, dialectal background and type of speech

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[17] In most cases, the highest or lowest F0 value on the respective syllable was measured. In cases of evident microprosodic perturbations, the nearest time point representing robust F0 computation was chosen.

disorder investigated, within-speaker comparisons for each parameter were deemed most appropriate. Specifically, three values per sentence were obtained for each parameter, resulting in 12 values per baseline sentence set (3 positions x 4 conditions). For the preliminary study, 60 measures were obtained per speaker and parameter; for the main study, due to the revised number of read sentences, 120 measures were obtained. The two factors that were important for the analysis were *information status* (i.e. new vs. given) and *sentence position* (i.e. initial vs. medial vs. final). The 3x2 factorial design meant that the values for each parameter were allocated to one of six different categories:

| | | |
|---|---|---|
| 1. initial new | 2. medial new | 3. final new |
| 4. initial given | 5. medial given | 6. final given |

For each category the values across the sentence sets were collapsed and the mean and standard deviation (SD) were calculated. Based on this, the differences in duration, intensity and F0 between new and given referents were calculated for each position (i.e. initial: category 1 minus category 4; medial: category 2 minus category 5; final: category 3 minus category 6) and subsequently tested for statistical significance. To account for individual differences, the data for each speaker were transformed to z-scores using the following formula: $V_{norm} = (V_x – V_{mean})/ SD$, where $V_x$ represented the observed raw value, $V_{mean}$ was the mean value of all measured intervals for that speaker and SD was the standard deviation.

For each parameter a series of two-factor repeated measures analysis of variance (ANOVA) were conducted with *information status* (two levels: new, given) and *sentence position* (three levels: initial, medial, final) serving as independent variables as well as *length of syllables* (in ms), *peak intensity* (in dB) and *peak F0* (in Hz) serving as dependent variables. In cases where Mauchly's test of sphericity was violated, the corrected F value provided by the Greenhouse-Geisser correction was used. Significant main effects for the factor *sentence position* were compared using the

Bonferroni correction (confidence interval adjustment) to ascertain which of the levels differed significantly.

#### 4.6.2.2 Magnitude of difference between new and given referents

To quantify the magnitude of difference between new and given referents, the *percentage difference* between the new and given versions of the same target word across sentences was calculated. Specifically, the differences between the respective new and given elements in each sentence position were calculated for each speaker and parameter, and subsequently transformed to a percentage value, which was then averaged. In the preliminary study, performances of the clinical speakers were directly compared with those of the matched control speakers. In the main study, due to the higher number of speakers with FAS, group performances were compared rather than individual performances. For each phonetic parameter a two factor mixed design ANOVA was conducted with *speaker/group* (control speaker(s) vs. speaker(s) with FAS) and *position* (initial, medial and final) serving as independent variables and *duration of syllables* (in ms), *peak intensity* (in dB) and *peak F0* (in Hz) serving as dependent variables.

#### 4.6.2.3 Pitch range

*Pitch range* analyses were carried out in relation to *level* and *span* - the two independent measures, which according to Ladd (1996) are required to establish a speaker's pitch range. *Level* describes the overall height of a speaker's voice; *span* determines the variation of frequencies that is covered by a speaker's voice. In this study, the measures of level and span were linked to tonal targets, thus following a linguistic approach of assessing pitch range. *Level* was equivalent to the value of the final low (FL, cf. figure 4.2), whereas *span* was computed by deducting the F0 value of the final low (FL) from the highest value measured on any of the target words (mostly H1). Both pitch range measures were statistically examined by means of independent samples t-tests with *speaker/group* (i.e. control speaker(s) vs. speaker(s) with FAS) serving as independent variable, and *level* and *span* serving as dependent variables. In the preliminary study matched speakers were compared directly, whereas in the main study group performances were assessed. In order to account for gender differences in pitch height, the Hz values were converted into semitones (ST; Nolan, 2003; Reetz, 1999), before undergoing statistical examination.

#### 4.6.2.4 Post-focal F0 lowering

The analysis of F0 lowering was conducted to assess the de-accentuation patterns of post-focal target words within sentences. For this purpose, the differences between the F0 maxima on target words (H1, H2, H3) in relation to the overall pitch range of the speaker were computed, converted into percentages and compared across conditions. For the preliminary study, matched speakers were compared, whilst for the main study group performances were examined. Due to the small sample size of the preliminary study, statistical examination was carried out using the non-parametric Mann-Whitney U test for independent samples. For the main study, independent samples t-tests were used, as the sample size was larger. In both tests, *speaker/group* served as independent variable and *percentage change* as dependent variable.

## 4.7 Data evaluation - Intra- and inter-rater reliability

Intra- and inter-rater reliability for transcription was completed on 10% of the overall data for intonation phrase boundaries, prominent syllables and classification of the structural elements, i.e. pitch accents and boundary tones. The same set of data, including scripted and unscripted data samples from different speakers, was used for both reliability measures. The data sets were compared with regard to the position of the phrase boundaries and the prominent syllables. Consensus between raters was measured as number of boundaries and prominences occurring in the same position, which were then divided by the total number of instances of pauses and prominences, and expressed as percentage value. For the subsequent evaluation of the structural categories only those instances were considered, which were identified by both raters.

Intra- and intra-rater agreement in intonation analysis is commonly established using percentage values (cf. Mayo et al., 1997; Pitrelli et al., 1994; Silverman et al., 1992), instead of statistical means such as Cohen's Kappa - a chance-adjusted measure of agreement, which is often employed to examine categorical data. There are a number of reasons as to why Cohen's Kappa may not be suited for establishing agreement on intonational labels. Firstly, Kappa is strongly influenced by the number of categories used, which allows one to manipulate its value by combining categories or not (Warrens, 2010). For intonational analyses this would imply that collapsing e.g. H*L and !H*L to one category of falling pitch accents may result in a different Kappa value than treating both labels separately. Secondly, Kappa computation requires that both raters employ the same categories, which may not always be the case for very infrequent intonation labels such as L*. Thirdly, the categorisation of Kappa values to represent fair, moderate or substantial agreement appears arbitrary as no supporting evidence for this classification was provided (Landis & Koch, 1977). This issue of validity, in combination with the absence of any intonational reference data, means that any Kappa value obtained with regard to assessing agreement on intonation labels would be difficult to interpret and hence be of limited explanatory power.

In addition to the re-assessment of the transcription, 10% of the phonetic data of the sentence set were re-measured to verify the obtained values. In order to determine the consistency of intra- and inter-rater agreement regarding the phonetic data, a Pearson correlation test statistic was performed. Intra-rater reliability measures were carried out by the experimenter three months after the intonational analysis had been completed; inter-rater reliability measures were conducted by a trained speech and language therapist with a special interest in prosody, who was familiarised with the annotation procedure used in this study.

Reliability scores of intra-rater agreement for each transcription category and text style are listed in table 4.8. Reliability for transcription was consistently over 90% indicating a very high degree of agreement. Overall intra-rater reliability for the set of sentences was 95%, for the passage data 96% and for the picture description 93%. The agreement regarding the identification of IP boundaries and prominent syllables was found to be around 96%, the re-labelling of pitch accents and boundary tones was around 92%. The calculation of the Pearson correlation coefficient (two-tailed) on the phonetic data was highly significant for duration ($r=0.986$, $N=96$, $p=0.000$)[18], intensity ($r=1.0$, $N=96$, $p=0.000$) and fundamental frequency ($r=0.996$, $N=160$, $p=0.000$), suggesting a very high level of agreement between the two test times.

| Categories | SENT % | PASS % | PICT % | overall |
|---|---|---|---|---|
| IP boundaries | 96.2 | 100 | 93.5 | 95.6 |
| Prominent syllables | 97.8 | 95.4 | 93.7 | 95.6 |
| Labels of structural elements | 91.6 | 93.8 | 91.5 | 92.3 |
| overall | 95.2 | 96.4 | 92.9 | --- |

Table 4.8: Intra-rater agreement in % for the transcription data of different text styles (% = percentage reliable)

The results of the inter-rater agreement are provided in table 4.9. The overall agreement for the transcription of the different text styles was at least 79%. Regarding the individual categories assessed, high inter-rater agreement was obtained for the identification of the IP boundaries. With 95% agreement, this was comparable to the intra-rater performance. A high agreement rate was also observed for the identification of the prominent syllables. The congruence pertaining to the

[18] In SPSS, the p-value is corrected to the third decimal place, which is why very low values are recorded as zero. In the remainder of this study, p-values are reported as generated by SPSS.

labelling of the structural elements was 69%, matching reliability scores obtained for ToBI transcriptions (Mayo et al., 1997; Pitrelli, Beckman & Hirschberg, 1994; Silverman et al., 1992). The statistical examination using the Pearson correlation coefficient (two-tailed) on the phonetic data was highly significant for each parameter (duration: r=0.937, N=96, p=0.000; intensity: r=1.0, N=96, p=0.000; fundamental frequency: r=0.992, N=160, p=0.000). The significant results indicate a very high level of inter-rater agreement for the phonetic labelling.

| Categories | SENT % | PASS % | PICT % | overall |
|---|---|---|---|---|
| IP boundaries | 95.6 | 93.8 | 94.1 | 94.5 |
| Prominent syllables | 88.4 | 77.0 | 80.5 | 82.0 |
| Labels of structural elements | 74.0 | 66.5 | 64.9 | 68.5 |
| overall | 86.0 | 79.1 | 79.0 | --- |

Table 4.9: Inter-rater agreement in % for the transcription data of different text styles (% = percentage reliable)

Examination of the inter-rater agreement results revealed a relatively low agreement on the structural categories which ranged from 65% to 74% depending on the type of text style assessed. However, a comparison with reference data in the literature shows that these percentages closely match reliability scores observed for ToBI transcriptions.[19] For instance, regarding pitch accent type Mayo et al. (1997) reported an overall agreement of 68%, Pitrelli et al. (1994) an agreement of 64%, and Silverman et al. (1992) an agreement of 61% to 67% depending on the transcribers' experience. A detailed analysis of the discrepancies between first and second rater in the present study showed that primarily two pitch accent pairs were less reliably labelled: H*L % versus H* L% and H*L versus !H*L. Regarding the first pair it appears that the phonetic shape of the contour was recognised by both raters but the F0 low was phonologically interpreted to belong to the pitch accent by one rater and to the boundary tone by the other. Regarding the second pitch accent pair disagreement occurred as to whether a falling contour constituted a full accent or a

[19] There is no study yet that has assessed inter-rater reliability for IViE transcriptions.

downstepped accent. When taking into account these two issues, the inter-rater agreement rate pertaining to the transcription of the structural labels rises to 81.2%.

The initial low level of inter-rater agreement in the current study as well as other published results highlight the importance of appropriate training of raters as well as the provision of clear instructions. For this study, the instructions included detailed information on the annotation system and the analysis procedure, explaining the different labels of pitch accents and boundary tones and providing practical tips as to how to establish the type of structural element used. In addition, the second rater was encouraged to read suggested materials such as the IViE labelling guide as well as practice labelling using the ToDI online tutorial in order to familiarise herself further with the labelling approach. This was followed by a practice session in which unrelated data were labelled and discussed.
Despite these efforts it is likely that the second rater's relative inexperience in analysing intonation may have had an effect on the agreement rates. More extensive training could thus have resulted in greater agreement. However, this would have been impractical for the current study as the time-consuming nature of intonational analysis was one of the main reason as to why no more experienced researcher could be entrusted with this task in the first place. Whilst the current level of agreement was thus judged appropriate to conduct the study in a reliable way, such issues need to be addressed in the wider field of intonation research.

## 4.8 Summary

This chapter presented the methodologies employed in this study, which adopted a multiple single case studies design. As part of this chapter, the participants of the study were introduced and relevant inclusion and exclusion criteria outlined. This was followed by a detailed description of the materials employed to elicit the speech samples that formed the basis for the investigation of the intonation patterns. In a further section, the data collection and transcription procedures were outlined, including the steps taken to arrive at the complete annotation of the corpus data. In a next step, the dimensional and phonetic analyses along with the statistical techniques were explained. Finally, results of the reliability measures were presented, showing satisfying agreement and therefore supporting the analysis of the intonation component in FAS within the proposed theoretical framework and transcription system.

As outlined previously, a preliminary study was conducted to validate research design and test materials. The findings are presented in the following chapter, together with a brief discussion that examines the implications of the results for the conduct of the main study.

# 5 RESULTS OF THE PRELIMINARY STUDY

This chapter reports the results of the preliminary study conducted to examine the suitability of the designed materials to investigate different aspects of intonation in FAS speech. The chapter is divided into three subsections. In section 5.1 the results of the four different dimensions of intonation, i.e. inventory and distribution of structural elements, phonetic implementation and function, are presented per speaker and per scripted and unscripted text styles. In section 5.2 the results of the phonetic parameter analyses are reported, which were conducted on the data of the sentence reading task to investigate the speakers' use of phonetic cues to signal the information status of discourse referents. Section 5.3 provides a summary of the performances in relation to the different analyses and outlines the implications of the preliminary results for the conduct of the subsequent main study.

## 5.1 Dimensions of intonation

The primary goal of this study was to provide a systematic description of the intonation system in FAS by assessing the four dimensions of intonation posited by Ladd (1996). The results relating to the different intonation dimensions are described in the following order:

- Inventory of structural elements (5.1.1)
- Distribution of structural elements (5.1.2)
- Phonetic implementation (5.1.3)
- Function in relation to information status (5.1.4)

In each section, the results of the scripted data, i.e. the sentence reading task (SENT) and the reading passage (PASS), are reported first, followed by the results of the unscripted data sets, i.e. picture description (PICT) and monologue (MONO). In this context it is important to note that in the sentence data set (SENT) 14% of the sentences (11/80) had to be excluded from the analysis, as a target word other than the expected one was highlighted. The affected sentences were all produced by control speakers. Overall, for the analysis of the four dimensions of intonation 863 pitch accents and 1044 boundary tones were examined. The analysis of the function of intonation, i.e. the marking of information status, was based on 555 target words across all text styles. However, in the reading passage, due to the small number of given referents, the analysis focused on new referents only. An overview of the exact number of structural categories and target words included per speaker and text style can be found in appendix E1.

### 5.1.1 Inventory of structural elements

This section reports the intonational inventory of the structural elements. Pitch accents are described first, followed by the boundary tones speakers have at their disposal. The section concentrates on the presence of the structural categories; an exact analysis of the frequency distribution is part of section 5.1.2.

#### 5.1.1.1 Pitch accents

**Scripted data**

Table 5.1 provides an overview of the pitch accents that the speakers used in the scripted data sets. As can be seen from the table, the data sets differ in terms of the variety of pitch accents employed, with the PASS data displaying a greater diversity of pitch accents than the SENT set. Whilst in the former text style four pitch accents were used by all speakers (H*L, !H*L, L*H and H*), in the latter only H*L and !H*L were employed by all participants. The remaining pitch accents L* and L*HL featured in both text styles, but were only used by some of the speakers.

| | SENT | | | | | | PASS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **H*L** | **!H*L** | **L*H** | **H*** | **L*** | **L*HL** | **H*L** | **!H*L** | **L*H** | **H*** | **L*** | **L*HL** |
| **PC1** | x | x | x | x | x | | x | x | x | x | x | |
| **PC2** | x | x | | x | | | x | x | x | x | x | |
| **PFAS** | x | x | | x | x | | x | x | x | x | | x |
| **PMS** | x | x | x | | x | x | x | x | x | x | x | |

Table 5.1: Inventory of pitch accents of scripted data sets per speaker (x indicates the presence of the respective pitch accent in the data set)

**Unscripted data**

The analysis of the pitch accent inventory of the unscripted data sets revealed that the same four pitch accents that were used by all speakers in the PASS data were also employed in the PICT and MONO data sets (cf. table 5.2). The pitch accents L* and L*HL were again only used by some of the speakers.

| | PICT | | | | | | MONO | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **H*L** | **!H*L** | **L*H** | **H*** | **L*** | **L*HL** | **H*L** | **!H*L** | **L*H** | **H*** | **L*** | **L*HL** |
| **PC1** | x | x | x | x | x | | x | x | x | x | x | |
| **PC2** | x | x | x | x | | | x | x | x | x | | |
| **PFAS** | x | x | x | x | | x | x | x | x | x | | |
| **PMS** | x | x | x | x | x | | x | x | x | x | x | x |

Table 5.2: Inventory of pitch accents of unscripted data sets per speaker (x indicates the presence of the respective pitch accent in the data set)

Levenshtein distance measures employed to quantify the differences in inventory between the clinical participants and the healthy control speakers revealed a distance of 1 for the scripted data and 1.5 for the unscripted data. The mean distance within each group was 0 for the scripted data and 1 for the unscripted data indicating a slightly larger difference in inventory across participants.

### 5.1.1.2 Boundary tones

The inventorial analysis of the boundary tones across the scripted and unscripted data sets revealed that all speakers employed the low boundary tone (L), the high boundary tone (H) as well as the level boundary tone (%).[20] Their use, however, varied slightly across text styles (cf. table 5.3). Whilst in the PASS, PICT and MONO data set all speakers employed the different types of boundary tones available, only two of them (PC2 and PFAS) did so in the SENT set.

Levenshtein distance measures revealed a distance of 0 for scripted as well as unscripted data indicating that the clinical speakers did not differ from the control participants in terms of their inventory of boundary tones.

| | **SENT** | | | **PASS** | | | **PICT** | | | **MONO** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **L** | **H** | **%** | **L** | **H** | **%** | **L** | **H** | **%** | **L** | **H** | **%** |
| **PC1** | x | | x | x | x | x | x | x | x | x | x | x |
| **PC2** | x | x | x | x | x | x | x | x | x | x | x | x |
| **PFAS** | x | x | x | x | x | x | x | x | x | x | x | x |
| **PMS** | x | | x | x | x | x | x | x | x | x | x | x |

Table 5.3: Inventory of boundary tones per text style and speaker (x indicates the presence of the respective boundary tone in the data set)

In summary, the results of the inventorial analysis show a similarly rich inventory of different types of pitch accents and boundary tones for all four speakers, indicating that the clinical participants have the same structural elements at their disposal as the matched control speakers. Importantly though, two points were noted regarding the structural inventory. Firstly, the complex tone L*HL was only found in the inventories of the clinical speakers. Secondly, inventorial differences were observed in relation to the different text styles, with the PASS, PICT and MONO data sets showing a greater variety of pitch accents and boundary tones than the SENT data set.

### 5.1.2 Distribution of structural elements

This section describes the distribution of the structural elements that form part of the inventory. The distribution of the pitch accents is reported first, followed by the

[20] The categories L and H include phrase-initial and -final boundary tones, i.e. %L and L% as well as %H and H%.

distributional analysis of the boundary tones. A detailed overview of the performances in terms of pitch accents and boundary tones per speaker and text style is provided in appendices E2 and E3.

#### 5.1.2.1 Pitch accents

**Scripted data**

The distributional analysis of the SENT set revealed that the falling pitch accent H*L was the most common accent used by all speakers. As can be seen from figure 5.1 (left), H*L accounted for at least 70% of all pitch accents. The second and third most frequently used pitch accents overall were H* and !H*L; the remaining pitch accents L*, L*H and L*HL were only marginally used.

The falling pitch accent H*L was also the most frequently used accent in the PASS data set (cf. figure 5.1 right). However, with a range of 38% to 63%, the percentages overall were considerably lower than the ones observed for the SENT set, resulting in a higher use of other pitch accents including H*, !H*L and L*H, in particular in PFAS and PMS. The remaining pitch accents L* and L*HL were again only infrequently used.

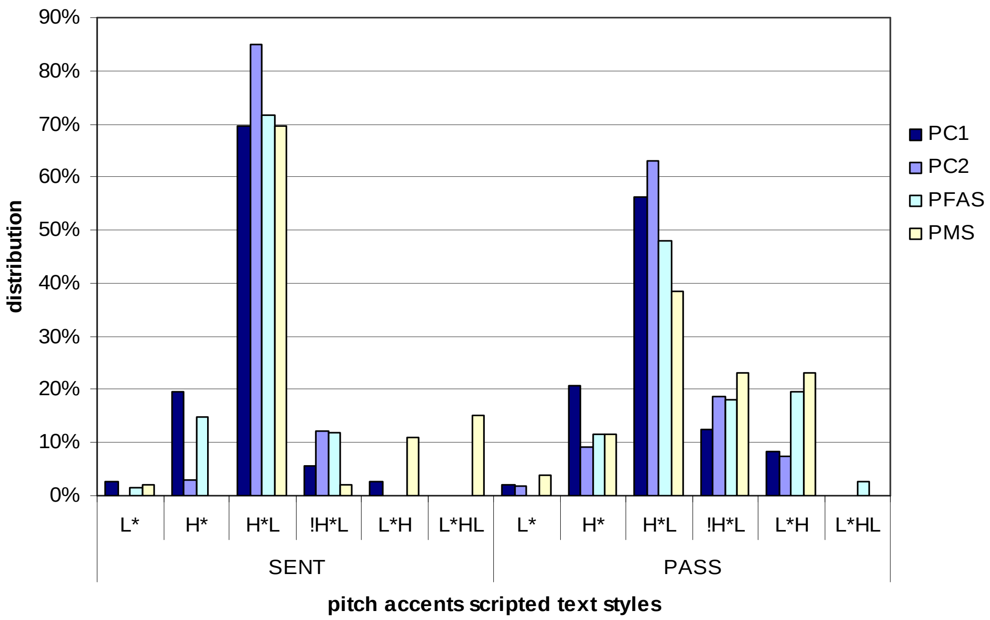


Figure 5.1: Distribution of pitch accents in the scripted data sets per speaker in %

**Unscripted data**

The distributional analysis of the unscripted data mirrored the patterns seen in the PASS data set. In both sets H*L was the most commonly used pitch accent followed by !H*L, L*H and H* (cf. figure 5.2). The only exception to that pattern was observed in the PICT data set, where PFAS used !H*L more frequently than H*L. The remaining pitch accents L* and L*HL were only marginally used.

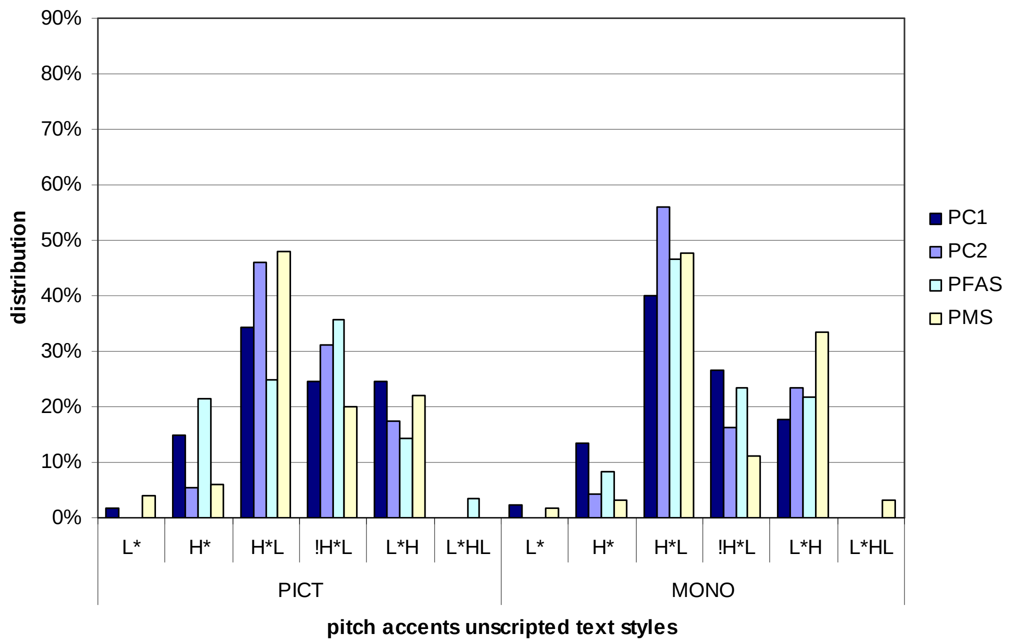


Figure 5.2: Distribution of pitch accents in the unscripted data sets per speaker in %

In summary, the comparison of pitch accent distribution in the scripted and unscripted data showed similar patterns regarding the most commonly used pitch accent in all speakers. However, the percentages for H*L differed across text styles, with a considerably lower percentage use in the PASS data and both unscripted data sets resulting in a more varied use of pitch patterns in these text styles. This led to a rise in the use of !H*L and L*H, in particular in the clinical speakers.

### 5.1.2.2 Boundary tones

**Scripted data**

The distributional analysis of the boundary tones revealed that in the SENT set the most commonly used tone to start an intonation phrase was the low boundary tone %L (cf. figure 5.3 left). PC1 and PMS used this tone exclusively, whereas PC2 and PFAS additionally used high boundary tones. The most common IP-final boundary tone for all speakers was the level boundary tone (%). While PC2 and PMS used this tone throughout, PC1 and PFAS showed a more varied pattern. In addition to the level tone, both speakers used the low boundary tone L%; PFAS further frequently employed the high boundary tone H%.

An in-depth analysis of the use of high boundary tones, which were only produced by PC2 and PFAS, revealed that these tones were only used at the beginning and end of sentence-internal intonation phrases, i.e. in cases where sentences were divided into smaller phrasing units. More precisely, PC2 used the high boundary tone %H to indicate the beginning of a sentence-internal intonation phrase, whereas the end of such phrases were marked by the level boundary tone (%). In contrast, PFAS used both high and low boundary tones to indicate the beginning and end of sentence-internal IPs.

In the PASS data set, the most common initial boundary tone for the control speakers was again %L, whereas both clinical speakers showed a preference for high boundary tones (see figure 5.3 right). The most common IP-final boundary tone for all speakers was the level boundary tone (%). Notable differences were observed as to the use of the high boundary tone. Whilst the control speakers used this tone very scarcely, in the clinical speakers it constituted about one fifth to one quarter of all boundary tones observed in IP-final position.

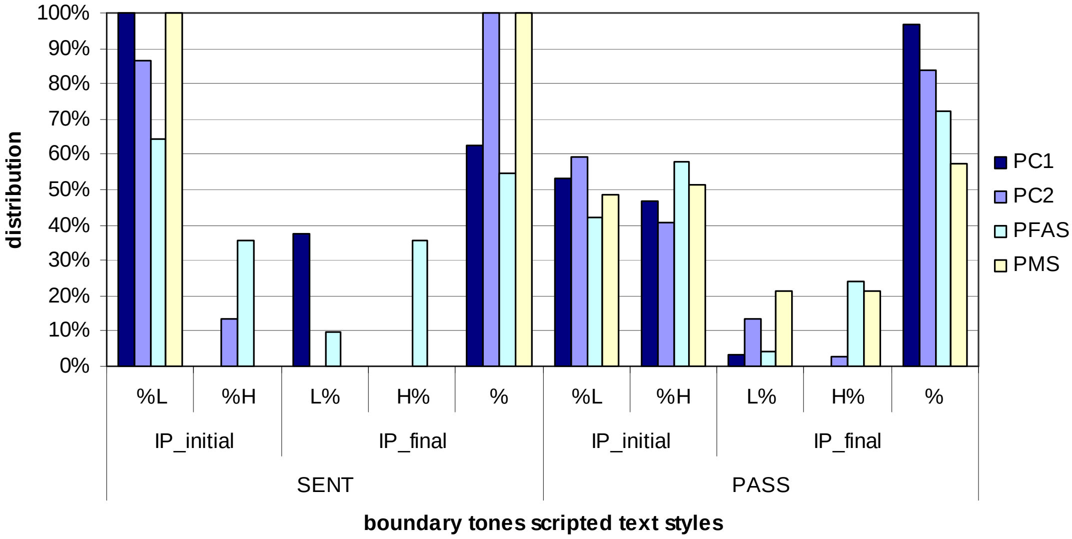


Figure 5.3: Distribution of boundary tones in the scripted data sets in IP-initial and -final position per speaker in %

### Unscripted data

The distributional analysis of boundary tones in the unscripted data sets showed similarities to the patterns seen in the scripted data sets. Specifically, PC1, PC2 and PMS preferably started their IPs with the low boundary tone %L, whereas PFAS used %H more frequently (cf. figure 5.4). In phrase-final position, the most prevalent boundary tone for all speakers was again the level tone (%). However, notable inter-speaker differences occurred in relation to the use of IP-final high boundary tone. Whilst PC1 hardly employed H%, their use made up at least 20% of all cases in the remaining speakers.

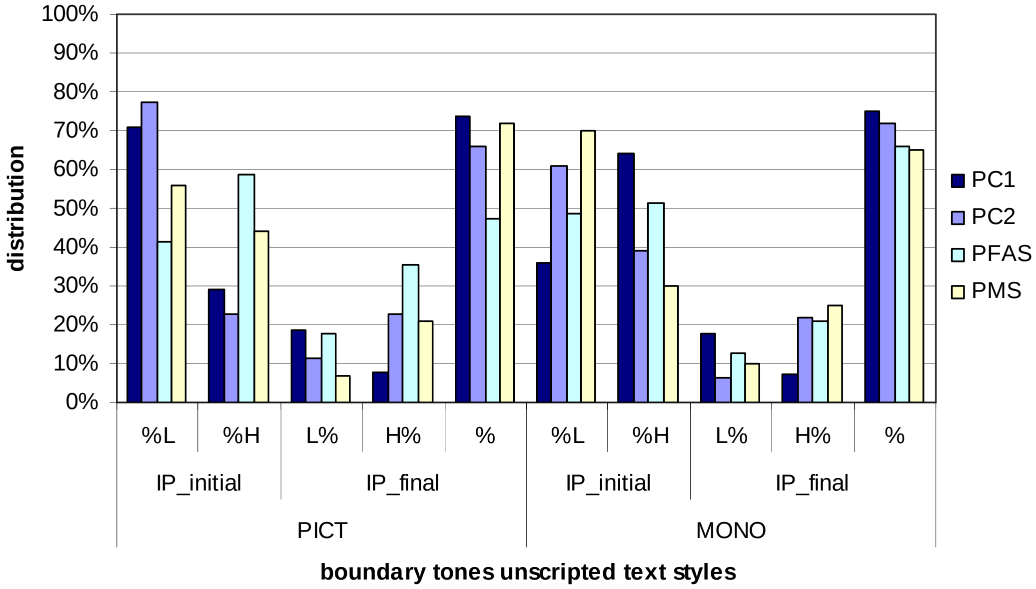


Figure 5.4: Distribution of boundary tones in the unscripted data sets in IP-initial and -final position per speaker in %

In summary, low and level tones accounted for the majority of tones used to indicate phrase boundaries, although in the clinical participants a tendency towards the use of high boundary tones could be observed. A further important difference relates to the nature of the text styles. Similar to the distribution patterns of the pitch accents, unscripted data elicited a more varied use of different types of boundary tones than scripted data.

### 5.1.3 Phonetic implementation

The following sections provide information on the phonetic realisation of the intonation patterns, including frequency of accentuation (5.1.3.1), phrasing and pausing (5.1.3.2 and 5.1.3.3).

#### 5.1.3.1 Frequency of accentuation

As part of the analysis of the phonetic implementation, the pitch accent-syllable ratio, i.e. the average distance between pitch accents, was calculated for each text style. The results, displayed in table 5.4, show that PC1, PC2 and PMS produced on average about one pitch accent every 4 syllables, whilst PFAS did so every 3 syllables. In other words, PFAS had the highest frequency of pitch accents of all speakers across text styles. In addition, her performance did not overlap at any point with that of the remaining speakers. That is, her furthest distance between two pitch accents of 3.3 syllables in the MONO data set was still smaller than any of the performances seen in the remaining speakers.

| | SENT | PASS | PICT | MONO | mean |
|---|---|---|---|---|---|
| **PC1** | 4.3 | 4.1 | 4.3 | 4.0 | 4.2 |
| **PC2** | 3.9 | 3.7 | 3.8 | 4.5 | 4.0 |
| **PFAS** | 2.9 | 2.7 | 2.8 | 3.3 | 2.9 |
| **PMS** | 4.2 | 3.9 | 3.4 | 3.9 | 3.9 |

Table 5.4: Pitch accent-syllable-ratio per speaker and text style

#### 5.1.3.2 Phrasing

Table 5.5 provides an overview of the mean intonation phrase length per speaker and text style. It shows that, on average, PFAS' phrases were about one third shorter that those of the remaining speakers. A more detailed description of scripted and unscripted text styles is provided in the following sections. The exact percentage values of the syllable frequency patterns per speaker and text style are given in appendix E4.

| | SENT | PASS | PICT | MONO | mean |
|---|---|---|---|---|---|
| **PC1** | 9.7 | 6.2 | 6.8 | 6.5 | 7.3 |
| **PC2** | 8.5 | 5.4 | 6.5 | 6.7 | 6.7 |
| **PFAS** | 4.7 | 4.1 | 4.5 | 5.2 | 4.6 |
| **PMS** | 9.7 | 6.2 | 6.7 | 6.2 | 7.2 |

Table 5.5: Mean IP length in syllables per speaker and text style

**Scripted data**

In the SENT set, PC1, PC2 and PMS had a mean phrase length of 8.5 syllables or higher, whereas PFAS produced phrases that with 4.7 syllables were about half that length (cf. table 5.5). The analysis of this data set further revealed that speakers PC1 and PMS produced all sentences as one IP; PC2 produced 87% of the sentences as one IP, the remaining 13% were divided into two IPs. For PFAS, the phrasal analysis yielded a more heterogeneous pattern, with the majority of the sentences consisting of two IPs (60%). A further 20% were broken up into three and four IPs, respectively; and only 20% of sentences were realised as one IP. These results suggest a tendency for PFAS to divide sentences into smaller phrasing units. This tendency was also observed in the PASS data set, where intonation phrases were on average one third shorter than those of the other speakers. As a result of PFAS' division of sentences into smaller units, phrases consisting of one to three syllables prevailed in both text styles (cf. figure 5.5).

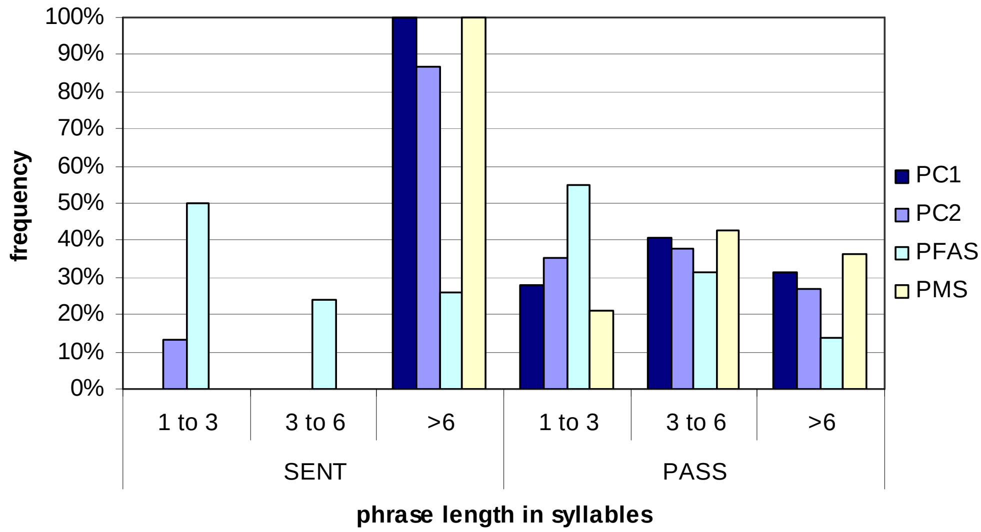


Figure 5.5: Phrase length in syllables for the scripted data sets in %

**Unscripted data**

The analysis of the phrasing patterns of the unscripted data sets mirrors PFAS' tendency for shorter phrases already seen in the scripted data sets. As evidenced in table 5.5, the mean IP length for PC1, PC2 and PMS ranged between 6.2 and 6.8

syllables per phrase, whereas PFAS produced intonation phrases that were at least two syllables shorter in the PICT set and at least one syllable shorter in the MONO data set. This pattern is also reflected in the frequency of the different phrase lengths (cf. figure 5.6). In the PICT data, where the difference between PFAS' mean IP length and that of the remaining speakers was more pronounced, phrases of one to three syllables were the most frequent. In the MONO data, where the difference in terms of phrase length was less pronounced, phrases consisting of four to six syllables prevailed.

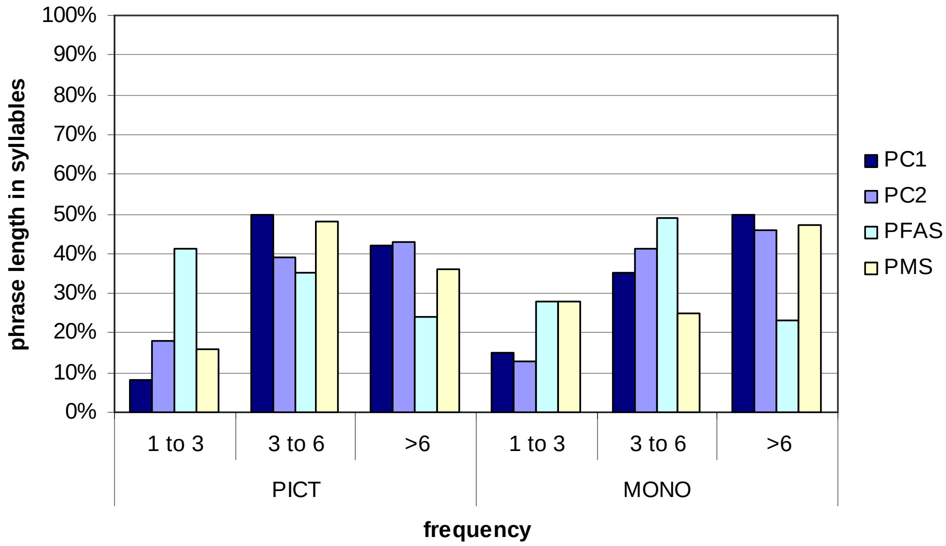


Figure 5.6: Phrase length in syllables for the unscripted data sets in %

In conclusion, the results of the phrase pattern analysis revealed a strong tendency for PFAS towards shorter phrases. The fact that this pattern was relatively consistent across all text styles indicates that the type of text style does not appear to have a role in the manifestation of phrasal changes in PFAS.

### 5.1.3.3 Pausing

As part of the implementational analysis, the pausing patterns of the SENT data were assessed in terms of *frequency* and *position* of pauses. Specifically, the analysis focused on the functional use of pauses in relation to the new element within a sentence. For this purpose, the sentences of those three conditions were examined where the position of the new element varied systematically from initial to medial to final position (cf. table 4.3 in section 4.3.1).

The analysis of the pausing patterns in the three conditions in question revealed that PC1 did no place any pauses between sentence elements, whereas PC2 produced pauses in 50% of the examined sentences. A comparison of the position of the highlighted element and the pause placement showed that 80% of the pauses were positioned directly before or after the new element. This finding indicates that pauses may have been strategically employed by PC2 to mark the position of the new element within the sentence.

The analysis of PFAS' pausing structure revealed a use of pauses in 87% of the examined sentences, of which 56% were found to be in proximity of the new element. At the same time, a strong preference for placing the pauses after target word 1 could be observed irrespective of the condition (69% after target 1; 6% after verb and 25% after target 2). Given this stark tendency towards one particular position, it appears unlikely that the pauses placed by PFAS served as a cue to new information.

PMS also produced 87% of the examined sentences with pauses. However, in contrast to PFAS, the position of the pauses appeared to vary in a purposeful manner across conditions, with 84% of the pauses being placed directly before or after the highlighted element, therefore equating percentages seen in PC2. That is, in the case of PMS, the pause pattern seems to be related to the position of the new element within the sentence.

In summary, pauses appear to be a common phenomenon in read sentences, although differences occurred as to the prevalence of pauses across speakers, with more pauses being observed in the sentences of the clinical speakers. In relation to the function of pauses no unified pattern or strategy could be identified. Whilst in speakers PC2 and PMS pauses appeared to serve as a cue to new information, no such specific functional pattern emerged for PFAS. That is, her pauses were not specifically inserted to signal linguistic function, i.e. to aid the identification of the highlighted element.

### 5.1.4 Function of intonation

The following section reports the results of the function of intonation in marking information status and is divided into three subsections. In the first section, the overall *accentuation* of new and given referents per text styles is detailed (5.1.4.1). This is followed by two sections providing information of *type* and *frequency* of pitch patterns employed to mark new and given referents (5.1.4.2 and 5.1.4.3). Regarding the investigation of given referents, the specific design of the SENT data set allowed to examine given referents in pre- and post-focal position, whereas the unscripted data sets assessed the use of given referents in general. As previously outlined, the PASS data set was not assessed in relation to given referents due to the small number of given instances.

#### 5.1.4.1 Accentuation patterns

**Scripted data**

The analysis of the accentuation patterns of the scripted data sets revealed that control speakers as well as clinical speakers marked *new referents* with a pitch accent. Control speakers did so in at least 90% of all cases, whereas both clinical speakers consistently assigned a pitch accent to every new referent. However, clear inter-speaker differences as to the frequency of accentuation occurred in relation to the marking of post-focally *given referents*. The control speakers PC1 and PC2 assigned pitch accents only in about 20% of all cases, thus showing a strong preference for the expected de-accentuation of given referents in post-focal position. PMS was even more consistent in de-accenting given referents, showing complete de-accentuation of all post-focally given referents. By contrast, PFAS marked about 75% of all given referents with a pitch accent, indicating that she used accentuation far more frequently than de-accentuation to mark given referents. A summary of the percentages per text style and speaker are provided in appendix E5.

**Unscripted data**

The analysis of the accentuation patterns of the unscripted data sets confirmed findings of the scripted data sets in relation to the marking of *new referents*. Again, control speakers marked new referents using a pitch accent in at least 90% of all cases, whereas the clinical participants showed 100% accentuation of new referents. Unlike in the SENT data set, however, accentuation also dominated the marking of *given referents* in the unscripted data sets. Specifically, in the PICT data set, control speakers and PMS marked between 67% and 81% of given referents with a pitch accent; PFAS assigned a pitch accent to 100%. A slightly lower overall accentuation rate could be observed in the MONO data set, with pitch accent assignment on given referents ranging from 57% to 90%. Once again, the highest accentuation rate in this data set was observed for PFAS.

Overall, these results highlight two aspects. Firstly, whilst the marking of new referents was similar across text styles, the marking of given referents appears to be strongly influenced by the type of text style used to elicit the data, with scripted data generally yielding a higher de-accentuation rate of given referents than unscripted data. Secondly, irrespective of the speaking style examined, PFAS consistently displayed the highest accentuation rate for given referents of all four speakers, indicating difficulties with de-accenting given referents.

#### 5.1.4.2 Type and frequency of pitch accents to mark NEW referents

**Scripted data**

The subsequent analysis concerning the type and frequency of pitch accents revealed that in the scripted data sets the most frequent pitch accent to mark new referents was H*L in all speakers (see figure 5.7 and appendix E6). This type of pitch accent accounted for at least 70% of all realisations in the SENT data and at least 39% in the PASS data. The lower percentage values observed in the PASS data are the result of a more varied use of pitch accents, with !H*L and L*H being employed more frequently compared to the SENT data.

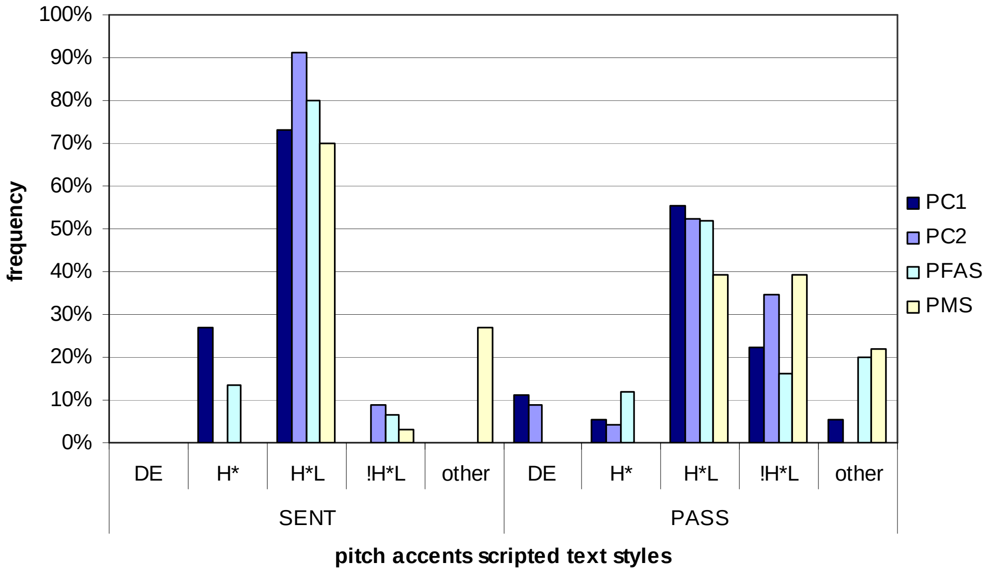


Figure 5.7: Type and frequency of pitch patterns for new referents per scripted text style and speaker in % (category *other* includes: L*, L*H and L*HL; DE=de-accentuation)

**Unscripted data**

The analysis of the marking of new referents in the unscripted data sets revealed a similar picture for the control speakers, where the most frequently used pitch accent was again H*L, followed by !H*L (cf. figure 5.8 and the table in appendix E6). In the clinical speakers, the use of pitch patterns to mark new referents was less consistent. For PFAS, the most prevalent pitch accent in the PICT sample was !H*L, whereas in the MONO sample H*L dominated the picture. PMS, on the other hand, generally showed a strong preference for the rising pitch accent L*H. In the PICT sample L*H and H*L were equally frequent, but in the MONO data set the use of L*H rose to more than 50%.

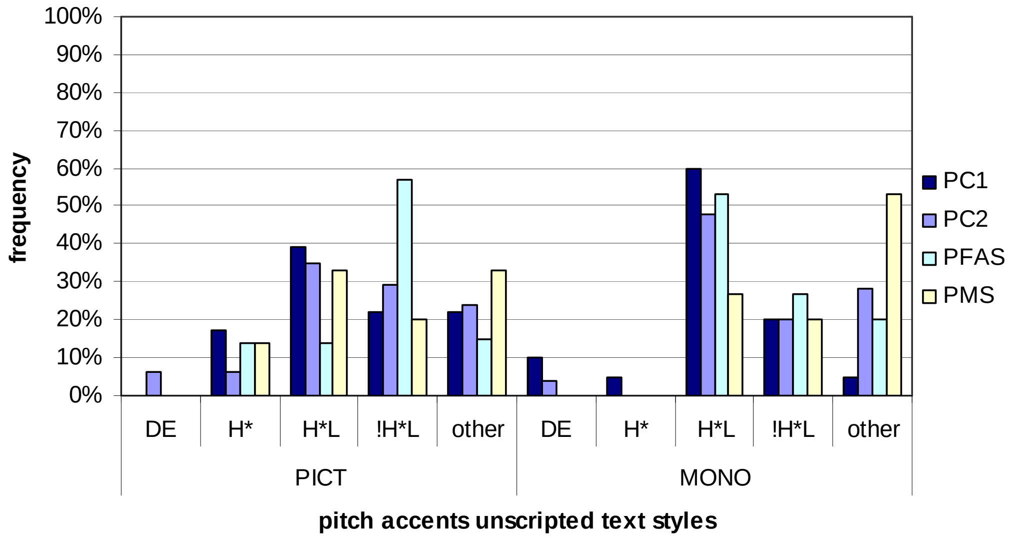


Figure 5.8: Type and frequency of pitch patterns for new referents per unscripted text style and speaker in % (category *other* includes: L*H and L*HL)

### 5.1.4.3 Type and frequency of pitch accents to mark GIVEN referents

**Scripted data – SENT data**

The analysis of the marking of given referents in the SENT data set revealed that in pre-focal position all speakers predominantly used H*L to indicate given referents (cf. figure 5.9 and the table in appendix E7). Other types of pitch accents were only infrequently observed. However, as already seen in the accentuation patterns (cf. section 5.1.4.1) differences between speakers emerged regarding the marking of givenness in post-focal position. While de-accentuation was the most common pattern in PC1, PC2 and PMS, accounting for at least 78% of all pitch patterns, the most frequent pattern to mark givenness used by PFAS was the downstepped pitch accent !H*L, followed by H*L. De-accentuation only occurred in 26% of all cases.

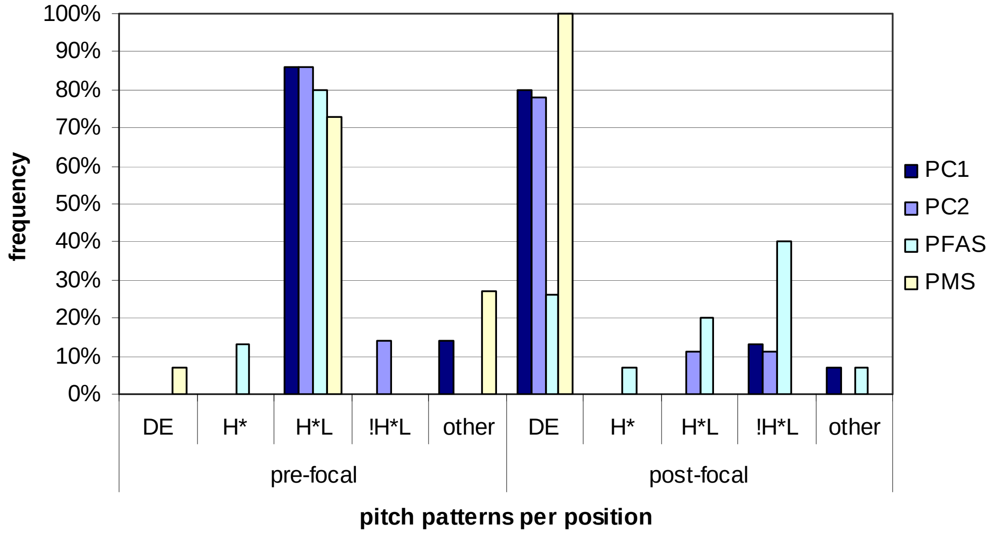


Figure 5.9: Type and frequency of pitch patterns for given referents in pre- and post-focal position in the SENT data set per speaker in % (category *other* includes: L*, L*H and L*HL)

**Unscripted data**

As outlined in section 5.1.4.1, most given referents in the PICT and MONO data sets were assigned a pitch accent by control speakers as well as clinical speakers (figure 5.10 and appendix E8). The control speakers de-accented given referents in about 20% (PICT) and 40% of all cases (MONO). The referents that were assigned a pitch accent were marked using H*L and !H*L. PMS used de-accentuation 33% (PICT) and 18% (MONO) of the time. In cases where he assigned pitch accents, he primarily used L*H and H*L. By contrast, no or hardly any de-accentuation of given referents was observed in speaker PFAS. Instead, pitch accents H*L and H* and, to a lesser degree, !H*L were employed to mark givenness.

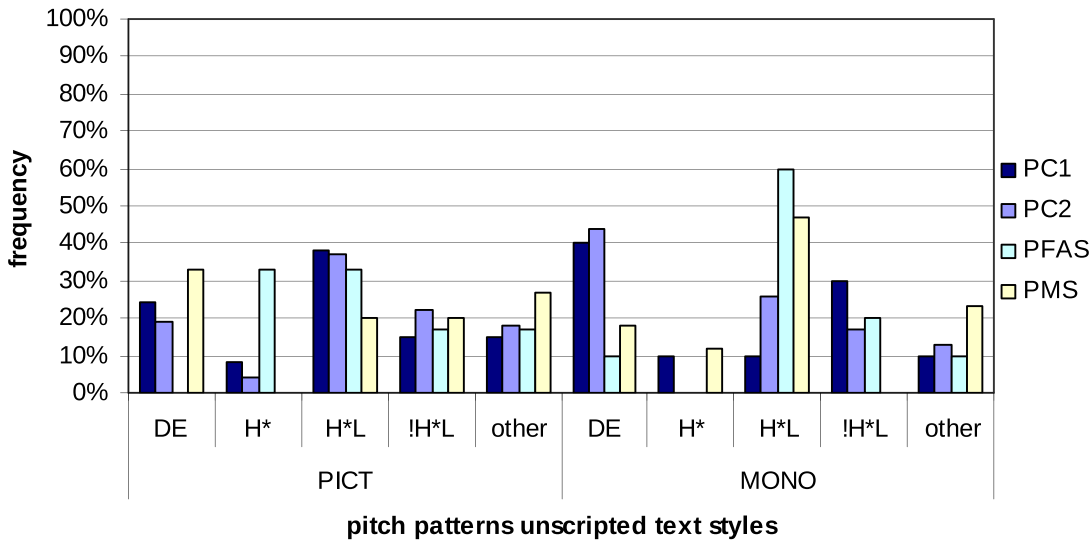


Figure 5.10: Type and frequency of pitch patterns for given referents per unscripted text style and speaker in % (category *other* includes: L*, L*H and L*HL)

In summary, the results regarding the marking of new and given referents across text styles indicate that PFAS generally used accentuation more frequently than the control speakers and PMS to mark given referents. Her strong preference for accenting also confirms findings from the analysis of the frequency of accentuation (cf. 5.1.3.1), which yielded a smaller pitch accent-syllable ratio for PFAS. At the same time it is important to note that, despite the relevance of de-accentuation for the signalling of given referents, the results revealed that only one of the four speakers - PMS - consistently de-accented given referents in post-focal position. This finding implies that although de-accentuation may represent the expected pattern to mark given referents in post-focal position, it is evidently not the only acceptable option.

### 5.1.5 Summary dimensions of intonation

The analysis of the *structural inventory* revealed that control speakers and clinical speakers have the same types of pitch accents and boundary tones at their disposal, whereby systematic differences were observed in relation to the different text styles. Whilst the PASS, PICT and MONO data sets yielded a similarly rich inventory, the presence of the structural elements in the SENT data set was less varied. This finding highlights the role text styles have in defining the make-up of a structural inventory.

The *distributional analysis* of the structural elements revealed that the clinical speakers, in particular PFAS, displayed a more frequent use of high boundary tones than the control speakers. The analysis of the distributional patterns further confirms that the use of pitch accents and boundary tones was more varied in the unscripted data sets than in the scripted sets. This finding implies that the distribution of structural elements may be partially determined by the type of text used to elicit speech.

The analysis of aspects of *phonetic implementation* showed that the average length of intonation phrases by PFAS was considerably shorter than that of the remaining speakers. At the same time, she produced the highest number of pitch accents overall. Differences between PFAS and the remaining speakers were further found in relation to the pausing pattern, where she produced more pauses than any of the other speakers.

The *functional* analysis of the intonation patterns in terms of information status revealed that the marking of new elements was comparable across speakers and text styles, whilst differences occurred in relation to the marking of given referents. In the scripted data set, de-accentuation was the preferred option for the control speakers and PMS, whereas in the unscripted data sets a tendency towards accentuation was observed. By contrast, PFAS generally used accentuation more frequently than the remaining speakers, indicating difficulties with the mechanism of de-accentuation. Whilst general tendencies regarding the use of de-accentuation were consistent across text styles, the results also showed that in order to assess the degree to which givenness is signalled using de-accentuation is strongly influenced by the nature of the text style, with scripted data appearing to be better suited to investigate de-accentuation than unscripted data sets.

## 5.2 Phonetic parameters

The following sections report the results of the analyses of the phonetic parameters *duration*, *intensity* and *F0* that sought to complement the descriptive information on the marking of linguistic function of intonation. Specifically, it was intended to examine whether the speaker with FAS was able to manipulate acoustic parameters to signal the information status of discourse referents. The results of the phonetic parameter analyses that were carried out on the sentence data set are presented in four sections. In section 5.2.1, the results for each of the three parameters are reported in terms of the difference in marking between new and given referents; section 5.2.2 describes the magnitude of difference between new and given information; section 5.2.3 concerns the pitch range within which new and given are marked; and section 5.2.4 reports the results of the post-focal F0 lowering analyses.

### 5.2.1 Difference between new and given referents

In order to establish whether there were differences in the marking of new and given discourse referents by means of phonetic parameters, a two-factor repeated measures ANOVA (givenness status x position) was conducted for each acoustic cue and participant. The results of the statistical examination are detailed below.

#### 5.2.1.1 Duration

Figure 5.11 provides an overview of the normalised mean duration values for new and given referents per speaker and sentence position. As can be seen from the figure, new referents in discourse generally appear to be longer than their given counterparts. Further detailed information on means and standard deviations (SD) is provided in appendix E9.

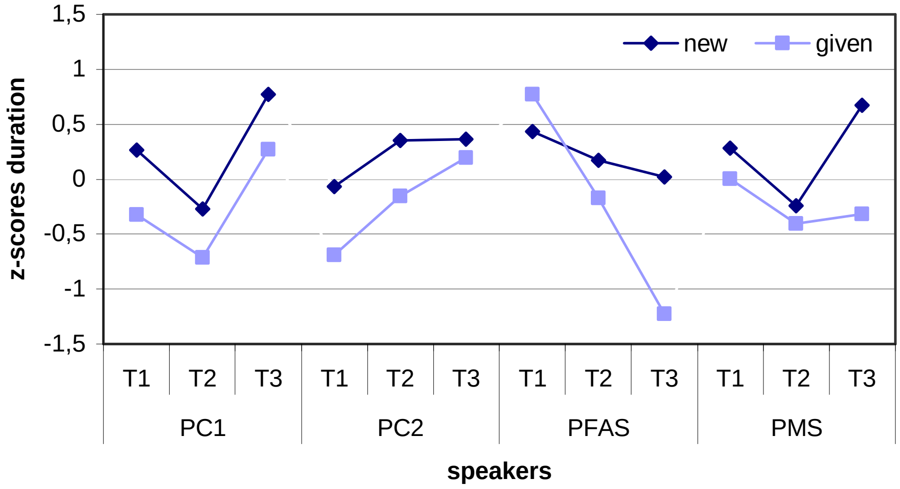


Figure 5.11: Normalised mean duration values per speaker and information status

Table 5.6 summarises the individual significance levels of main effects and interactions yielded for the parameter *duration*. For the control speakers a statistically significant main effect was found for *information status* (PC1: *F*(1)=13.486, p=0.005; PC2: *F*(1)= 5.195, p=0.049). The main effect for *sentence position* was not significant (PC1: *F*(1,271)=3.170, p=0.095; PC2: *F*(2)=1.485, p=0.254), nor was the interaction effect between information status and position (PC1: *F*(1,075)=0.074, p=0.809; PC2: *F*(2)=0.695, p=0.512). These results show that new discourse referents produced by the control speakers were significantly longer than given referents, regardless of the position they were in.

The statistical examination for PFAS yielded a significant main effect for *information status* (*F*(1)=13.876, p=0.005) and *sentence position* *F*(2)=8.187, p=0.003). Pairwise comparisons using Bonferroni for the latter factor revealed significant differences between initial and final sentence position (p=0.022) as well as medial and final position (p=0.026). In addition to the significant main effects, the two-way interaction between the factors *information status* and *position* turned out to be significant as well (*F*(2)=10.162, p=0.001). The significant interaction implies that the successful marking of information status differed as a function of sentence position. Specifically, whilst PFAS elongated new referents compared to given ones in medial and final position, the inverse pattern was observed in initial sentence position (cf. figure 5.11).

The test of within-subject effects for PMS revealed a significant main effect for *information status* ($F(1)=7.742$, $p=0.021$), but not for *sentence position* ($F(2)=0.937$, $p=0.339$). The interaction between both factors was significant ($F(2)=7.017$, $p=0.006$). These results indicate that PMS significantly elongated new referents compared to given referents, with differences between new and given increasing towards the end of the sentence.

| speaker | status | position | status*position |
|---|---|---|---|
| PC1 | p=0.005 | n.s. | n.s. |
| PC2 | p=0.049 | n.s. | n.s |
| PFAS | p=0.005 | p=0.003 | p=0.001 |
| PMS | p=0.021 | n.s. | p=0.006 |

Table 5.6: Summary of the ANOVA results of the parameter *duration* per speaker (n.s. = not significant)

### 5.2.1.2 Intensity

Figure 5.12 displays the normalised mean peak intensity values per speaker and information status. As can be seen from the figure, new discourse referents generally seem to be louder than the corresponding given referents. Detailed information on means and standard deviations (SD) is provided in appendix E9.

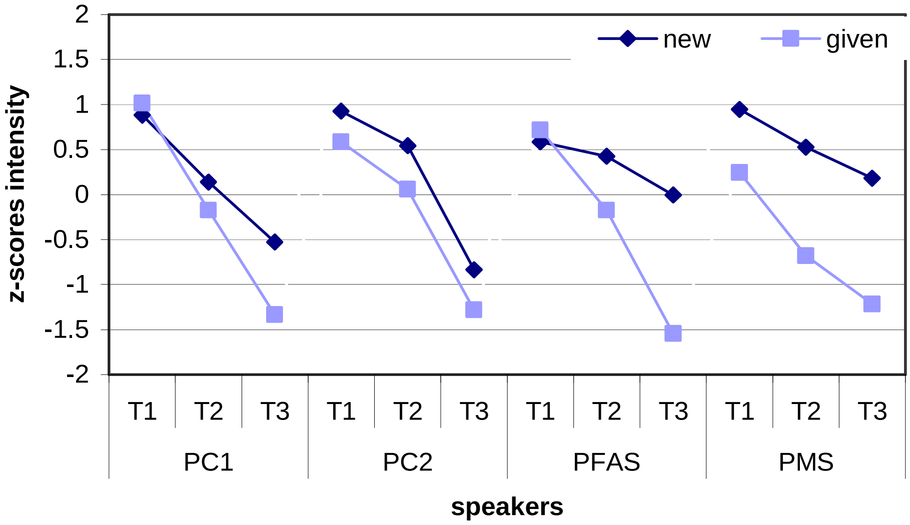


Figure 5.12: Normalised mean peak intensity values per speaker and information status

Table 5.7 provides a summary of the significant main effects and interactions for the parameter *intensity* per speaker. For the control speakers, a statistically significant main effect was found for *information status* (PC1: *F*(1)=11.028, p=0.009; PC2: *F*(1)=9.965, p=0.012) and *sentence position* (PC1: *F*(1.856)=28.494, p=0.000; PC2: *F*(2)=40.132, p=0.000). In PC1, pairwise comparisons using Bonferroni for the factor *sentence position* revealed significant differences between all sentence positions (initial-medial: p=0.008; initial-final: p=0.000; medial-final: p=0.009). For PC2, the pairwise comparisons yielded highly significant positional effects between initial and final position (p=0.000) and medial and final position (p=0.001). The two-way interaction between the independent factors was not significant for either of the control speakers (PC1: *F*(1.768)=3.622, p=0.055; PC2: *F*(2)=0.241, p=0.789). The results suggest that both control speakers differentiated between new and given referents, with new referents being produced significantly louder than given referents. The significant main effect for position implies that performances were influenced by the position of the referent within the sentence.

For PFAS statistically significant main effects were found for both factors, i.e. *information status* (*F*(1)=17.116, p=0.003) and *sentence position* (*F*(2)=14.881, p=0.000).

The pairwise comparisons for factor *position* revealed significant differences between initial and final position (p=0.002) as well as medial and final position (p=0.035). In addition to the significant main effects, the two-way interaction between both examined factors was highly significant ($F$(2)=23.719, p=0.000). The results suggest that PFAS by and large successfully differentiated between new and given referents by manipulating loudness levels. However, her performance was clearly influenced by the position of the target words. Whilst in initial position she did not employ intensity to distinguish between new and given referents, she did so in medial and final position with loudness differences between new and given referents increasing considerably towards the end of the sentence. That is, in PFAS the marking of information status differed as a function of sentence position.

The analysis of within-subject effects for PMS revealed highly significant main effects for *information status* ($F$(1)=63.353, p=0.000) and *sentence position* ($F$(2)=7.803, p=0.004). Pairwise comparisons of the factor *sentence position* showed that peak intensity only differed significantly between initial and final position (p=0.005). Similar to the control speakers, the two-way interaction between both independent factors was not significant ($F$(2)=2.204 p=0.139). The results suggest that PMS successfully differentiated between new and given referents with new referents being louder than given referents. The significant main effect for position further indicates that performances were influenced by the position of the referent within the sentence.

| **speaker** | **status** | **position** | **status*position** |
|---|---|---|---|
| PC1 | p=0.009 | p=0.000 | n.s. |
| PC2 | p=0.012 | p=0.000 | n.s. |
| PFAS | p=0.003 | p=0.000 | p=0.000 |
| PMS | p=0.000 | p=0.004 | n.s. |

Table 5.7: Summary of the ANOVA results of the parameter *intensity* per speaker (n.s. = not significant)

### 5.2.1.3 F0

Figure 5.13 shows the normalised mean F0 values per speaker and new and given referents in the different sentence positions. As can be seen from the figure, new referents generally appeared to be higher in pitch than given referents. Detailed information on means and standard deviations (SD) is provided in appendix E9.

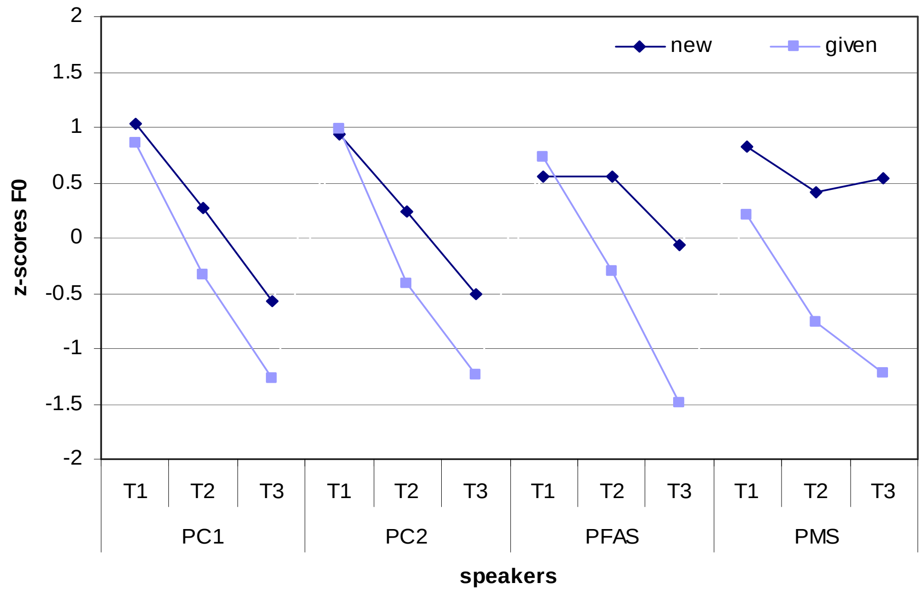


Figure 5.13: Normalised mean F0 values per speaker and information status

Table 5.8 summarises the significant main effects and interactions obtained as part of the within-speaker analyses of the parameter *F0*. For PC1, a statistically significant main effect was yielded for *information status* (*F*(1)=7.724, p=0.021; and *sentence position* (*F*(2)=60.767, p=0.000), whereas in PC2 only the main effect for *position* turned out to be significant (PC2: *F*(2)=49.495, p=0.000). For the variable *information status* only a trend towards the same pattern was observed (*F*(1)=4.728, p=0.058). Pairwise comparisons using Bonferroni for the factor *sentence position* revealed significant differences between all sentence positions for both control speakers (PC1: initial-medial: p=0.002; initial-final: p=0.000; medial-final: p=0.001; PC2: initial-medial: p=0.001; initial-final: p=0.000; medial-final: p=0.003). The two-way interaction between the independent factors was not significant for either of the two speakers (PC1: $F(2)=1.030$, p=0.377; PC2: $F(2)=2{,}793$, p=0.088). According to these results, PC1 successfully differentiated between new and given referents, with new referents being higher in pitch than given referents, whereas PC2 only showed a trend to do so. Performances were further influenced by the position of the referent within the sentence.

For PFAS, significant main effects were obtained for both factors, i.e. *information status* ($F(1)=12.412$, p=0.006) and *sentence position* ($F(2)=32.843$, p=0.000). The pairwise comparison for *position* showed significant differences between all three positions (initial-medial: p=0.042; initial-final: p=0.000; medial-final: p=0.002). In addition to the significant main effects, the interaction between both examined factors was significant as well ($F(2)=6.213$, p=0.009). These results suggest that PFAS in general distinguished between new and given referents by manipulating the parameter F0. However, the position of the target word within the sentence had a role in the successful signalling of information status. In initial position, given referents were on average higher than new referents. This pattern changed in medial and final position, with differences between new and given referents increasing considerably over the course of the sentence.

The analysis of the within-subject effects for PMS revealed significant main effects for *information status* ($F(1)=16.533$, p=0.003) and *sentence position* ($F(2)=12.105$, p=0.000). Pairwise comparison of factor *sentence position* using Bonferroni yielded significant results between initial and medial (p=0.002) and initial and final position (p=0.002). The two-way interaction between both factors was significant as well ($F(2)=8.634$ p=0.002). Overall, these results indicate that new referents were marked with higher F0 values than given referents. The significant main effect for position implies that performances were influenced by the position of the referent within the sentence.

| speaker | status | position | status*position |
|---|---|---|---|
| PC1 | p=0.021 | p=0.000 | n.s. |
| PC2 | n.s | p=0.000 | n.s. |
| PFAS | p=0.006 | p=0.000 | p=0.009 |
| PMS | P=0.003 | p=0.000 | p=0.002 |

Table 5.8: Summary of the ANOVA results of the parameter *F0* per speaker (n.s. = not significant)

Overall, the statistical analyses revealed that all four speakers by and large used the three parameters examined to differentiate between new and given referents. More precisely, new referents were significantly longer, louder and higher in pitch than given referents. At the same time, the analyses also revealed differences between speakers relating to position and interaction effects. Whilst the control speakers and PMS showed positional effects only for the parameters intensity and F0, PFAS did so across the board. She further consistently exhibited interaction effects, with effects taking the same form for each parameter. Specifically, in medial and final position new referents were longer, louder and higher in intensity, with differences between new and given increasing substantially towards the end of the sentence. However, in initial position the inverse pattern was observed, indicating particular difficulties in PFAS to properly adjust parameters at the beginning of sentences.

### 5.2.2 Magnitude of difference between new and given referents

This section reports the results of the percentage difference analyses, which were calculated for each parameter to quantify the difference between new and given versions of the same target word across sentence positions. Based on this, the performances of the matched speakers pairs, i.e. PC1 and PFAS and PC2 and PMS, were compared using a two-factor mixed design ANOVA (speaker x position).

Figure 5.14 summarises the percentage difference between new and given referents across utterances per parameter and speaker. An overview of the exact values per parameter, speaker and position is provided in appendix E10. In both control speakers, a trend was observed for duration to become less important as an indicator of information status towards the end of the sentence, as indicated by the decrease in percentage difference. Intensity and F0 were found to increase in relevance over the course of a sentence, reflected in the greater difference between new and given versions of a target word. By contrast, the performances of the clinical speakers show that all three parameters were of increasing importance towards the end of a sentence. That is, PFAS and PMS replicated the intensity and F0 patterns of the control speakers, but displayed the opposite pattern for duration.

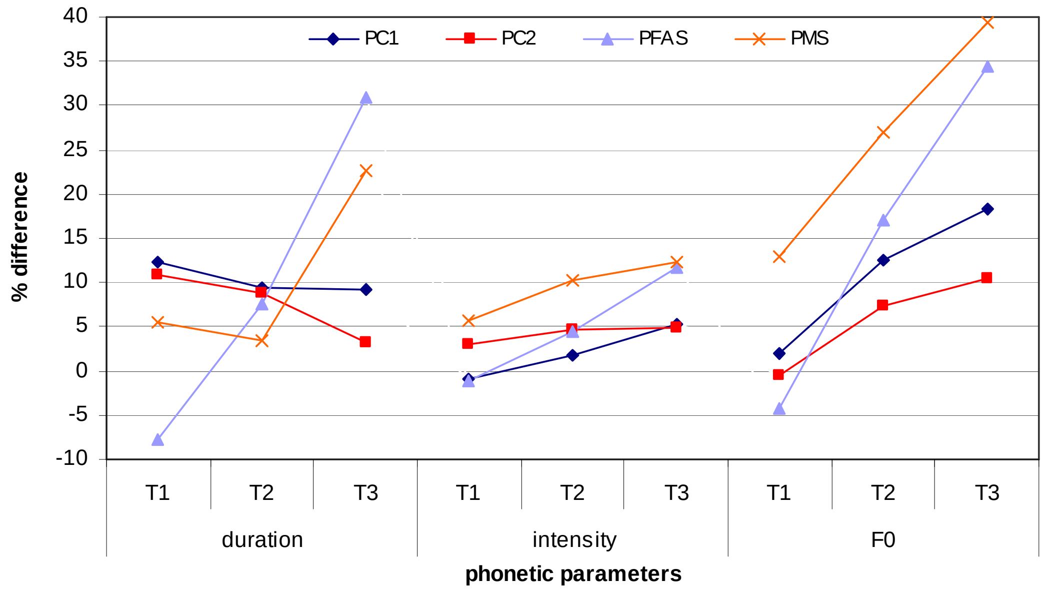


Figure 5.14: Percentage difference between new and given referents across utterances per parameter and speaker

The statistical examination of both speaker pairs yielded relatively heterogeneous patterns. For speakers PC1 and PFAS a significant main effect was found for *speaker* for intensity ($F(1)=5.450$, p=0.048), but not for duration or F0 ($F(1)=0.022$, p=0.990 and $F(1)=1.692$, p=0.230, respectively). This result suggests that for intensity percentage difference was significantly higher for PFAS than for PC1. The main effect for *sentence position* was significant for each parameter (duration: $F(2)=9.246$, p=0.002; intensity: $F(2)=17.462$, p=0.000; F0: $F(2)=18.296$, p=0.000). Significant interaction effects between *speaker* and *position* were found for duration ($F(2)=12.601$, p=0.001), but not for intensity and F0 ($F(2)=2.152$, $p=0.149$ and $F(2)=3.061$ $p=0.075$, respectively).

The ANOVA results for PC2 and PMS showed a significant main effect for the variable *speaker* for intensity and F0 ($F(1)=7.181$, $p=0.028$ and $F(1)=25.977$, $p=0.001$, respectively) but not for duration ($F(1)=0.302$, $p=0.598$). This finding indicates that for intensity and F0, PMS showed a higher percentage difference between new and given referents than the control speaker. The main effect for *sentence position* was only significant for F0 (F0: $F(2)=25.193$, $p=0.000$; duration: $F(2)=1.076$, $p=0.364$; intensity: $F(2)=2.782$, $p=0.092$), suggesting variation as to the degree of percentage difference across sentence positions. Significant interaction effects between both variables were found for duration and F0 ($F(2)=4.486$, $p=0.028$; $F(2)=4.248$, $p=0.033$, respectively), but not for intensity ($F(2)=0.802$, $p=0.466$).

### 5.2.3 Pitch range

In order to assess pitch range differences between matched speakers, independent samples t-tests were employed.

Figure 5.15 summarises the measures of *level* and *span* calculated per speaker. The four different markers for each speaker represent the mean values computed for each of the four conditions examined (cf. section 4.3.1). An overview of the exact values for each measure per speaker is provided in appendix E11. From figure 5.15 it can be seen that the speakers vary as to their height of voice, with the male speakers clustering at the lower end of the level continuum and the female speakers clustering at the higher end of the continuum. The statistical examination of *level* revealed significant differences between speakers of both pairs (PC1 and PFAS: $t(38)=2.972$, $p=0.005$; PC2 and PMS: $t(30.12)=2.542$, $p=0.016$), suggesting a lower voice for the clinical speakers. In terms of *span*, both clinical speakers showed higher values than their matched control speakers, indicating that they employed a wider linguistic pitch range than the control speakers. This was reflected in the statistical results, which were highly significant for both speaker pairs (PC1 and PFAS: $t(38)$=-4.844, p=0.000; PC2 and PMS: $t(38)$=-5.503, p=0.000). At the same time, span measures across conditions were more varied in both clinical speakers compared to the control speakers, whose results clustered together more narrowly, indicating a greater variation in the clinical group.

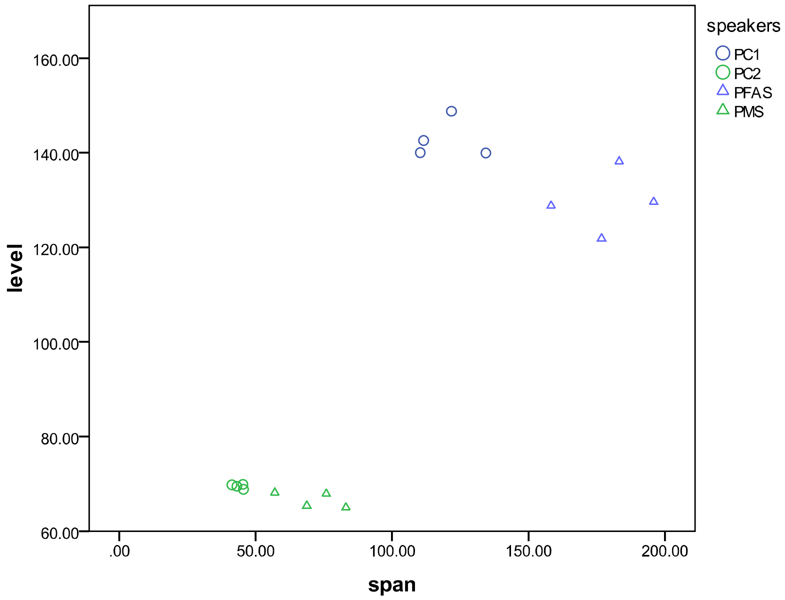


Figure 5.15: Mean level and span measures per speaker

### 5.2.4 Post-focal F0 lowering

The performances of the different speakers in terms of post-focal F0 lowering was analysed using Mann-Whitney U tests.

Figure 5.16 provides an overview of the individual pitch patterns with the position of the new referent varying from initial to medial and final sentence position. An overview of the means and standard deviations (SD) per speaker and measurement point can be found in appendix E12.

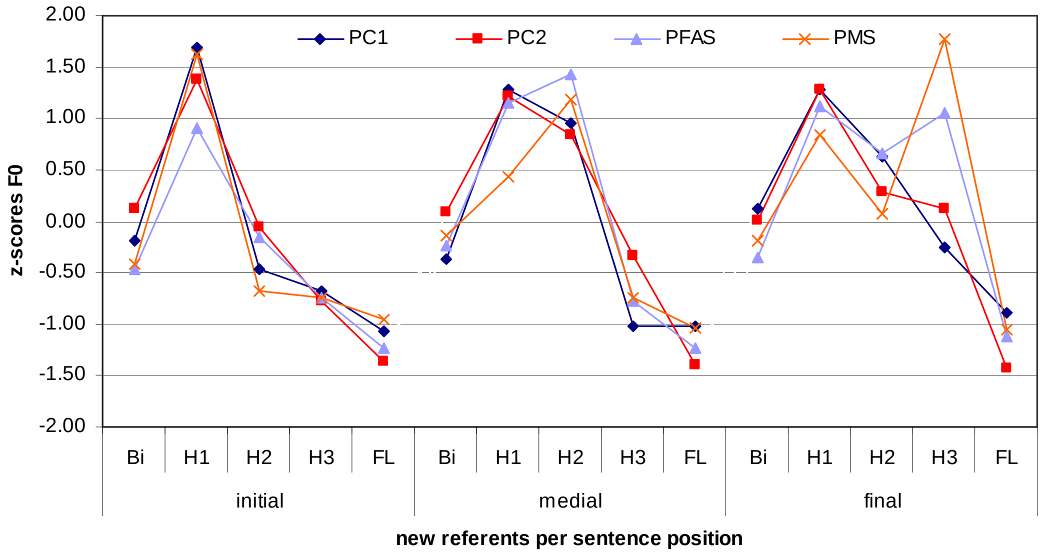


Figure 5.16: Normalised pitch patterns per speaker with referents in initial, medial and final sentence position

Table 5.9 complements the de-accentuation analyses, summarising the percentage change between the F0 maxima in relation the overall pitch span by speaker and position of the new referent. Given the de-accentuation constraint in post-focal position, the highest percentage fall was expected to occur between H1 and H2 - if the new referent was in initial position, between H2 and H3 - if the new referent was positioned medially, and between H3 and FL - if the new referent was elicited in final position.

| | **initial new** | | | **medial new** | | | **final new** | | |
|---|---|---|---|---|---|---|---|---|---|
| | **H1-H2** | **H2-H3** | **H3-FL** | **H1-H2** | **H2-H3** | **H3-FL** | **H1-H2** | **H2-H3** | **H3-FL** |
| **PC1** | 76.3 | 7.8 | 15.9 | 13.2 | 85.2 | 0.4 | 31.8 | 32.7 | 27.1 |
| **PC2** | 50.7 | 27.0 | 22.3 | 18.5 | 36.6 | 39.2 | 35.1 | 3.6 | 61.3 |
| **PFAS** | 47.3 | 27.9 | 24.8 | -3.4 | 74.0 | 17.6 | 20.0 | -11.7 | 83.4 |
| **PMS** | 88.7 | 2.1 | 9.2 | -19.4 | 74.3 | 15.0 | 27.5 | -60.0 | 100.0 |

Table 5.9: Percentage change between F0 maxima in relation to overall pitch range per speaker and condition (negative value indicates a rise)

The analyses of the speakers' performances showed that in initial and medial position the F0 peak of the new element was followed by a substantial lowering of the following F0 peak, suggesting successful de-accentuation. However, the extent to which F0 was lowered differed between speakers and within matched speaker pairs. Statistical comparison for PC1 and PFAS revealed a significant difference for initial position (U=2.00, p=0.028), but not for medial position (U=9.00, p=0.465). More precisely, in initial position PC1's percentage change was significantly greater than that of PFAS[21], whereas in medial position performances were comparable. The further statistical analysis of the percentage change from H3 to FL for new referents in final position turned out to be significant as well (U=0.00, p=0.009), with PFAS displaying a significantly greater fall towards the final low than PC1. Altogether, the findings suggest that PFAS experienced difficulties in lowering F0 following new referents in sentence-initial position.

The analyses of the second speaker pair revealed a more homogeneous pattern with PMS consistently displaying a greater percentage change across positions than PC2 (initial: U=0.00, p=0.009; medial: U=3.00, p=0.047; U=0.00, p=0.005). This finding indicates that PMS lowered pitch after the post-focal element more significantly than PC2. Interestingly, in both clinical speakers - but in particular in PMS - F0 up-step towards the new referent in medial and final position was observed. This suggests that the excursion of the percentage fall towards the following element was magnified by increasing peak height in the first place.

In summary, the analyses of the phonetic parameters showed that speakers generally successfully manipulated the different parameters to differentiate between new and given referents in discourse, whereby new referents were longer, louder and higher in pitch than given referents. Regarding the performances of the clinical speakers, two important aspects are worth highlighting. Firstly, the acoustic

[21] In the preliminary study, the clinical speakers were directly compared with their matched control speakers. As a result of the pairwise analysis, significant results might be an artefact of the pairing. For instance, in terms of percentages, PC2 displayed a similar fall from H1 to H2 in sentence-initial position as PFAS. This, however, was not considered as PFAS was only compared to her matched control speaker. The implications of this pairwise comparison are important to consider when interpreting results.

analyses revealed strong positional effects in the performances of PFAS, with effective manipulation of parameters in medial and final position, i.e. towards the end of a sentence, but not in initial position. This tendency was also reflected in the de-accentuation patterns, where percentage changes in relation to overall pitch range were comparable to or significantly greater than those of the matched control speaker in medial and final position, but not in sentence-initial position. Secondly, for both clinical speakers percentage difference calculations revealed an increasing relevance of each parameter over the course of the sentence, whereas in the control speakers this tendency was observed only for intensity and F0. In addition, clinical and control speakers differed as to the degree of percentage increase, with clinical speakers generally showing a greater difference between new and given versions of a target word over the course of a sentence than the control speakers. Overall, clinical speakers did use acoustic cues to mark the information status of referents, although in PFAS the degree to which this was successful was strongly influenced by the position of the target word within the sentence.

## 5.3 Summary of findings and implications for main study

In the following section the performances of the clinical speakers are briefly summarised and compared to those of the healthy control speakers in terms of the dimensions of intonation and the phonetic parameters examined. Based on this, the extent to which the aims of the preliminary study have been accomplished is briefly assessed.

The analysis of the dimensions of intonation revealed similarities between control speakers and clinical speakers, but also highlighted differences - not only between both speaker groups, but also between the clinical speakers. Specifically, the inventorial analysis revealed that all four speakers had the same structural inventory at their disposal. Individual differences, however, were found in relation to the distribution, implementation and functional use of these structural elements.

The distributional analysis showed preferences for different types of pitch accents and boundary tones in the speakers. PFAS exhibited a clear tendency towards the use of high boundary tones, whereas PMS was found to have the highest percentage of rising and tritonal pitch accents of all speakers. Further differences were observed in relation to the implementation of pitch patterns. PFAS produced intonation phrases that were considerably shorter than those of the remaining speakers. She further produced more pitch accents and more pauses than any other speaker. By contrast, the phrasing and pitch accent realisation of PMS were comparable to those of the control speakers. The same picture was observed regarding the functional level of intonation. Whilst in PMS the function of intonation as a marker of information status was clearly unaffected, PFAS showed a strong tendency towards the accentuation of given referents - suggesting difficulties in implementing the de-accentuation constraint. This observation was partly corroborated by findings from the phonetic analyses. More precisely, in cases where the new referent was in sentence-initial position, the subsequent lowering of F0 was found to be less effective in PFAS than in the matched control speaker. The same pattern was observed for intensity and duration, with new referents being louder and longer in medial and final position, but not in initial position. Overall, these findings indicate that in PFAS the successful exploitation of phonetic cues to aid the marking of information status was substantially determined by the position of the target word within the sentence.

In general, the results showed that the selected test materials and text styles were appropriate to investigate intonation patterns in PFAS' speech as differences between her and healthy speakers could be captured. In addition, it was found that the type of text style appeared to have an influence on the classification of the intonational inventory, with unscripted data generally yielding a fuller variety of pitch accents and boundary tones than the scripted data sets. At the same time, the results revealed that the scripted materials seemed to be more appropriate to investigate the specific function of intonation, as de-accentuation patterns signalling givenness were most pronounced in the SENT data set. These findings suggest that both scripted and unscripted text styles have their advantages in assessing intonation patterns. Taking the relevance of different text styles regarding the description of intonation patterns into account, it was decided to employ the same methods of elicitation in the main study.

Apart from highlighting the importance of investigating different text styles, the results have also exposed a few minor issues with the current scripted test materials that required amendments in view to the main study (cf. section 4.3.5). Firstly, the analysis of the sentence set revealed that target words such as *Berlin* were produced with great inter- and intra-speaker variability in terms of word stress and were therefore replaced. Secondly, the exclusion of some of the sentences produced by the control speakers considerably reduced the number of sentences available for the investigation of information status. As a consequence, the number of sentences in the set was doubled to 40 in order to yield a more robust analysis basis. Thirdly, the reading passage turned out to be imbalanced in terms of the number of new and given referents. Although the passage allowed the researcher to investigate a fair amount of new referents, the analysis of givenness was restricted to a few referents. The reading passage was therefore substituted by a passage that was balanced in terms of the number of new and given referents. Fourthly, although the test materials effectively captured differences in the intonation realisation in PFAS, they were not designed to identify the underlying causes of the observed changes. For that reason, screening tests for dysarthria and apraxia of speech were included in the main study in an attempt to explore the underlying nature of intonation changes in FAS.

# 6 RESULTS OF THE MAIN STUDY

The previous chapter reported the results of the preliminary study. It was found that in terms of dimensions of intonation, PFAS presented with a retained structural inventory. Changes in its distribution and implementation, however, impacted on the successful marking of information status. In order to answer the question whether these findings may represent more global characteristics of intonation in FAS, the intonation patterns of a further three speakers with FAS and their respective matched control speakers were investigated in the main study. This chapter presents the results of these three case studies. The key sections of the chapter are equivalent to those of the preliminary study. That is, the results of the dimensions of intonation are presented first, including the description of inventory, distribution, phonetic implementation and function of intonation (6.1). This is followed by the presentation of the results of the phonetic parameter analyses (6.2). In section 6.3, the outcome of the screening tests are presented, which were conducted to assess the involvement of dysarthric and/or apractic features in the speech of the clinical participants.

For presentation purposes, the data of most of the analyses are conflated resulting in the examination of two speaker groups: the control group (MC) and the clinical group (MFAS). In cases where the performances across speakers differ considerably, individual variation is described as well.

## 6.1 Dimensions of intonation

In the following sections, the results of the analysis of the four dimensions of intonation are detailed for the participants of the main study. As in the preliminary study, the results of the different dimensions are presented in the order outlined below:

- Inventory of structural elements (6.1.1)
- Distribution of structural elements (6.1.2)
- Phonetic implementation (6.1.3)
- Function in relation to information status (6.1.4)

The results of the scripted data sets are usually reported first, followed by the unscripted data sets. The analysis of the dimensions of intonation was based on a total of 1584 pitch accents and 1802 boundary tones. For the analysis of the function of intonation, i.e. the marking of information status, 1159 target words were examined. The tables in appendix F1 detail information on the exact number of structural categories and target words included per speaker and text style.

### 6.1.1 Inventory of structural elements

This section reports the intonational inventory of the speakers in terms of pitch accents and boundary tones, whereby emphasis is on the presence of the structural categories. Information on the frequency distribution of the structural elements is provided in section 6.1.2.

#### 6.1.1.1 Pitch accents

**Scripted data**

Table 6.1 provides an overview of the pitch accents that were used in the scripted data sets. In both text styles, the pitch accents H*L, !H*L and H* were used by all speakers. The remaining pitch accents L*H, L*HL and L* were only used by some speakers. Whilst L*H and L*HL were found in both text styles and speaker groups, L* only featured in the inventory of two control speakers and only in the SENT data set.

Levenshtein distance measured for the scripted data revealed a mean distance of 1.56 between speaker groups. The distance calculated with each group was 0.67 for the speakers with FAS and 2 for the control speakers. The higher distance obtained for the control speakers suggests that they used the different pitch accents less consistently than the speakers with FAS.

| | SENT | | | | | | PASS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **H*L** | **!H*L** | **L*H** | **H*** | **L*** | **L*HL** | **H*L** | **!H*L** | **L*H** | **H*** | **L*** | **L*HL** |
| **MC1** | x | x | x | x | | | x | x | x | x | | |
| **MC2** | x | x | x | x | x | | x | x | | x | | x |
| **MC3** | x | x | | x | x | | x | x | | x | | |
| **MFAS1** | x | x | x | x | | | x | x | x | x | | |
| **MFAS2** | x | x | x | x | | x | x | x | x | x | | x |
| **MFAS3** | x | x | | x | | | x | x | x | x | | x |

Table 6.1: Inventory of pitch accents of scripted data sets per speaker (x indicates the presence of the respective pitch accent in the data set)

**Unscripted data**

The analysis of the pitch accent inventory of the unscripted data sets revealed that the same three pitch accents that were common to all speakers in the scripted data sets were also employed by all speakers in the unscripted data sets, i.e. H*L, !H*L and H* (cf. table 6.2). In addition to that, the pitch accent L* was used by all speakers in the PICT data set, resulting in four commonly used pitch accents for this text style. The remaining pitch accents L*H and L*HL also featured in both text styles. Whilst L*H was used by the clinical group in both data sets, its occurrence in the inventory of the control group was less consistent. Regarding L*HL, MFAS2 was found to be the only one using this pitch accent in the unscripted data sets.

The analysis of the unscripted data sets revealed a mean distance of 0.33 across groups, whereby the control speakers exhibited a distance of 0 and the speakers with FAS a distance of 0.67. This result shows that the inventories across speakers were more similar in the unscripted data sets than in the scripted data sets.

| | PICT | | | | | | MONO | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **H*L** | **!H*L** | **L*H** | **H*** | **L*** | **L*HL** | **H*L** | **!H*L** | **L*H** | **H*** | **L*** | **L*HL** |
| **MC1** | x | x | | x | x | | x | x | x | x | | |
| **MC2** | x | x | x | x | x | | x | x | | x | x | |
| **MC3** | x | x | x | x | x | | x | x | x | x | x | |
| **MFAS1** | x | x | x | x | x | | x | x | x | x | x | |
| **MFAS2** | x | x | x | x | x | x | x | x | x | x | | |
| **MFAS3** | x | x | x | x | x | | x | x | x | x | | |

Table 6.2: Inventory of pitch accents of unscripted data sets per speaker (x indicates the presence of the respective pitch accent in the data set)

### 6.1.1.2 Boundary tones

The inventorial analysis of the boundary tones across text styles revealed that all speakers employed the three different types of boundary tones available (cf. table 6.3). Restrictions were only found in MC2, who did not use the level boundary tone in the SENT data set.

Levenshtein distance measures revealed a distance of 0 for scripted as well as unscripted data indicating that both speaker groups employed the same boundary tones.

| | SENT | | | PASS | | | PICT | | | MONO | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **L** | **H** | **%** | **L** | **H** | **%** | **L** | **H** | **%** | **L** | **H** | **%** |
| **MC1** | x | x | x | x | x | x | x | x | x | x | x | x |
| **MC2** | x | x | | x | x | x | x | x | x | x | x | x |
| **MC3** | x | x | x | x | x | x | x | x | x | x | x | x |
| **MFAS1** | x | x | x | x | x | x | x | x | x | x | x | x |
| **MFAS2** | x | x | x | x | x | x | x | x | x | x | x | x |
| **MFAS3** | x | x | x | x | x | x | x | x | x | x | x | x |

Table 6.3: Inventory of boundary tones per text style and speaker (x indicates the presence of the respective boundary tone in the data set)

In summary, the results of the inventorial analysis of the different text styles revealed a similarly rich inventory of pitch accents and boundary tones for both speaker groups, suggesting that control speakers and clinical speakers have the same structural elements at their disposal. As in the preliminary study, inventorial differences were observed in relation to the different text styles, with the unscripted data sets yielding a more varied inventory of pitch accents and boundary tones than the scripted sets. Regarding the pitch accent inventory, it was further noted that L*H seemed to be more common among the clinical group and the presence of L*HL could be mainly attributed to MFAS2. Despite this variation, the overall results suggest that the categorical inventories of both speaker groups are similarly rich - a result, which corroborates findings from the preliminary study.

### 6.1.2 Distribution of structural elements

This section reports the results of the distributional analysis of the structural inventory. As in previous sections, the frequency distribution of the pitch accents is described first, followed by that of the boundary tones. An overview of the individual performances in terms of pitch accents and boundary tones is provided in appendices F2 and F3.

#### 6.1.2.1 Pitch accents

**Scripted data**

Figure 6.1 presents the frequency distribution of pitch accents used in the scripted data sets per speaker group. In the SENT data set, H*L represented the most frequent pitch accent in both speaker groups. In the control group, it accounted for 63% of all realisations, followed by H* and !H*L. The remaining pitch accents L*H and L* were only marginally used. Within-group analysis revealed relatively homogeneous patterns. The only notable difference occurred in relation to the use of H*, which accounted for 40% of all realisations in MC1, whereas MC2 and MC3 employed this pitch accent only in 12% and 14% of all cases, respectively.

In the clinical group, H*L made up 57% of all pitch accent realisations. The second and third most commonly used pitch accents were H* and L*H, indicating differences between speaker groups in relation to the frequency of the rising pitch accent. Whilst L*H was hardly used by the control group, it accounted for 16% of all pitch accents in the clinical speakers. Analysis of individual speaker performances revealed that the higher use of L*H could be solely attributed to MFAS1, for whom L*H was the most frequent pitch accent of the SENT data set with 43%.

Pitch accent H*L was also the most common accent used by both speaker groups in the PASS data. However, whilst H*L accounted for 56% of all realisations by the control speakers, it only made up about 40% in the clinical group. Although the lower percentage obtained for the clinical group indicates a higher use of other pitch accents in this speaker group, the frequency distributions of the pitch accents remained the same as in the SENT data set. The higher frequency of L*H in the clinical group could again be associated with MFAS1, who showed a similarly high use of L*H (39%) as in the SENT data.

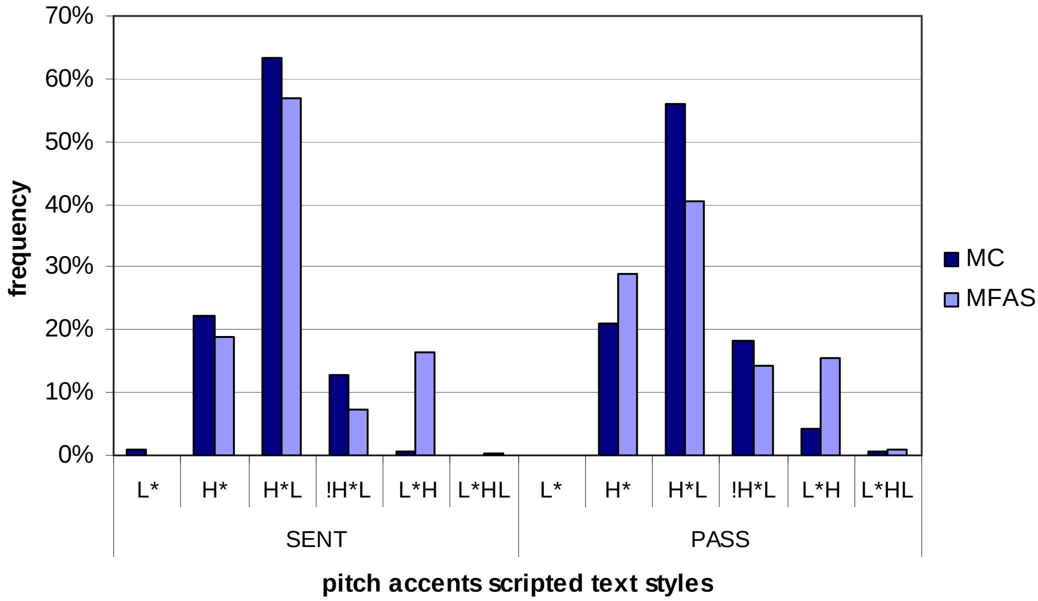


Figure 6.1: Distribution of pitch accents in the scripted data sets in %

**Unscripted data**

Figure 6.2 displays the frequency distribution of pitch accents used in the unscripted data sets per speaker group. In the PICT data, H*L constituted once again the most frequent pitch accent used by both speaker groups. In the control group, its use accounted for 55% of all pitch accents, followed by H* and !H*L. The remaining pitch accents L*H and L* were only marginally employed.

In the clinical group, the pitch accent H*L accounted for only 39% of all realisations. The overall difference of 16% to the control group mirrors patterns already seen in the PASS data set. The second and third most frequent pitch accents were L*H and H*, followed by a marginal use of !H*L, L* and L*HL, once again indicating clear differences in frequency between speaker groups in the use of pitch accent L*H. Different to the scripted text styles, MFAS1 was not the only speaker contributing to the higher use of L*H in this data set. MFAS3 also used this pitch accent in a quarter of all cases.

In the MONO data set, H*L remained the most commonly used pitch accent for both speaker groups, accounting for 37% and 31% of all pitch accents, respectively. That is, the difference between speaker groups observed before levelled off to 6%. The relatively low percentage obtained for H*L for both groups indicates that the remaining pitch accents were used more frequently, resulting in a more varied use of pitch accents in this data set. Overall, however, frequency distributions of pitch accents remained similar. In the control group, H*L was followed by !H*L, H*, L*H and L*.

In the clinical group, the $2^{nd}$ and $3^{rd}$ most frequent pitch accents were L*H and H*, followed by !H*L and L*. Within-group analysis showed that this time L*H was equally used by all clinical speakers.

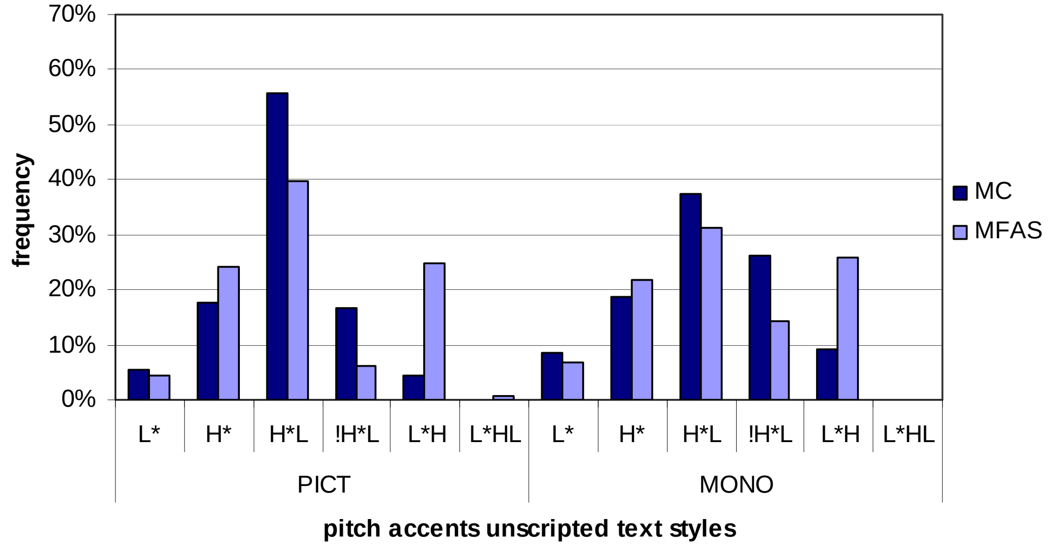


Figure 6.2: Distribution of pitch accents in the unscripted data sets in %

In summary, the analysis of frequency patterns of scripted and unscripted data sets revealed a number of similarities and differences across groups and text styles. Similarities were found in relation to the use of H*L, which constituted the most frequent pitch accent across groups and text styles. In addition, both speaker groups generally showed consistent frequency patterns across text styles. The most pronounced difference between groups involved the use of the rising pitch accent L*H, which was considerably higher in the clinical group. Whilst in the scripted data sets the higher use of L*H was solely attributed to MFAS1, all clinical speakers showed a tendency towards the use of L*H in the unscripted data set. The higher frequency of rises in the clinical participants confirms observations made in the preliminary study. A further difference concerned the overall variation of pitch accent use, with unscripted data inviting a more varied use of pitch patterns than the scripted data sets, particularly the SENT data set. This finding also supports observations already made in this regard in the preliminary study.

### 6.1.2.2 Boundary tones

**Scripted data**

The distributional analysis of the boundary tones revealed that in the SENT data set the most frequent tone to start an IP for both speaker groups was the low boundary tones %L (cf. figure 6.3 left). In IP-final position, control speakers equally used the level tone (%) and the low boundary tone L%, whereas in the clinical speakers the level tone clearly dominated. Frequency variation was further observed in relation to H%. Here, within-group analysis showed that only one of the three control speakers used the high boundary tone at all, whereas it was used by all three speakers with FAS.

In the PASS data, the control speakers equally used %L and %H to indicate IP-initial boundaries, whereas the clinical speakers preferred the use of low boundary tones (cf. figure 6.3 right). The most common tone to mark IP-final boundaries for both speaker groups was the level tone (%). Differences were again observed in relation to the use of H%. Control speakers used this tone only infrequently, but it constituted about a quarter of all boundary tones in the clinical speakers.

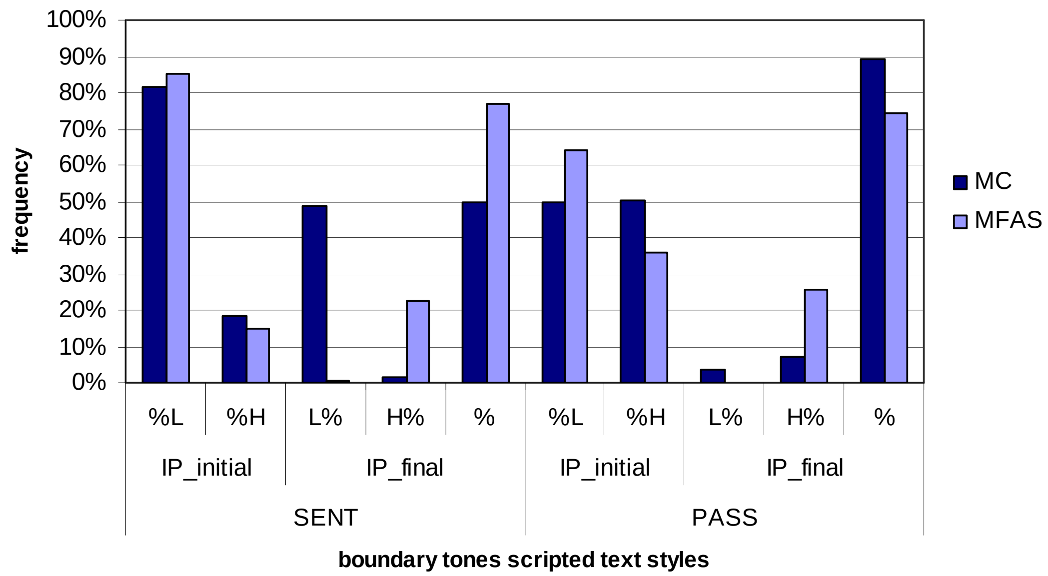


Figure 6.3: Distribution of boundary tones in the scripted data sets in IP-initial and -final position in %

**Unscripted data**

The distributional analysis of the boundary tones in the unscripted data sets revealed similar performances across positions and speaker groups (cf. figure 6.4). In phrase-initial position, the low boundary tone %L prevailed in both speaker groups, whereas in phrase-final position the level tone % was the most frequently used tone. One of the few differences in the frequency distribution was observed in relation to the use of high boundary tones. Whilst in the PICT data H% was more prevalent in the control group than in the clinical group, in the MONO data set the use of H% was more balanced, with both speakers groups using the boundary tone in around 20% of all cases.

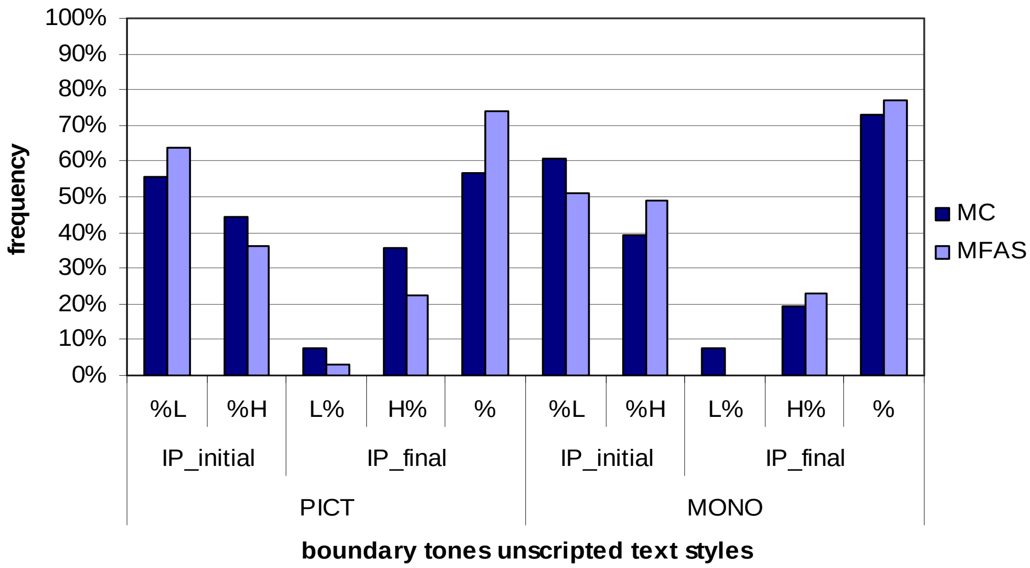


Figure 6.4: Distribution of boundary tones in the unscripted data sets in IP-initial and -final position in %

In summary, low and level boundary tones accounted for the majority of tones used across data sets, with low boundary tones being prevalent in initial position, and level tones demarcating boundaries in phrase-final position. Differences between speaker groups and text styles were mainly observed in relation to the use of H%. Specifically, whilst the use of this boundary tone was relatively constant for the clinical group, in the controls speakers H% was mostly associated with the unscripted data sets. In addition, similar to the frequency distribution of the pitch accents, unscripted data yielded a more varied use of different types of boundary tones than scripted data.

### 6.1.3 Phonetic implementation

The following subchapter provides information on the phonetic realisation. It is divided into three sections detailing the frequency of pitch accent realisation (6.1.3.1), the phrasing as well as pausing patterns (6.1.3.2 and 6.1.3.3).

#### 6.1.3.1 Frequency of accentuation

Table 6.4 displays the individual results and mean values of the pitch accent-syllable ratio calculated for each text style. As can be seen from the table, the control speakers produced on average about one pitch accent every four syllables. By contrast, the clinical group consistently showed a higher frequency of pitch accents across text styles. They produced on average one syllable less between pitch accents than the control speakers, thus mirroring results obtained for PFAS in the preliminary study. The only exception to this pattern was observed in the monologue task, where the difference between groups narrowed down to 0.3 syllables. In addition, the monologue constituted the only text style, where speaker performances between groups overlapped, implying a more frequent use of pitch accents in the control speakers, or more precisely MC1.

| | **SENT** | **PASS** | **PICT** | **MONO** | **mean** |
|---|---|---|---|---|---|
| **MC1** | 4.2 | 4.1 | 4.0 | 3.3 | 3.9 |
| **MC2** | 4.1 | 4.4 | 4.4 | 3.9 | 4.2 |
| **MC3** | 4.3 | 4.4 | 4.4 | 3.9 | 4.3 |
| **mean** | **4.2** | **4.3** | **4.3** | **3.7** | **4.2** |
| **MFAS1** | 2.8 | 3.5 | 3.5 | 3.6 | 3.3 |
| **MFAS2** | 3.4 | 3.5 | 3.3 | 3.8 | 3.5 |
| **MFAS3** | 3.5 | 3.6 | 3.4 | 3.3 | 3.5 |
| **mean** | **3.2** | **3.5** | **3.4** | **3.4** | **3.4** |

Table 6.4: Pitch accent-syllable-ratio per text style and speaker

### 6.1.3.2 Phrasing

Table 6.5 provides an overview of the mean length of intonation phrases per speaker and text style. It shows that the clinical speakers tended to divide their intonation phrases into smaller phrasing units than the control speakers, therefore confirming findings from the preliminary study. A detailed description of the performances in relation to the scripted and unscripted text styles sets is given in the following sections. The exact percentage values of the frequency patterns per speaker and text style are given in appendix F4.

| | SENT | PASS | PICT | MONO | mean |
|---|---|---|---|---|---|
| **MC1** | 9.7 | 6.6 | 5.4 | 4.6 | 6.6 |
| **MC2** | 9.0 | 7.7 | 6.1 | 6.1 | 7.2 |
| **MC3** | 9.8 | 7.1 | 7.3 | 6.1 | 7.6 |
| **mean** | **9.5** | **7.1** | **6.3** | **5.6** | **7.1** |
| **MFAS1** | 7.9 | 5.9 | 5.9 | 5.7 | 6.4 |
| **MFAS2** | 7.5 | 5.7 | 4.9 | 6.7 | 6.2 |
| **MFAS3** | 4.9 | 6.1 | 6.1 | 4.5 | 5.4 |
| **mean** | **6.8** | **5.9** | **5.3** | **5.4** | **5.9** |

Table 6.5: Mean IP length in syllables per text style and speaker

**Scripted data**

The analysis of the mean IP length revealed that in both scripted data sets the control speakers had a higher mean length of phrases than the clinical speakers (cf. table 6.5). The difference between groups was more pronounced in the SENT data set with 2.7 syllables than in the PASS data, where it only amounted to 1.2 syllables. However, individual speaker analyses also showed considerable variation as to the mean length of intonation phrases. For instance, in the SENT data set, MFAS3 produced intonation phrases that were about half the length of those of the control speakers, whereas the mean IP length of the remaining two clinical speakers, MFAS1 and MFAS2, was only about one third shorter than that of the control speakers.

The analysis further revealed that in the SENT data set 93% of the sentences produced by the control speakers were realised as one IP; the remaining 7% consisted of two IPs. A more heterogeneous phrasing pattern was observed for the clinical group, where sentences consisted of up to four intonation phrases. The majority of sentences was realised as one IP (57%), a further 29% consisted of two intonation phrases, 13% of three phrases and 1% of four phrases. These results indicate a tendency for the speakers with FAS to divide sentences into smaller phrasing units. As a result of this tendency, phrases with a syllable length of six and higher, which represented the most frequent type of phrase length, were more frequently observed in the control speakers than in the clinical participants (cf. figure 6.5).

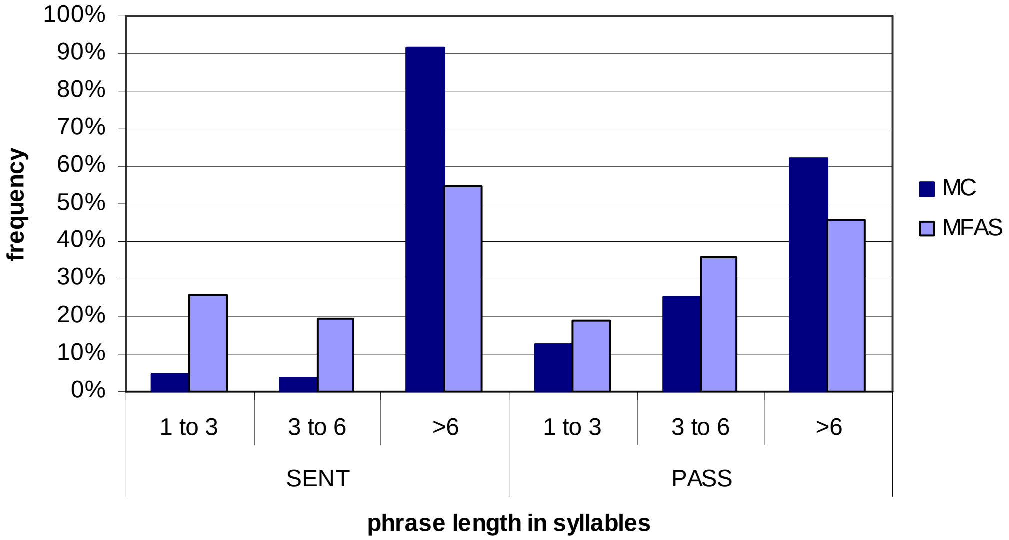


Figure 6.5: Phrase length in syllables for the scripted data sets in %

**Unscripted data**

The analysis of the mean phrase length in both unscripted data sets revealed a higher mean length of phrases for the control group than for the clinical group, consequently mirroring the tendency for shorter phrases already observed in the scripted data sets. However, whilst the difference in mean phrase length between speaker groups was one syllable in the PICT data set, it levelled off to only 0.2 syllables in the MONO data set (cf. table 6.5).

The subsequent analysis of the frequency patterns for the PICT data set showed a similar trend as observed in the PASS data set, with phrases longer than six syllables representing the most frequent phrase length in both speaker groups (cf. figure 6.6). In the MONO data set, however, there was a shift in both groups in the most frequent phrase length from phrases that were longer than six syllables towards phrases of four to six syllables.

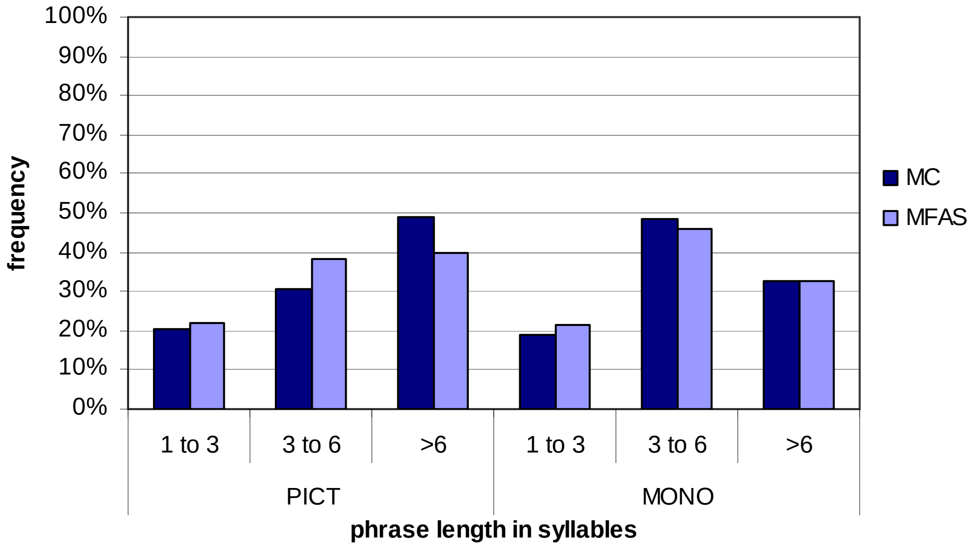


Figure 6.6: Phrase length in syllables for the unscripted data sets in %

In summary, the analysis of the phrasing patterns revealed that in both speaker groups scripted materials resulted in the elicitation of longer intonation phrases than unscripted materials. The comparison of group performances further showed that the clinical speakers consistently produced shorter phrases than the control speakers, whereby the difference in phrase length was more pronounced in the scripted data than in the unscripted data sets.

#### 6.1.3.3 Pausing

The pausing patterns of the SENT data set were assessed qualitatively in terms of *frequency* and *position* of pauses. As in the preliminary study, the analysis concentrated on the functional use of pauses in relation to the new referent within a sentence.

The analysis of the pausing patterns in the three conditions in question revealed that all three control speakers inserted pauses, albeit the extent to which this occurred differed. Whilst MC1 and MC2 produced pauses in 30% and 50% of the examined sentences respectively, MC3 only did so in 17% of the sentences. The comparison of the position of the pauses relative to the highlighted element revealed that 73% (MC1), 88% (MC2) and 100% (MC3) of the pauses were found in proximity of the new element. That is, in the control speakers the position of the pauses appeared to be related to the position of the new element in the sentence, therefore confirming observations made in the preliminary study.

The analysis of the pausing pattern of the clinical group revealed an overall higher use of pauses across conditions compared to the control group. MFAS1 and MFAS2 produced pauses in about half of the examined sentences (50% and 53%, respectively); MFAS3 did so in 73% of all sentences. The relationship between pause placement and position of new information appeared to be less congruent. MFAS1 placed 48% of the pauses before or after new information, whereas MFAS2 did so for 65% of his pauses. However, this result could be an artifact of his preference for placing pauses after target word 2 which occurred in 60% of all cases. In MFAS3, 63% of the pauses were in proximity of the new information. Overall, the results of the clinical speakers show a lower coincidence between pause placement and position of the new element compared to the control speakers. This finding suggests that if pausing was employed as a cue to reinforce existing cues to structuring discourse, it was of less relevance to the clinical speakers than it was to the control speakers.

In summary, the findings of the pausing pattern analysis suggest considerable individual variation in both speaker groups as to the placement of pauses. Overall, however, the clinical speakers displayed a slightly higher tendency to insert pauses.

Despite the higher frequency of pauses in the clinical group, the relationship between pauses position and new element within a sentence appeared to be less clear cut than in the control group, reducing the likelihood of pauses being employed as an additional cue to discourse structuring.

### 6.1.4 Function of intonation

In the following three subsections, the use of pitch accents to mark the information status of referents is detailed. The first section focuses on the overall *accentuation* of new and given referents per data sets (6.1.4.1). This is followed by two sections reporting on the *type* and *frequency* of pitch accents used to indicate information status with results for new and given referents being reported separately (6.1.4.2 and 6.1.4.3). As in the preliminary study, the marking of given referents in the SENT data is reported in terms of pre- and post-focal position, whereas in the remaining text styles the general marking of given referents is covered.

#### 6.1.4.1 Accentuation patterns

**Scripted data**

The analysis of the accentuation patterns of the scripted data sets revealed that both speaker groups consistently assigned a pitch accent to new referents, therefore exhibiting parallel patterns. Clear differences between speaker groups, however, were found in relation to the marking of given referents. Control speakers accented given referents only in about 15% in the SENT data set and 31% of all cases in the PASS data, thus showing a clear preference for de-accentuation. By contrast, 89% (SENT) and 80% (PASS) of given referents produced by the clinical speakers were assigned a pitch accent. Individual speaker performances for the clinical group revealed that the accentuation rate of given referents was consistently above the 70% mark (cf. appendix F5), confirming a prevalence of accentuation similar to the one seen in PFAS in the preliminary study.

**Unscripted data**

The analysis of accentuation patterns in the unscripted data sets mirrored findings from the scripted data sets, showing that new referents were assigned a pitch accent by the control speakers in the majority of cases (94%), whereas the clinical speakers did so throughout (cf. appendix F5). The marking of given referents by both speaker groups was also dominated by accentuation. Here, control speakers exhibited an average accentuation rate of 61% and 63%, respectively, whilst the clinical group performed above the 90% mark.

Overall, these results reflect findings from the preliminary study in that the marking of given referents appears to be influenced by the text style used to elicit the data, with scripted data yielding a higher de-accentuation rate than unscripted data. In addition, the speakers with FAS consistently exhibited a higher accentuation rate for given referents than the control speakers.

### 6.1.4.2 Type and frequency of pitch accents to mark NEW referents

**Scripted data**

The subsequent analysis of type and frequency of pitch accents in the scripted data sets suggests a similar use of pitch accents to indicate new referents in discourse, with both speaker groups most frequently employing H*L (cf. figure 6.7 and appendix F6). The generally lower percentage obtained for the PASS data reflects a rise in the use of !H*L in this set. Remaining pitch accents were only marginally used.

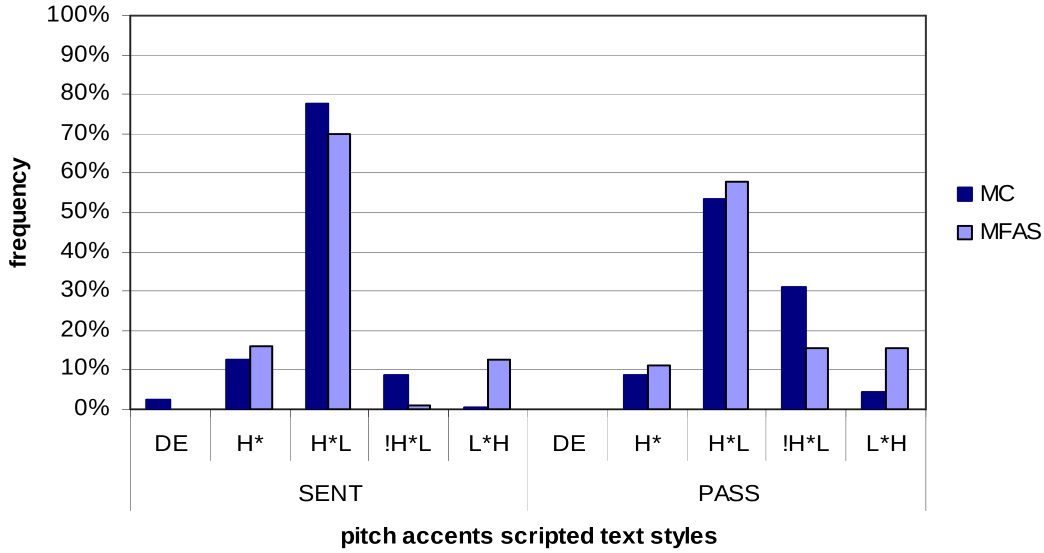


Figure 6.7: Type and frequency of pitch patterns for new referents per scripted text style in %

**Unscripted data**

The analysis of the unscripted data sets revealed changes in the use of pitch accents in the clinical group compared to the control group (cf. figure 6.8 and appendix F6). Whilst the control speakers still most frequently employed H*L to mark new referents in discourse, followed by !H*L and H*, the clinical speakers employed H*L and L*H equally often, reflecting individual preferences for certain pitch accents. The high percentage of rising pitch accents could be attributed to MFAS1 and MFAS3. In both speakers, L*H was the most frequent pitch accent employed to mark new discourse referents.

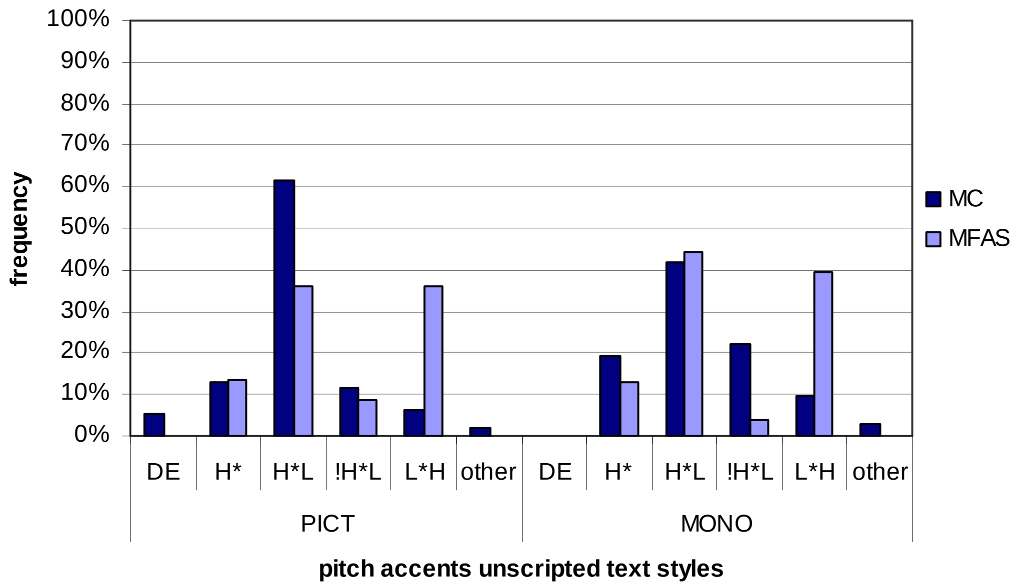


Figure 6.8: Type and frequency of pitch patterns for new referents per unscripted text style in % (category *other* includes: L* and L*HL)

### 6.1.4.3 Type and frequency of pitch accents to mark GIVEN referents

**Scripted data – SENT data**

The analysis of the marking of given referents in the SENT data set revealed that in pre-focal position both speaker groups employed H* and H*L to an equal extent (cf. figure 6.9 and appendix F7). The clinical group additionally employed L*H. The remaining pitch patterns were only marginally used. Clear differences between the groups as to the marking of given referents arose in post-focal position. Whilst in the control speakers de-accentuation dominated the picture with over 80% use, the most frequent pattern of the clinical speakers was the use of H*L with more than 50%, followed by !H*L. The expected de-accentuation pattern was only observed in about 11% of all realisations.

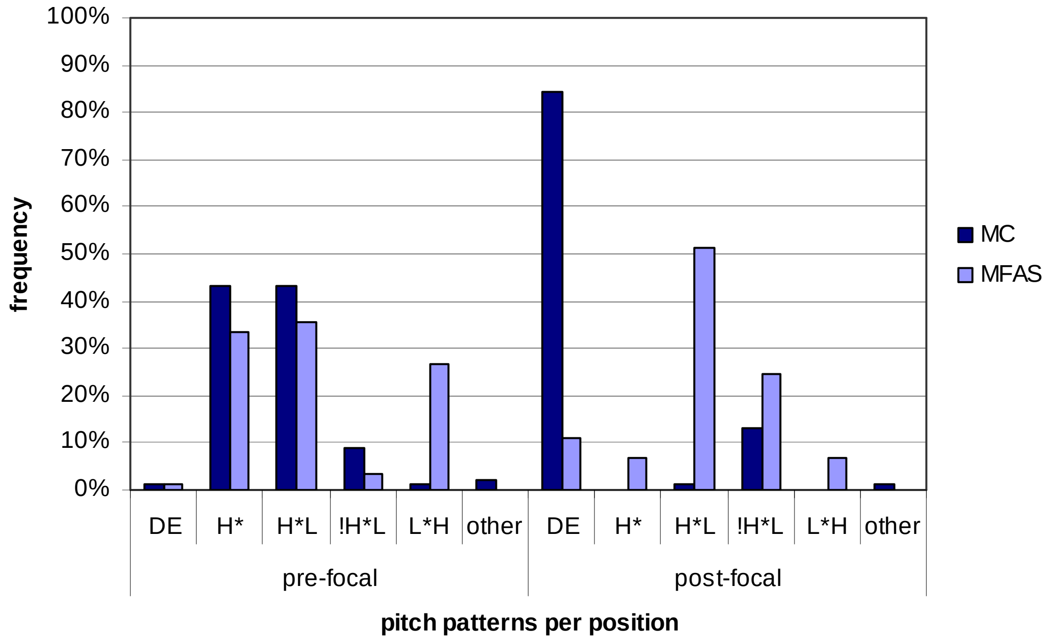


Figure 6.9: Type and frequency of pitch patterns for given referents in pre- and post-focal position in SENT data set in % (category *other* includes: L* and L*HL)

**Scripted data – PASS data**

The analysis of the PASS data set confirmed the strong preference in control speakers to de-accent given referents, as de-accentuation was the most prevalent pitch pattern with 69% of instances, followed by !H*L and H*L. The analysis further evidenced the prevalence of accentuation in the marking of given referents in the clinical speakers. Here, de-accentuation accounted for only 20% of all patterns, whereas !H*L and H*L were clearly more frequent (cf. figure 6.10 and appendix F7).

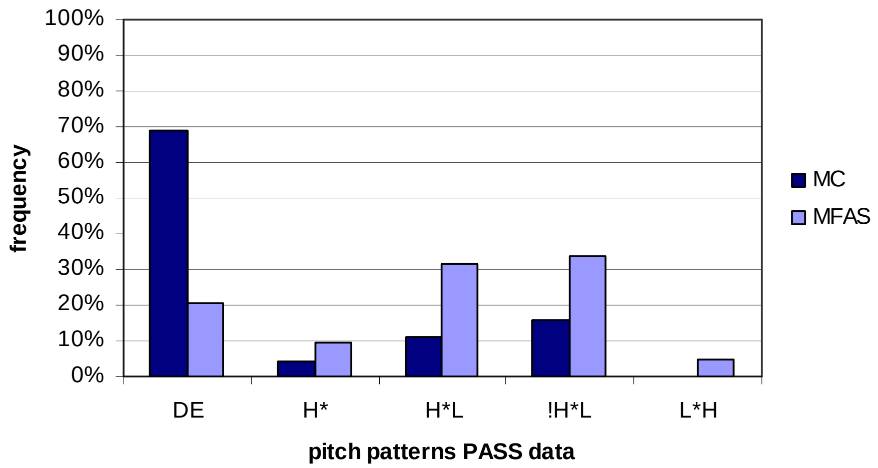


Figure 6.10: Type and frequency of pitch patterns for given referents in PASS data set in %

**Unscripted data**

In the unscripted data sets, the majority of referents were assigned a pitch accent by both speaker groups (cf. figure 6.11 and appendix F7). The control group de-accented close to 40% of the referents in both sets. Those referents that were assigned a pitch accent were marked by H*L, !H*L and H*. Specifically, H*L dominated the picture in the PICT data set, whilst the use of pitch accents in the MONO data set was more heterogeneous.

In the clinical group, de-accentuation accounted for less than 10% of all realisations of given referents, showing that it was absent or only occasionally observed. Instead, pitch accents H*L, L*H and H* were frequently used. H*L constituted the dominant pitch accent in the PICT set, whereas in the MONO data set H* was more frequent.

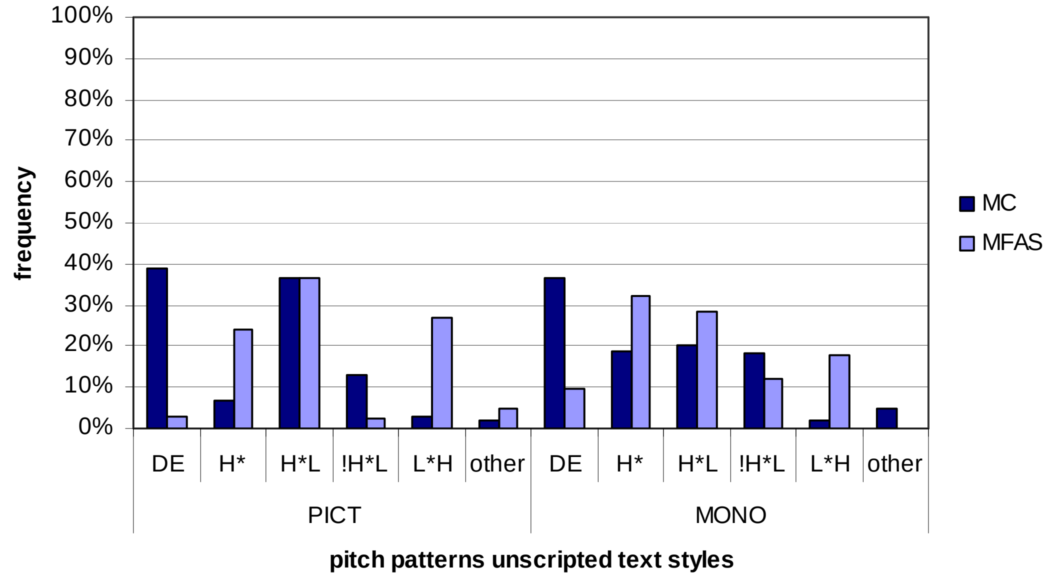


Figure 6.11: Type and frequency of pitch patterns for given referents per speaker and unscripted text style in % (category *other* includes: L* and L*HL)

In summary, the analysis of the functional use of intonation patterns across data sets can be summed up by two main points. Firstly, irrespective of the nature of the text style, speakers with FAS consistently showed a higher percentage of accentuation of given referents than the control speakers. Secondly, whilst in the clinical group the accentuation and de-accentuation patterns were relatively stable across text styles, the control speakers' patterns differed depending on the type of text style, with unscripted data triggering a higher percentage of accentuation of given referents than the scripted data sets. This shift away from de-accentuation towards accentuation confirms findings from the preliminary study.

### 6.1.5 Summary dimensions of intonation

The analysis of the *structural inventory* revealed a similarly rich inventory of pitch accents and boundary tones for control speakers and clinical speakers, with unscripted data sets yielding a more varied inventory than the scripted data set. The only notable difference between speaker groups related to the use of L*H, which appeared to be employed more widely across text styles by the clinical speakers than by the control speakers.

The subsequent *distributional analysis* of the structural elements revealed relatively consistent frequency patterns across text styles for both speaker groups, with H*L being the most frequent pitch accent and low and level tones accounting for the majority of boundary tones employed. In both speaker groups, the unscripted text styles triggered a more varied use of structural elements than the scripted text styles. Clear distributional differences between both speaker groups were observed regarding the use of L*H and H%. The former was produced much more frequently by the clinical speakers than by the control speakers, whereas the latter was relatively constant for the clinical group, but in the control speakers mostly associated with the unscripted data sets.

The analysis of the *phonetic implementation* showed performance differences between control and clinical speakers regarding the frequency of accentuation, the pausing and phrasing patterns. Specifically, the clinical speakers produced more pitch accents than the control speakers, they had a shorter mean length of phrases and a tendency to insert more pauses. Regarding the latter, it was further found that the pauses in the sentence set were not systematically employed as an indicator of information status.

The *functional* analysis in terms of the marking of information status by means of intonation also revealed clear differences between speaker groups. Whilst the clinical speakers mostly accented given elements in post-focal position, control speakers showed the expected de-accentuation patterns. Additionally, in the clinical speakers the accentuation rate of given referents remained relatively constant across text styles, whereas for the control speakers a shift towards accentuation was observed in the unscripted data. This shift highlights once again the role of the text style in the assessment of the dimensions of intonation.

## 6.2 Phonetic parameters

In the following sections, the results of the phonetic parameter analyses are detailed, which were conducted to complement the categorical information on the ability to mark information status in speakers with FAS. Just as in the preliminary study, the results are presented in four sections. In section 6.2.1, the results for the three parameters duration, intensity and F0 are described in terms of the difference in marking between new and given referents. In section 6.2.2, the magnitude of difference between new and given information is reported, whereas section 6.2.3 concerns the pitch range within which new and given information is marked. The final subsection 6.2.4 reports the results of the post-focal F0 lowering analyses.

### 6.2.1 Difference between new and given referents

In order to establish whether speakers with FAS employ acoustic cues to differentiate between new and given referents in discourse, a two-factor repeated measures ANOVA (givenness status x position) was conducted for each participant in relation to the three acoustic parameters examined, i.e. duration, intensity and F0. The results of the statistical analyses are presented in the following sections.

#### 6.2.1.1 Duration

Figure 6.12 displays the normalised mean duration values for new and given referents per sentence position. For demonstration purposes, the results of the control speakers are averaged across speakers, whilst the results of the clinical speakers are displayed individually. As can be seen from the figure, new discourse referents generally appear to be longer than their given counterparts, confirming results from the preliminary study. Detailed information on means and standard deviations (SD) is provided in appendix F8.

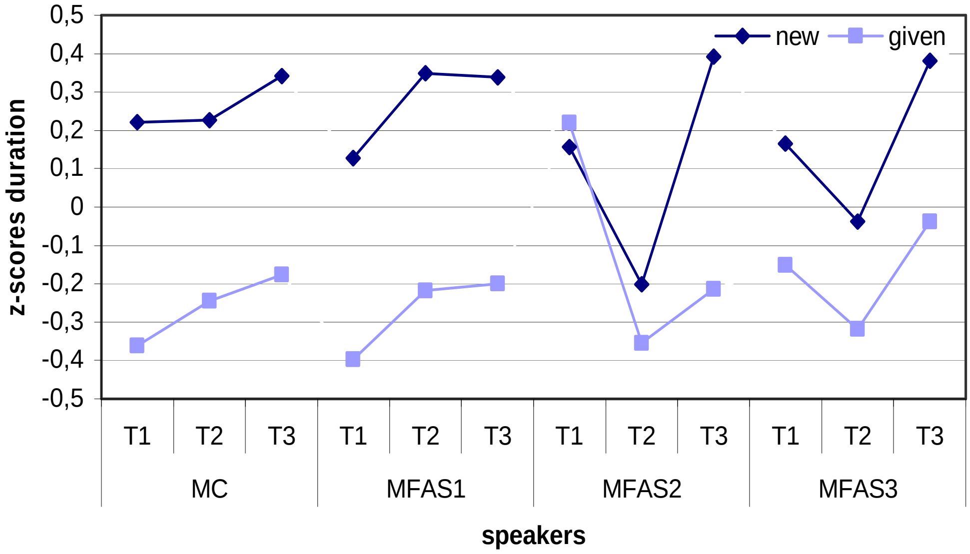


Figure 6.12: Normalised mean duration values for the control group (MC) and the individual clinical speakers (MFAS1-3) per information status and position

Table 6.6 summarises the individual significance levels of the main effects and interactions obtained for the *durational* parameter. For the control speakers, a statistically highly significant main effect was yielded for *information status* (MC1: $F(1)=13.688$, p=0.002; MC2: $F(1)= 65.236$, p=0.000; MC3: $F(1)= 71.541$, p=0.000). The main effect for *sentence position* was not significant (MC1: $F(2)=0.552$, p=0.580; MC2: $F(2)=0.244$, p=0.785; MC3: $F(2)=0.060$, p=0.942) neither was the interaction effect between both variables (MC1: $F(2)=0.394$, p=0.677; MC2: $F(2)=0.332$, p=0.719; MC3: $F(2)=1.527$, p=0.230). The results suggest that control speakers significantly elongated new referents in discourse compared to given referents, irrespective of their position within the sentence.

The statistical examination of the performances of the clinical speakers revealed a more heterogeneous pattern. MFAS1 and MFAS3 mirrored results of the control speakers, showing a highly significant main effect for *information status* (MFAS1: $F(1)=21.604$, p=0.000; MFAS3: $F(1)=12.229$, p=0.002), but not for *sentence position* (MFAS1: $F(2)=0.327$, p=0.723; MFAS3: $F(1.498)=0.561$, p=0.528) or the interaction between both variables (MFAS1: $F(2)=0.014$, p=0.986; MFAS3: $F(2)=0.300$, p=0.742).

By contrast, none of the main effects for MFAS2 turned out to be significant (*information status*: $F(1)=3.208$, p=0.089; *position*: $F(1.409)=1.443$, p=0.250), whereas the interaction between both factors reached significance level ($F(2)=3.729$, p=0.033). These results suggest that MFAS1 and MFAS3 differentiated between new and given referents by significantly elongating new discourse referents, whereas MFAS2 experienced difficulties to do so using durational cues.

| speaker | status | position | status*position |
|---|---|---|---|
| MC1 | p=0.002 | n.s. | n.s. |
| MC2 | p=0.000 | n.s. | n.s |
| MC3 | p=0.000 | n.s. | n.s |
| MFAS1 | p=0.000 | n.s | n.s. |
| MFAS2 | n.s. | n.s. | p=0.033 |
| MFAS3 | p=0.002 | n.s | n.s. |

Table 6.6: Summary of the ANOVA results of the parameter *duration* per speaker (n.s. = not significant)

### 6.2.1.2 Intensity

Figure 6.13 shows the normalised mean peak intensity values for new and given referents per sentence position. The results of the control group are averaged across speakers, whereas the results of the clinical speakers are displayed individually. As can be seen from the figure, new discourse referents generally seem to be louder than their given counterparts. Detailed information on means and standard deviations (SD) is given in appendix F8.

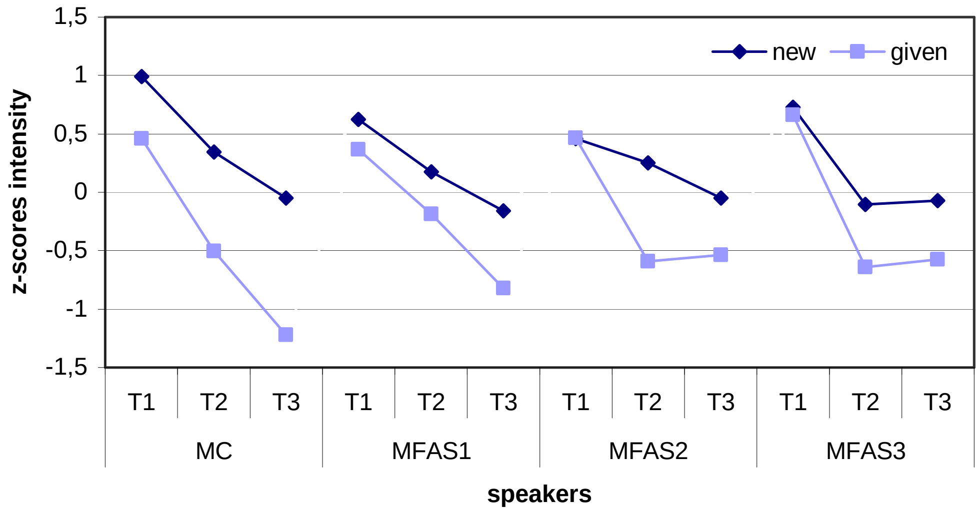


Figure 6.13: Normalised mean peak intensity values for the control group (MC) and the individual clinical speakers (MFAS1-3) per information status and position

Table 6.7 provides a summary of the individual significance levels of the main effects and interactions for the parameter *intensity*. The statistical examination of the results of the control speakers revealed highly significant main effects for variables *information status* (MC1: $F(1)=36.685$, p=0.000; MC2: $F(1)=114.673$, p=0.000; MC3: $F(1)=64.419$, p=0.000) and *sentence position* (MC1: $F(1.304)=10.596$, p=0.002; MC2: $F(2)=44.503$, p=0.000; MC3: $F(2)=101.969$, p=0.000). Pairwise comparisons using Bonferroni for the variable *sentence position* yielded significant differences between positions for each speaker. In MC1, differences reaching significance level were found between initial and medial position (p=0.047), as well as between initial and final position (p=0.000). In MC2 and MC3, highly significant differences between all three position were observed (MC2: initial-medial and initial-final: p=0.000, medial-final: p=0.001; MC3: p=0.000 each). In addition, the interaction between the variables *information status* and *position* was found to be significant in MC2 (MC2: $F(2)=15.825$, p=0.000), but not in MC1 and MC3 (MC1: $F(2)=2.560$, p=0.091; MC3: $F(2)=2.069$, p=0.140). These results indicate that the control speakers used intensity levels to differentiate between new and given referents, with new referents being produced significantly louder than given referents. The results further suggest sentence positional influences on performances.

For the clinical speakers, significant main effects were found for *information status* (MFAS1: $F(1)=12.341$, $p=0.002$; MFAS2: $F(1)=14.735$, $p=0.001$; MFAS3: $F(1)=4.856$, $p=0.040$) and *sentence position* (MFAS1: $F(2)=8.286$, $p=0.001$; MFAS2: $F(2)=6.476$, $p=0.004$; MFAS3: $F(2)=21.149$, $p=0.000$), consequently mirroring results of the control speakers. Pairwise comparisons for *sentence position* revealed significant differences between initial and final position for MFAS1 ($p=0.004$). For MFAS2 and MFAS3, positional effects were observed between initial and medial position (MFAS2: $p=0.011$; MFAS3: $p=0.000$) as well as initial and final position (MFAS2: $p=0.033$; MFAS3: $p=0.000$). For none of the clinical speakers the interaction between both variables turned out to be significant (MFAS1: $F(2)=1.354$, $p=0.270$; MFAS2: $F(2)=2.614$, $p=0.086$; MFAS3: $F(2)=1.469$, $p=0.243$). In summary, the clinical speakers - just as the control speakers - manipulated loudness levels to differentiate between new and given referents, with new referents being significantly louder than given referents.

| speaker | status | position | status*position |
|---|---|---|---|
| MC1 | p=0.000 | p=0.002 | n.s. |
| MC2 | p=0.000 | p=0.000 | p=0.000 |
| MC3 | p=0.000 | p=0.000 | n.s. |
| MFAS1 | p=0.002 | p=0.001 | n.s. |
| MFAS2 | p=0.001 | p=0.004 | n.s. |
| MFAS3 | p=0.040 | p=0.000 | n.s. |

Table 6.7: Summary of the ANOVA results of the parameter *intensity* per speaker (n.s. = not significant)

#### 6.2.1.3 F0

Figure 6.14 displays the normalised peak F0 values for new and given referents per sentence position. As with the other parameters, the results of the control group are averaged across speakers, whilst the performances of the clinical speakers are shown separately. As can be seen from the figure, speakers generally marked new referents with a higher pitch than given referents. Detailed speaker information on means and standard deviations (SD) is provided in appendix F8.

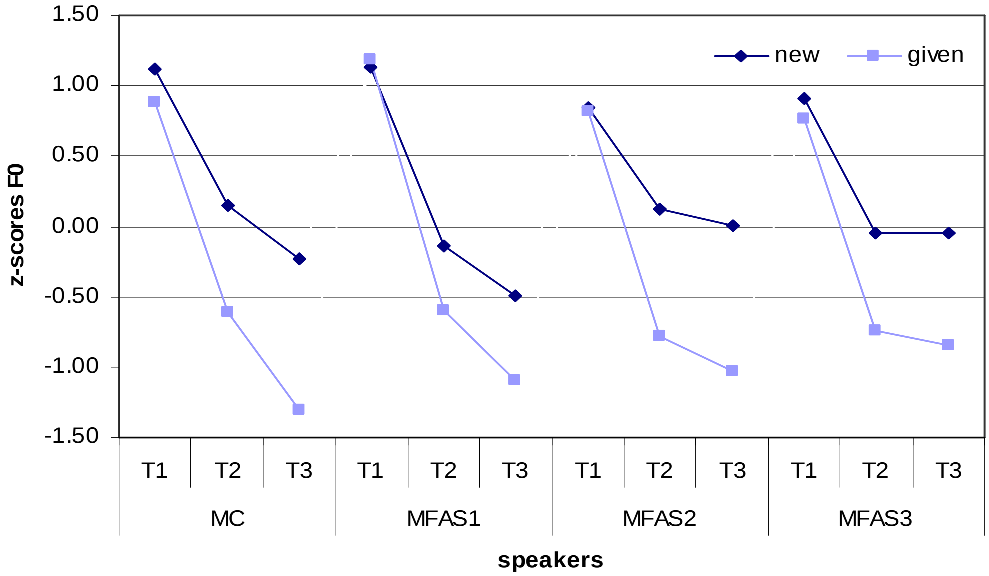


Figure 6.14: Normalised mean peak F0 values for the control group (MC) and the individual clinical speakers (MFAS 1-3) per information status and position

Table 6.8 provides a summary of the individual significance levels of the main effects and interactions for the parameter *F0*. The statistical examination of the results of the control speakers yielded significant main effects for *information status* (MC1: $F(1)=122.878$, p=0.000; MC2: $F(1)=50.820$, p=0.000; MC3: $F(1)=9.538$, p=0.006) and *sentence position* (MC1: $F(2)=213.152$, p=0.000; MC2: $F(2)=56.093$, p=0.000; MC3: $F(1.180)=210.156$, p=0.000). Pairwise comparisons for the variable *sentence position* revealed significant differences between all positions for each control speaker (MC1: p=0.000 each; MC2: initial-medial and initial-final: p=0.000, medial-final: p=0.024; MC3: p=0.000 each). Significant interaction effects between the variables *information status* and *sentence position* were also observed in all three speakers (MC1: $F(2)=11.627$, p=0.000; MC2: $F(2)=14.929$, p=0.000; MC3: $F(1.370)=4.810$, p=0.027). These results suggest that the control speakers successfully differentiated between new and given referents by manipulating F0 levels, with new referents being produced with a higher pitch than given referents. The results further indicate that the position of the referents within the sentence had a role in the marking of information status in that pitch height for new and given referents decreased steadily over the course of the sentence.

For the clinical participants highly significant main effects were observed for variables *information status* (MFAS1: $F(1)=11.899$, $p=0.003$; MFAS2: $F(1)=33.946$, $p=0.000$; MFAS3: $F(1)=20.219$, $p=0.000$) as well as *sentence position* (MFAS1: $F(2)=55.354$, $p=0.000$; MFAS2: $F(2)=37.294$, $p=0.000$; MFAS3: $F(2)=49.857$, $p=0.000$), thus showing the same statistical patterns as the control speakers. The subsequent examination of the factor *sentence position* revealed significant differences at the level of $p=0.000$ between initial and medial as well as initial and final position for all three clinical speakers. Importantly, none of the clinical speakers showed a significant difference between medial and final position, which was observed for all control speakers. Interaction effects between *information status* and *sentence position* were significant for MFAS1 and MFAS2, but not for MFAS3 (MFAS1: $F(2)=17.517$, $p=0.000$; MFAS2: $F(1.537)=7.702$, $p=0.004$; MFAS3: $F(2)=2.613$, $p=0.086$). These results suggest that the clinical speakers, similar to the control speakers, successfully differentiated between new and given discourse referents by means of pitch height. New referents were consistently higher in pitch than given referents. Findings further showed positional effects, with clinical speakers exhibiting a significant decrease in pitch height between initial and medial position, but not between medial and final position, as reflected in the results of the Bonferroni comparisons. That is, towards the end of a sentence, clinical speakers employed F0 to a lesser extent to mark givenness than did control speakers.

| speaker | status | position | status*position |
|---|---|---|---|
| MC1 | p=0.000 | p=0.000 | p=0.000 |
| MC2 | p=0.000 | p=0.000 | p=0.000 |
| MC3 | p=0.006 | p=0.000 | p=0.027 |
| MFAS1 | p=0.000 | p=0.000 | p=0.000 |
| MFAS2 | p=0.000 | p=0.000 | p=0.004 |
| MFAS3 | p=0.000 | p=0.000 | n.s. |

Table 6.8: Summary of the ANOVA results of the parameter *F0* per speaker (n.s. = not significant)

In summary, the analyses revealed that the control speakers used the three different parameters examined to mark the information status of referents. As in the preliminary study, new referents were significantly longer, louder and higher in pitch than given referents, with positional effects being observed for the parameters intensity and F0. Whilst MFAS1 and MFAS3 showed the same patterns, MFAS2 significantly manipulated intensity and F0, but did not succeed in doing so using the durational cue. Regarding the marking of givenness using F0 it was further noted that the clinical speakers employed F0 to a lesser degree towards the end of a sentence to mark givenness than the control speakers. This tendency is also reflected in the subsequent analysis of F0 lowering (cf. section 6.2.4).

### 6.2.2 Magnitude of difference between new and given referents

In this section, the results of the percentage difference analyses are presented, which were calculated for each parameter to quantify the difference between new and given versions of the same target word across sentence positions and speaker groups. The data of each parameter underwent statistical examination using a mixed design ANOVA (group x position).

In figure 6.15 the percentage difference between new and given referents across utterances per parameter and group are summarised. An overview of the exact values per parameter, group and position is provided in appendix F9. As can be seen from figure 6.15, the percentage difference for duration decreased gradually in the control group, indicating that duration as an indicator of information status became less important towards the end of the sentence. In contrast to that, intensity and F0 were found to increase in relevance over the course of the sentence, reflected in the increasing difference between new and given versions of a target word. The clinical speakers replicated the trends for intensity and F0, but showed the inverse pattern, i.e. an increase, for duration. That is, in the clinical speakers an increase of percentage differences were observed for all three parameters, suggesting that each of them were of growing importance towards the end of a sentence.

Individual speaker analyses, however, revealed differences between the performances, in particular in relation to the durational parameter. Specifically, MFAS1 displayed a decrease in percentage difference towards the end of a sentence, thus mirroring control speakers' performances. By contrast, MFAS2 and MFAS3 showed an increase across positions. However, whilst the increase in percentage difference by MFAS2 was close to 18%, the percentage difference by MFAS3 rose 1% only. In other words, the increase in the percentage difference found in the clinical group as a whole, could primarily be attributed to the performance of MFAS2. This finding indicates that, although the statistical examination suggested that MFAS2 struggled to differentiate between new and given referents in discourse using duration (cf. section 6.1.2.1), he appears to use the magnitude of difference instead, with the difference in length between new and given referents increasing considerably towards the end of the sentence.

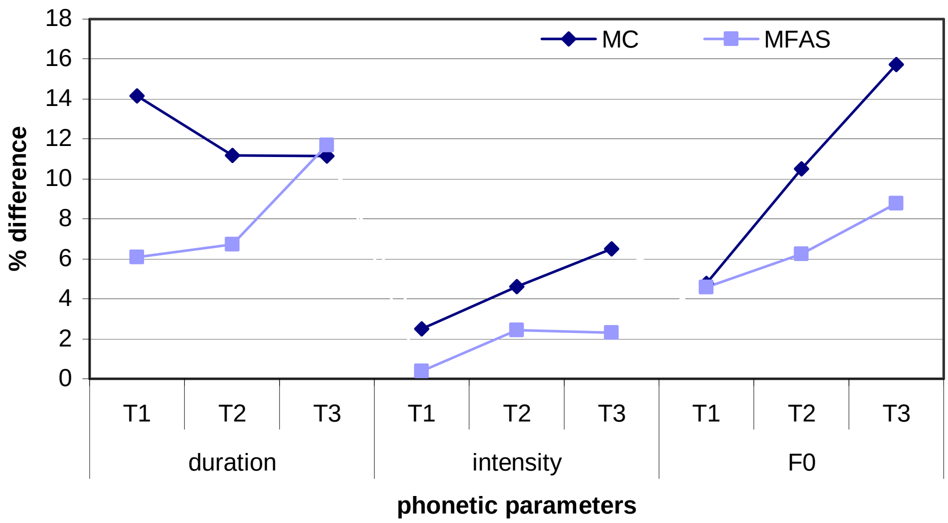


Figure 6.15: Percentage difference between new and given referents across utterances per parameter and speaker

The ANOVA results revealed a significant main effect for *group* for each of the parameters (duration: $F(1)=4.664$, $p=0.035$; intensity: $F(1)=24.440$, $p=0.000$; F0:

*F*(1)=6.051, p=0.017). This indicates that percentage differences across positions were consistently smaller in the speakers with FAS than in the control speakers. The main effect for position was significant for intensity and F0 (*F*(2)=13.179, p=0.000 and *F*(1.799)=31.568, p=0.000, respectively), but not for duration (*F*(2)=0.563, p=0.571), suggesting positional effects on the degree of percentage difference for intensity and F0. A significant interaction between the variables *group* and *position* were only observed for F0 (*F*(2)=6.401, p=0.002), but not for duration and intensity (*F*(2)=1.732, p=0.182; *F*(2)=1.973, p=0.144, respectively).

### 6.2.3 Pitch range

For the examination of group differences relating to pitch range, independent samples t-tests were employed.

Figure 6.16 provides an overview of the level and span measures per individual speaker and speaker group. The four measurement points displayed per speaker correspond to the mean values computed for each of the four conditions examined. Detailed information on means per measure, condition and speaker is provided in appendix F10. As can be seen from figure 6.16, speakers varied as to their height of F0 and range, with two specific patterns emerging. Firstly, the female participants (MC1 and MFAS1) clustered at the higher end of the *level* and *span* continua, whilst the male participants clustered at the lower end. Secondly, the clinical speakers consistently exhibited higher values for both measures than the control speakers, indicating a higher F0 and wider linguistic pitch range for clinical participants. The statistical examination confirms these observations, showing highly significant differences between speaker groups for *level* (*t*(222.804)=4.667, p=0.000) and *span* (*t*(203.855)=-4.718, p=0.000).

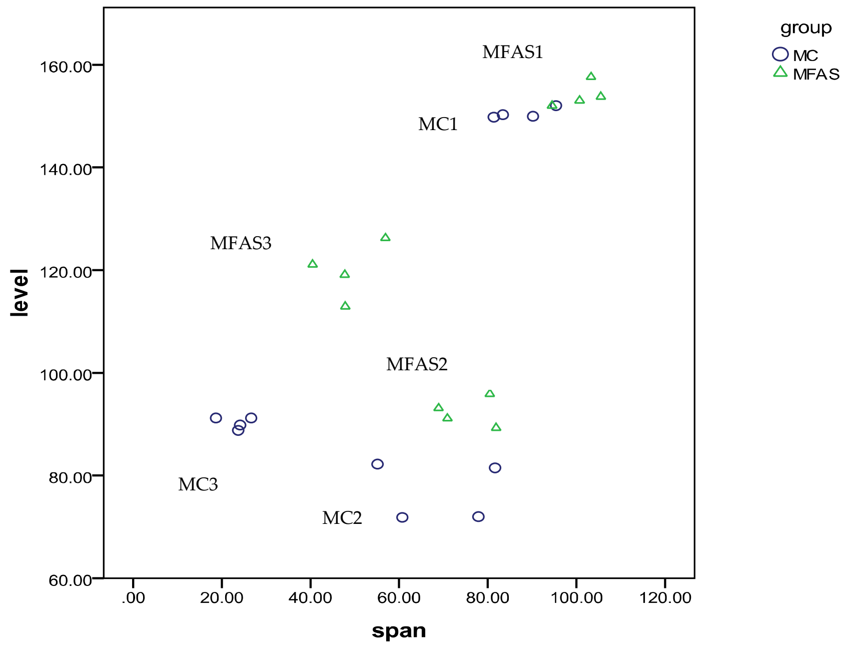


Figure 6.16: Mean level and span measures per group and speaker

### 6.2.4 Post-focal F0 lowering

The performances of the speaker groups in terms of post-focal F0 lowering was analysed using independent samples t-tests.

Figure 6.17 displays the normalised pitch patterns for each group with the position of the new referent varying from initial to final position. Detailed information on the means and standard deviations (SD) per speaker and measurement point is provided in appendix F11.

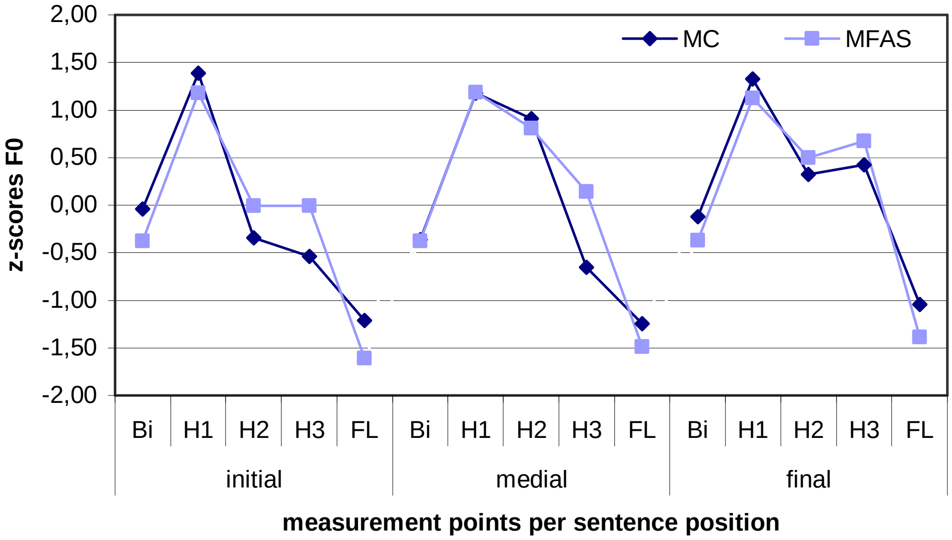


Figure 6.17: Normalised pitch patterns per speaker group with referents in initial, medial and final sentence position

Table 6.9 complements the analysis of the de-accentuation patterns, summarising the percentage change between the F0 maxima as well as the F0 maximum and the final low in relation to the overall pitch span per speaker group and condition. As outlined in the preliminary study, the highest percentage fall was expected to occur between H1 and H2, if the new referent was in initial position, between H2 and H3, if the new referent was positioned medially and between H3 and FL, if the new referent was elicited in final position.

| | **initial new** | | | **medial new** | | | **final new** | | |
|---|---|---|---|---|---|---|---|---|---|
| | **H1-H2** | **H2-H3** | **H3-FL** | **H1-H2** | **H2-H3** | **H3-FL** | **H1-H2** | **H2-H3** | **H3-FL** |
| **MC** | 67.3 | 6.6 | 26.1 | 10.5 | 59.6 | 23.5 | 40.6 | -4.1 | 62.0 |
| **MFAS** | 40.6 | 0.1 | 58.9 | 12.6 | 23.4 | 59.9 | 24.8 | -7.1 | 79.9 |

Table 6.9: Percentage change between F0 maxima in relation to overall pitch range per speaker group and condition (negative value indicates a rise)

The analysis of the F0 lowering patterns revealed that in initial position, the greatest percentage fall for the control speakers was observed between H1 and H2, whereas for the clinical speakers the greatest percentage change occurred between H3 and the final low. The difference between speaker groups in relation to the H1-H2 fall was highly significant ($t(58)=5.829$, p=0.000). That is, the control speakers lowered the pitch height on H2 more significantly than the clinical speakers, indicating that the latter group was less successful in using de-accentuation to mark given referents in post-focal position. This pattern was replicated in medial position, with differences in group performances reaching significance level ($t(58)=6.309$, p=0.000). The statistical results further yielded significant results in terms of percentage difference for the final sentence position ($t(58)=-3.512$, p=0.001). In this case, however, the percentage fall observed for the clinical speakers was more pronounced than that of the control speakers.

In summary, the results suggest that clinical speakers experienced difficulties to lower pitch height and thus to use de-accentuation as an indicator of post-focal givenness. Instead, they invariably realised the greatest percentage fall in sentence-final position.

Overall, the analyses of the phonetic parameters revealed that the speakers manipulated the different parameters to differentiate between new and given referents in discourse, with new referents generally being longer, louder and higher in pitch than given referents. The only exception to this pattern was observed in MFAS2, who did not employ the durational parameter in the same way as the other speakers. Although the clinical speakers were found to employ acoustic cues to differentiate between new and given referents, significant differences compared to the performance of the control speakers were also observed. Firstly, it was found that in the clinical speakers the magnitude of difference between new and given information was significantly smaller for each parameter. Secondly, the degree of F0 lowering was significantly smaller in the clinical speakers compared to the control speakers, indicating restrictions in the ability to lower pitch in post-focal position.

## 6.3 Results of the screening tests

This section reports the results of the screening tests that were conducted to assess the contribution of phonatory-respiratory as well as apractic problems to the speech patterns in FAS. The results of the phonation-respiration screening are presented in section 6.3.1, those of the apraxia of speech (AoS) screening in section 6.3.2.

### 6.3.1 Respiration-phonation screening

Table 6.10 provides an overview of the acoustic-phonetic and perceptual measurements along with the respective ratings each speaker achieved. For the control speakers, the results revealed appropriate breathing and phonation patterns, as well as appropriate volume and pitch levels. This is reflected in the overall rating ranging from 8.7 to 8.89 out of 9. Minor restrictions of the control speakers' performance were only occasionally observed. For instance, MC1 did not properly manage the stepwise increase of loudness; MC2 did not accomplish the full score for indicating questions and answers using pitch; and MC3 produced shorter duration times in some of the maximum performance tests.

The rating for the clinical speakers ranged from 6.15 to 7.49, reflecting restrictions in respiratory and phonatory support as well as in the ability to modulate volume and pitch. The extent to which difficulties were experienced differed across speakers, with MFAS2 performing slightly better than the remaining two speakers. Of the categories assessed, respiration and phonation appeared to be more compromised than intonation. Apart from the lack of efficient breath support, changes in voice quality were evident in all three speakers. They had noticeably more voice breaks and unvoiced stretches than the control speakers, with MFAS3 being particularly affected. This indicates that, at least in one of the speakers, laryngeal problems were present, in addition to the problems observed with respiration and phonation.

| | | CONTROL SPEAKERS | | | | | | CLINICAL SPEAKERS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | MC1 | | MC2 | | MC3 | | MFAS1 | | MFAS2 | | MFAS3 | |
| **RESPIRATION** | | | **RA** | | **RA** | | **RA** | | **RA** | | **RA** | | **RA** |
| at rest | | | 9 | | 9 | | 9 | | 9 | | 9 | | 9 |
| 1-20 N | no. pauses | 0 | 9 | 0 | 9 | 0 | 9 | 4 | 5 | N/A | N/A | 3 | 5 |
| 1-20 F | no. pauses | 0 | 9 | 0 | 9 | 0 | 9 | 3 | 5 | 1 | 7 | 0 | 6 |
| CONV | | | 9 | | 9 | | 9 | | 6 | | 7 | | 6 |
| RESP overall | | | 9 | | 9 | | 9 | | 6.25 | | 7.67 | | 6.5 |
| **PHONATION -** duration[1] | | | | | | | | | | | | | |
| /a/ | in s | 17.3 (1) | 9 | 23.8 (5) | 9 | 6.8 | 7 | 14.5 (1) | 7 | 19.8 (12) | 7 | 6.6 (11) | 5 |
| /s/ | in s | 17.3 | 9 | 26.8 | 9 | 13.8 | 7 | 8.3 | 5 | 13.6 | 7 | 6.6 | 5 |
| /z/ | in s | 15.2 (1) | 9 | 24.9 | 9 | 11.9 (1) | 7 | 8.6 | 5 | 23.9 (27) | 7 | 6.2* | 5 |
| s/z ratio | | 1.13 | | 1.07 | | 1.16 | | 0.97 | | 0.57 | | 1.06 | |
| **PHONATION** – loudness[2] | | | | | | | | | | | | | |
| 1-5 up | range dB | 6.5 (3.5) | 7 | 17.5 (5) | 9 | 15 (5) | 9 | 13.6 (3) | 6 | 18.3 (4) | 7 | 9 (3) | 6 |
| 1-5 down | range dB | 15.1 (5) | 9 | 27.7 (5) | 9 | 25 (5) | 9 | 17.1 (3.5) | 7 | 21.6(4.5) | 7 | 12.4 (3.5) | 7 |
| CONV | | | 9 | | 9 | | 9 | | 6 | | 7 | | 6 |
| PHON overall | | | 8.67 | | 9 | | 8 | | 6 | | 7 | | 5.67 |
| **INTONATION**[2] | | | | | | | | | | | | | |
| /a/ up | range Hz | 133.5 | 9 | 135 | 9 | 153 | 9 | 77.5 | 5 | 41.5 | 5 | 53 | 7 |
| 1-5 up | range Hz | 224 (5) | 9 | 212 (5) | 9 | 169 (5) | 9 | 45 (4) | 5 | 194 (5) | 9 | 72 (4) | 7 |
| 1-5 down | range Hz | 226 (5) | 9 | 215 (5) | 9 | 85 (5) | 9 | 198 (4.5) | 9 | 119.5 (5) | 9 | 62.5 (4) | 7 |
| Q/A | | 9/10 | 9 | 8/10 | 7 | 9/10 | 9 | 6/10 | 5 | 9/10 | 9 | 9/10 | 9 |
| CONV | | | 9 | | 9 | | 9 | | 7 | | 7 | | 7 |
| INTO overall | | | 9 | | 8.6 | | 9 | | 6.2 | | 7.8 | | 7.4 |
| RATING overall | | | **8.89** | | **8.87** | | **8.7** | | **6.15** | | **7.49** | | **6.52** |

Table 6.10: Results of the respiration-phonation screening with measurements and corresponding rating results (RA, Enderby 2008) per speaker ([1] voice breaks in brackets, [2] steps in brackets, *unvoiced)

In addition, speech rate measures including *speaking rate*, *articulation rate* and *pause time* relative to speaking time were conducted on the PASS, PICT and MONO data sets to obtain further information on articulatory agility and pausing behaviour. Table 6.11 displays the different measures calculated for speakers and speaker groups.

| | speaking rate | | | articulation rate | | | pause time | | |
|---|---|---|---|---|---|---|---|---|---|
| | **PASS** | **PICT** | **MONO** | **PASS** | **PICT** | **MONO** | **PASS** | **PICT** | **MONO** |
| **MC1** | 3.3 | 1.6 | 2.1 | 4.2 | 3.6 | 4.2 | 21.7 | 56.0 | 49.4 |
| **MC2** | 5.0 | 3.5 | 3.2 | 6.3 | 4.4 | 4.2 | 19.4 | 20.3 | 24.0 |
| **MC3** | 4.2 | 3.8 | 3.6 | 5.4 | 5.3 | 4.6 | 22.6 | 27.5 | 21.5 |
| **mean** | **4.2** | **3.0** | **3.0** | **5.3** | **4.4** | **4.3** | **21.2** | **34.6** | **31.7** |
| **MFAS1** | 2.1 | 2.1 | 2.1 | 2.8 | 3.4 | 3.6 | 25.6 | 39.2 | 40.7 |
| **MFAS2** | 2.6 | 3.1 | 3.2 | 3.4 | 3.9 | 4.3 | 24.5 | 21.5 | 26.1 |
| **MFAS3** | 2.3 | 2.2 | 2.2 | 3.2 | 3.4 | 3.4 | 27.9 | 35.1 | 35.3 |
| **mean** | **2.3** | **2.4** | **2.5** | **3.1** | **3.6** | **3.8** | **26.0** | **31.9** | **34.0** |

Table 6.11: Speaking rate, articulation rate (syllables per second) and pause time relative to speaking time (in %) per speaker and speaker group

As can be seen from the table, the control speakers exhibited a faster speaking rate and articulation rate than the clinical speakers irrespective of the type of text style examined. Differences between speaker groups were more pronounced in the PASS data than in the unscripted data sets. Within-group analyses further revealed that control speakers achieved the fastest rates in the reading passage, whilst speakers with FAS fared better in the unscripted data sets.

The analysis of the pause time ratio relative to speaking time revealed comparable performances between speaker groups. For both groups the percentage of pauses was lowest in the reading passage and rose in the unscripted data sets. The results of the unscripted data sets further revealed a high individual variability as to the overall pause time, confirming findings from the pausing analysis conducted as part of the phonetic implementation analysis (cf. 6.1.3.3), which also suggest that pausing is highly speaker-dependent.

Overall, the results of the speech rate measures showed that, compared to the control speakers, the clinical speakers spoke more slowly and had a reduced articulatory agility. The parallel patterns observed for articulation and speaking rate combined with the relatively comparable pausing times across speaker groups suggest that the reduced speaking rate in the clinical speakers may be a direct consequence of the reduced articulatory speed, reflecting difficulties in speech motor control.

### 6.3.2 AoS screening

Table 6.12 provides an overview of the AoS screening results of the clinical speakers.

| **SUBTESTS** | **SPEAKERS** | | |
|---|---|---|---|
| | **MFAS1** | **MFAS2** | **MFAS3** |
| **A INCREASING WORD LENGTH (max 60)** | | | |
| 1-syll average | 18 | 20 | 19 |
| 2-syll average | 19 | 19 | 18 |
| 3-syll average | 17 | 19 | 18 |
| Deterioration of performance score (1 syll – 3 syll) | 1 | 1 | 1 |
| Raw score | 1 | 1 | 1 |
| Classification (impairment) | none | none | none |
| **B REPEATED TEST TRIALS (max 30)** | | | |
| Raw score over 3 trials | 22 | 30 | 30 |
| Classification (impairment) | mild | none | none |
| **C INVENTORY OF ARTICULATION CHARACTERISTICS (max 15)** | | | |
| Features present | 4 | 2 | 3 |
| Classification (impairment) | none | none | none |

Table 6.12: Results of the apraxia of speech screening per subtest and clinical speaker

The analysis of *increasing word length* yielded a deterioration of performance score of 1 for each speaker. The resulting raw score of 1 indicates that performances were by and large not affected by increasing word length. Minor variability in the production of sounds included word-initial schwa insertions and occasional velarisation of fricative /h/in MFAS1; devoicing of initial consonants and replacing the velar nasal /ŋ/ by its alveolar counterpart in word-final position in MFAS2, and imprecise articulation (e.g. /f/ in hopefully) along with a voice that grew weaker over time in MFAS3.

The *repeated trials* test revealed some changes in vowel or consonant production over several trials in MFAS1, pointing to a mild impairment in that area. The variations observed included vocalic and consonantal changes, with vowel changes prevailing. None of the variations were phonemic in nature.

The examination of the presence of *articulation characteristics* specific to AoS showed that some features associated with AoS could be observed in the speech of each clinical participant[22]. However, the scores achieved in this subtest were too few in number to clearly establish the presence of AoS in the participants' speech. The features observed in the speech of MFAS1 included changes in voicing and vowel production. Furthermore, schwa-insertion was noted, which was restricted to word-initial position though, and was not observed between syllables or in consonant clusters. At times, MFAS1 further displayed difficulties to initiate speech. MFAS2 and MFAS3 also showed occasional non-phonemic voicing errors and vowel changes. Like MFAS1, MFAS3 struggled to initiate speech.

In summary, it is noteworthy that all speakers exhibited some form of infrequent consonantal or vocalic variation. However, the variations observed in FAS speech were too few to readily establish a clear presence of AoS features in the speech of the participants investigated here, as a mild impairment pointing towards the presence of speech apractic features in FAS speech was only observed in one of the speakers. Given the infrequent occurrence of AoS characteristics, but the fairly consistent presence of phonation-respiration issues, it stands to reason that the latter

[22] The presence of articulation characteristics was assessed using the speech that was elicited as part of the screening test as well as connected speech.

had a bigger impact on the overall speech performances of the individuals with FAS than any AoS feature.

## 6.4 Summary

The analyses of the four different dimensions of intonation revealed that clinical speakers of the main study have the same structural inventories at their disposal as the control speakers. At the same time, clear differences between speaker groups became evident in relation to the distribution and implementation of these structural categories, which ultimately impacted on the way information status was signalled in FAS speech. Specifically, it was found that de-accentuation as a marker of post-focal givenness was compromised in all three clinical speakers, reflected in a more frequent use of accentuation as well as a significantly decreased ability to lower pitch range in post-focal position. Despite the restrictions witnessed in terms of the suppression of post-focal pitch range, the phonetic analyses also revealed that the ability to manipulate parameters was to some extent retained, as speakers by and large successfully differentiated between new and given referents by means of phonetic parameters. More precisely, new referents were significantly longer, louder and higher in pitch than given referents, albeit individual analyses revealed that speakers exploit the different cues to different degrees, rendering the marking of information status highly speaker-dependent.

The following chapter will discuss the findings for both investigations, i.e. the preliminary study (chapter 5) and the main study (chapter 6), in relation to the research aims set out in chapter 3.

# 7 DISCUSSION

This chapter reviews the findings of the study in relation to the main objective posed in chapter 3. The overarching aim of the present study was to describe the dimensions of intonation in FAS speech within the autosegmental-metrical (AM) framework of intonational theory (Ladd, 1996) and to explore the intricate interplay of tonal representation, distribution, phonetic implementation and functional aspects of intonation. Regarding the latter, phonological and phonetic means of marking givenness were investigated to obtain information on how speakers with FAS employ the different encoding strategies. To this effect, the speech of four individuals with FAS was elicited using a variety of scripted and unscripted text styles and compared to the performances of gender-, age- and dialect-matched control participants.

The discussion chapter is divided into four sections. The first part (7.1) integrates and discusses the findings from the analysis of the different dimensions of intonation with reference to previous research, where possible. Based on this discussion, the second part of the chapter (7.2) draws conclusions as to the nature of intonation in FAS. It is discussed which levels of intonation may be preserved in FAS speech and which may be affected, in an attempt to precisely identify the level of intonation disturbance. As part of this section a model is suggested that, integrating the findings of the current study, summarises how intonation might be realised in FAS. In section 7.3, the findings of the thesis are further viewed in light of current explanations pertaining to the underlying nature of FAS, evaluating whether the present data support these explanations or not. The chapter concludes by outlining how the observed intonational changes might contribute to the perception of a foreign accent in speech (7.4).

## 7.1 Dimensions of intonation

This section discusses the findings of the present study in relation to the different dimensions of intonation, in turn addressing aspects of the inventory, distribution, phonetic implementation and function of intonational structures, i.e. phonological and phonetic marking of information status (7.1.1-7.1.4). This is followed by an evaluation of the role of the different text styles in shaping the dimensions of intonation (7.1.5). The conclusions drawn from this discussion section will hereafter serve as a basis to discuss the nature of intonation in FAS.

In the interest of clarity, at the beginning of each dimension section the results of both preliminary and main case studies are summarised to obtain an overview of the speakers' performances, before discussing specific aspects of each dimension. The results of preliminary and main case studies were considered together as there were strong similarities in relation to the speakers' performances and the materials used to elicit the data. The discussion will largely focus on the group trends that emerged from the findings, with individual speaker performances being addressed where relevant.

### 7.1.1 Inventory of structural elements

The present study revealed that all speakers with FAS have the same categorical elements, i.e. pitch accents and boundary tones, at their disposal as the control speakers. Specifically, the pitch accents L*, H*, H*L, !H*L and L*H were used by control speakers and speakers with FAS alike, as was the complete set of boundary tones (%L, %H, L%, H%, %). The inventorial analysis further showed that none of the speakers employed H*LH. Differences between the two groups were observed regarding the use of L*HL, which featured in the inventory of three speakers with FAS, but was only used by one control speaker. Overall, these findings indicate a similarly rich categorical inventory in both speaker groups, suggesting that the abstract phonological representations of pitch accents and boundary tones are unaffected in FAS and can be realised without difficulties.

The assumption of retained phonological representations in FAS is in line with findings from Verhoeven and Mariën (2002, 2004, 2010), authors of the only series of research papers to investigate the categorical inventory of intonation in FAS. Verhoeven and Mariën found that their speaker with FAS successfully produced the four major Dutch intonation contours, adhering to rules of intonational well-formedness, and concluded that the contours in this speaker were unaffected.
A retained structural inventory in disordered speech was also observed by Mennen et al. (2008). Based on the analysis of read speech in two speakers with hypokinetic dysarthria, the authors found that both speakers had the same pitch accents and boundary tones at their disposal as the healthy control speakers. Although the numbers of speakers investigated in the above studies are too few to draw conclusions about the overall nature of the structural representations in speech disorders, their results combined with the current findings suggest a trend that the abstract phonological representations of intonation might generally be unaffected in disordered speech. There is thus a need for further studies investigating the intonation patterns of speakers with FAS and other forms of speech disorders known to affect intonation in order to substantiate this conclusion.

As outlined above, the only notable inventorial variation between participants was observed in relation to the use of the rise-fall pitch accent L*HL, which only featured in the inventory of five of the ten speakers including PFAS, MFAS2, MFAS3, PMS and control speaker MC2. This finding comes as a surprise as, according to the IViE corpus (Grabe, 2004; cf. section 2.3.2), which was analysed in terms of its pitch accent inventory, tritonal tones are unaccounted for in declaratives. There are a number of explanations as to why L*HL only featured in the inventory of some of the participants. First of all, the IViE corpus only examined the pitch accent use in nuclear, i.e. in utterance-final position, whereas in this study L*HL predominantly occurred in pre-nuclear position. A direct comparison of the results of the present study with those of the IViE corpus is therefore limited. Secondly, the use of L*HL in the scripted data sets, in particular in the SENT set, may be an artifact of the task design, which required speakers to highlight specific words within a sentence. At times, L*HL might have been employed by speakers to emphatically highlight the respective words. Thirdly, the use of L*HL by only some of the participants may be the result of speaker-specific preferences for certain pitch accents. In this context, it is important to note that L*HL was used by healthy as well as clinical speakers, which makes it unlikely for L*HL to be a purely clinical feature.

The inventorial analysis further showed that the precise inventorial make-up was to some extent influenced by the type of text style investigated, with the unscripted data sets yielding a more varied inventory than the scripted data sets. In this context it was further noted that some pitch accents were either associated with scripted or with unscripted data. More specifically, whilst pitch accents H*L, !H*L, L*H and H* were frequently used throughout, L*HL was more likely to be part of the scripted data sets, and L* part of the unscripted sets. As discussed above, the prevalence of L*HL in the scripted data sets, in particular the SENT set, may well be a result of the task design or a speaker-specific preference. Accounting for why L* is more robustly represented in the unscripted data sets may not be as straightforward and there are several plausible reasons for its presence in these text styles.

One reason concerns the structure of the utterances that were produced in the unscripted data sets, where speakers had to allocate more cognitive resources to speech planning. A detailed analysis of the instances of L* revealed that it was often associated with stretches of speech that expressed some kind of afterthought, essentially adding or correcting previous information. This is illustrated in the picture description excerpt given in appendix G, where in phrase 12 and 13 MFAS1 corrected previously provided information.

Another reason that could account for the imbalanced use of L* across text styles is inconsistent labeling due to uncertainties as to the presence or absence of pitch accents. Compared to ToBI, uncertainties pertaining to pitch accent labeling are not explicitly addressed in IViE, where no distinction is made between stressed and accented syllables, leaving room for interpretation as to when to assign L*. This constitutes a common problem for labelers, in particular when the pitch range is very reduced (Venditti, 1997, 2005). Although intra-rater agreement pertaining to L* was relatively robust in the present study, further studies would be helpful to elucidate whether the current definition of L* provided by IViE is sufficient to warrant a reliable transcription of this pitch accent.

### 7.1.2 Distribution of structural elements

As part of the analysis of the different dimensions of intonation, the present study examined the distribution of pitch accents and boundary tones in FAS speech. Similarities across groups were found in relation to the clear prevalence of falling pitch accents, in particular H*L, and the marginal use of pitch accents L* and L*HL. Clear distributional differences between speaker groups concerned the use of the rising pitch accent L*H, which was more frequently employed among the speakers with FAS. Notably, the distribution of L*H in the latter group was clearly influenced by the type of text style examined, with unscripted data displaying a higher percentage use of L*H than the scripted data.

As can be seen from the above summary, the higher incidence of L*H in the speakers with FAS was the only specific difference in the distribution of pitch accents between clinical speakers and control speakers. Close inspection of the scripted data revealed that the higher frequency of L*H could solely be attributed to MFAS1, whereas in the unscripted data the use of L*H increased considerably in all speakers with FAS. Initially, MFAS1's unvarying preference for rising pitch patterns was assumed to reflect her Scottish background. However, a few issues arose that questioned this initial assumption. Firstly, although rising intonation patterns are known to be a feature of Scottish English (among others Aufterbeck, 1999;

Cruttenden, 1997; Fletcher et al., 2005; Ladd, 1996; Mayo et al., 1997), they are generally associated with the dialectal versions of the Western areas, in particular Glasgow, but not with the variety spoken in Fife (Aufterbeck, 1999), the region where MFAS1 was brought up and had lived throughout her life. Secondly, MC1, the dialect-matched control speaker for MFAS1, did not show the same strong preference for L*H, but used pitch accents H*L and H* more frequently instead. This disparity indicates that the strong preference for L*H in MFAS1 may not be attributable to her Scottish background.

An alternative explanation for the high incidence of rising pitch accents in MFAS1 concerns the presence of timing difficulties in this speaker. There is a potential that the physiological changes of FAS impact on the way F0 is generated and controlled, leading to a change in the way peaks are aligned with the words of the utterance. On the other hand, rising pitch patterns are also known to be a marker of continuation and the frequent use of L*H in MFAS1 may represent a strategy on part of the speaker to express continuation, which is compromised due to the presence of long pauses and initiation problems in her speech. The frequent use of L*H may therefore constitute a compensatory mechanism which serves to bridge slow and halting speech production.

This explanation may not only account for the frequent occurrence of L*H in the speech of MFAS1, but could also explain the increased use that was displayed by the remaining speakers with FAS in the unscripted data sets. The fact that the rise in L*H only occurred in the unscripted data sets shows that most speakers with FAS were sensitive to employing the rising pitch accent only in those speaking styles, where the marking of continuation was of higher relevance to effective communication. Therefore, the distributional differences observed in relation to the use of pitch accent L*H could well represent a compensatory strategy employed by the speakers with FAS to express continuation.

Similar conclusions were drawn by Verhoeven and Mariën (2002, 2004, 2010), who observed a particularly frequent use of continuation patterns in the conversational data of their Dutch speaker with FAS. The authors argued that the speaker might use these patterns to indicate that she has not finished her turn yet and that there is more information to come before yielding the floor. In spite of the parallels between the findings by Verhoeven and Mariën (2002, 2004, 2010) and the results of the current study, it is important to note that the studies differed as to the nature of the data examined. Whilst Verhoeven and Mariën investigated conversational data, the present study employed semi-spontaneous speech tasks, which did not involve turn taking as such. As a result, the frequent use of L*H in the present study may represent a means to mark continuation, but it cannot be considered a direct marker of turn taking.

The strategic use of structural elements as a means to mark continuation was further reflected in the distribution of the final high boundary tone H%. Detailed analyses revealed that the speakers with FAS employed H% at a constant level across data sets, whereas control speakers hardly used this tone in read speech, but reached similar levels of usage as the speakers with FAS in the unscripted data sets. That is, in the control speakers H% as a means of marking continuation was only employed in the unscripted data.

Taking the findings from the analysis of both types of structural elements together, it becomes evident that control speakers employed the boundary tone H% to indicate continuation, whereas the speakers with FAS relied on both the boundary tone H% and the pitch accent L*H to do so. Two possible explanations might account for this group-specific difference in distributional patterns. On the one hand, combining the use of pitch accents and boundary tones could be interpreted as an attempt on the part of the speakers with FAS to increase or reinforce the effectiveness of their continuation marking. On the other hand, using both types of structural elements may simply have proven necessary as the speakers with FAS did not employ the final high boundary tone H% across scripted and unscripted text styles as effectively to indicate continuation as the control speakers. Consequently, the speakers with FAS may have employed the rising pitch accent L*H as an additional means to compensate for the less efficient use of H% as a marker of continuation. Either way, the distributional analysis showed that in the speakers with FAS, the use of specific pitch accents and boundary tones, known to be markers of continuation, differed from that of the healthy speakers investigated. There is some evidence that the observed higher use of continuation markers in FAS speech could be a functional mechanism that is in place to compensate for the potential impact of slower speech rate, longer pauses and initiations problems.

These results cast a different light on some of the finding of previous FAS case studies that reported rising F0 contours at the end of utterances, where a fall would have been expected or considered to be more appropriate (cf. section 3.2.2; e.g. Berthier et al., 1991; Blumstein et al., 1987; Dankovičová et al., 2001; Katz et al., 2008; Monrad-Krohn, 1947; Moonis et al., 1996). Initially interpreted as an inherent feature of FAS speech, in light of the present findings the utterance-final rises in F0 observed in these studies could be re-interpreted as an effort on the part of the speakers with FAS to express continuation.

Interestingly, a more frequent use of the high boundary tone H% and the rising pitch accent L*H was also observed in the participant with mild dysarthria (PMS). The similarity in the use of continuation patterns between PMS and the speakers with FAS suggests that the higher use of continuation markers is not a disorder-related strategy specific to FAS, but could represent a general compensation strategy employed by speakers with any kind of speech disorder that involves the risk of losing one's speaking turn. However, further investigations with a higher number of individuals with different types of dysarthria and with methodologies designed to investigate discourse structure and turn taking mechanisms are needed to corroborate these findings.

### 7.1.3 Phonetic implementation

So far, the structural analysis of the current data has revealed a retained inventory of phonological representations in speakers with FAS along with distributional differences pertaining to specific pitch accents and boundary tones. When investigating the implementation of these intonation patterns, differences between FAS and healthy speakers were also identified with regard to the frequency of accentuation, phrasing and pausing. The findings related to each aspect are summarised and discussed in the following sections.

**Frequency of accentuation**

In terms of the frequency of accentuation, speakers with FAS displayed a higher frequency of pitch accents than the control speakers irrespective of the text style investigated. The consistency of this pattern is reflected in the absence of overlap in the frequency patterns of the speakers with FAS and the control speakers. The only exception to this concerned the performance of MC1 in the MONO data set, in which MC1 displayed a similarly high frequency of accents as the speakers with FAS. [23]

The higher frequency of accentuation in the speakers with FAS is consistent with findings from previous FAS case studies reported in the literature (Berthier et al., 1991; Graff-Radford et al., 1986; Wendt et al., 2007). Wendt et al. (2007) investigated the prosodic characteristics of read speech in a German speaker with FAS and found that she produced twice the number of pitch accents as the matched control speaker. A higher rate of pitch accentuation was also reported by Berthier et al. (1991) and Graff-Radford et al. (1986). Although both studies did not explicitly investigate the

[23] MC1 struggled with the monologue task and required relatively frequent prompting on the part of the experimenter. It is likely that her difficulties with this task, which were also reflected in frequent and long pausing, have had an impact on the rate of accentuation and phrasing (cf. following section). This finding shows that the intonational make up of a dimension is not only influenced by the type of text style elicited, but also by how well the respective speaker responds to the different task designs.

frequency of accentuation, they reported that in some sentences produced by the speakers with FAS almost every single content word received a pitch accent, which is likely to have resulted in a higher frequency of accentuation than would be expected. This tendency in speakers with FAS to highlight every single content word of a sentence was also observed in sentence reading task of the present study. Whilst the control speakers only accented words in the respective three target positions, i.e. the nouns in subject-, object- and adverbial positions (cf. section 4.3.1), the speakers with FAS tended to additionally assign pitch accents to other words in the sentence including the verb, determiners and prepositions. The fact that these words regularly received a pitch accent was certainly one reason for the increased accentuation observed in the current speakers with FAS. Another reason that accounts for the higher number of pitch accents in these speakers was the low incidence of de-accentuation of post-focally given referents, which will be addressed in greater detail in section 7.1.4.

**Phrasing**

Differences in performance patterns between both speaker groups were also uncovered in relation to the phrasing of utterances, whereby the speakers with FAS consistently produced shorter IPs than the healthy control speakers. However, variation within the FAS group was observed in relation to the degree to which the utterances were split up into smaller phrasing units. In the SENT data set, two of the speakers with FAS, PFAS and MFAS3, produced IPs that were about half the length than those of the healthy speakers, whilst MFAS1 and MFAS2 realised phrases that were on average about one third shorter. In the remaining text styles, the IPs produced by the speakers with FAS were generally about one third shorter than those of the control speakers, although the difference levelled off towards the MONO data set. Close inspection of the data revealed that this could be attributed to MC1, who produced very short IPs in the monologue task, probably as a result of the difficulties she experienced with this task (cf. footnote 21).

The present study is not the first one to find a shorter mean length of phrases in FAS speech. Wendt et al. (2007), who did not only investigate the accentuation in their speaker with FAS but also the phrasing patterns, reported considerably shorter phrasing units in the speech of the individual with FAS compared to the control speaker. Whilst the speaker with FAS realised a short text passage comprising 55 syllables in 14 phrases, the control speaker produced the very same passage in three phrases. However, it is important to note that the short text that was analysed in terms of its prosodic phrasing was an excerpt of a larger text passage, so that it is not entirely clear how representative the cited numbers are.

With the exception of Wendt et al. (2007), none of the FAS case studies in the literature have directly investigated the prosodic phrasing in FAS speech, but there are indications in some of the reported cases that smaller phrasing units could be a relatively common feature of FAS speech. A relatively large number of studies have reported inappropriate inter- and intra word pausing (Berthier et al., 1991; Graff-Radford et al., 1986; Gurd et al., 1988; Ingram et al., 1992; Laures-Gore et al., 2006; Miller et al., 2006; Wendt et al., 2007) and given that pauses are one of the main markers of phrasal structuring, the tendency to pause more frequently might indicate that utterances were divided into smaller phrasing units.

Smaller than usual phrasing units have also been reported in individuals with speech disorders other than FAS. Heselwood (2007), for instance, investigated the speech of a young man who developed difficulties with speaking after suffering from an aneurysm and found that the speaker frequently had to take breaths at unexpected places, that way changing the phrasing patterns of his speech. In addition, Mennen et al. (2008) observed that their speakers with Parkinsonian dysarthria frequently placed boundary tones at syntactically implausible positions, resulting in about a quarter more intonation phrases than the matched control speakers. Similarly, Vance (1994) reported a multiple sclerosis related case of ataxic dysarthria, in which speech production was interspersed with frequent and longer-than-normal pauses, leading to short, irregularly spaced phrases. Whilst in the Heselwood (2007) study, the smaller phrasing units seen in the speaker were almost certainly caused by the extreme effort required to produce speech at all, in the latter two studies by Mennen et al. (2008) and Vance (1994) reduced breath control was considered the most likely reason for the shorter phrasing units.

Evidence that breath support and control was also an issue in the current speakers with FAS comes from the screening tests conducted as part of the main study, where all participants with FAS showed problems with sustained phonation, reflected in shorter phonation times or frequent interruptions. Furthermore, performances in phonation tasks seemed to correlate with the mean length of phrasing to the effect that MFAS1 and MFAS2, whose phrases were only about one third shorter than those of the control speakers, performed better in the sustained phonation tasks than MFAS3, whose phrases were only half the length of those produced by the healthy speakers. Consequently, difficulties in phonatory and/or respiratory support could well have impacted on the phrasal structuring of utterances in the speakers with FAS investigated here.

**Pausing**

The pausing pattern of utterances is closely interrelated to the phrasal structuring as pauses, in particular those indicated by boundary tones, usually result in a division of utterances into smaller units. The causal relationship between both aspects has been confirmed by findings of the present study. Although individual variation was relatively high in terms of number and position of pauses for both speaker groups, the speakers with FAS clearly displayed a tendency to insert more pauses than the control speakers. A further difference between the speaker groups emerged in relation to the position of the pauses in the SENT set in relation to the new element in discourse. Whilst in the control speakers the position of pauses and the position of the new element were strongly related, no such relationship was observed for the speakers with FAS.

The findings of the present study concerning the high incidence of pauses in the speakers with FAS confirm previous findings on pause structuring in FAS speech. As established earlier, many FAS case studies reported inappropriate and at times long pausing either at phrase boundaries or elsewhere in the utterance (e.g. Berthier et al., 1991; Graff-Radford et al., 1986; Gurd et al., 1988; Laures-Gore et al., 2006; Wendt et al., 2007). However, these studies did not elaborate on its precise manifestation in FAS speech in terms of number of pauses or length of pauses in relation to speaking time. As a result, no conclusive inferences can be made as to the possible causes of these pauses. The most likely explanation for the frequent insertion though, is a lack of breath support or control, which has been established for the speakers with FAS investigated in this study.

Regarding the functional use of pauses to mark new information, Baumann et al. (2007) reported a relationship between the position of pauses and the position of the new information as observed in the current control speakers. Specifically, the authors found that in some instances a minor phrase break occurred before the highlighted item and concluded that the use of pauses can have a functional purpose, constituting a speaker-specific strategy that is applied to reinforce existing cues to structuring discourse. Although the position of the pauses in the present study differed from those in Baumann et al.'s study (2007) - the pauses that were placed by the control speakers were consistently positioned after the highlighted item - the positional consistency suggests that the control speakers might have employed pauses as a means to aid the identification of the new information in discourse.

Whilst this finding implies that pauses can be of functional relevance to healthy speakers, no such link between the placement of pauses and the position of the new information in discourse could be established for the speakers with FAS. However, what is not entirely clear from the results is whether the speakers with FAS did not employ this strategy at all or whether they were not able to use it effectively, as the effect might have been masked by the frequent insertion of pauses in general. This means that even if pausing was employed by the speakers with FAS as an additional cue to discourse structuring, it lost its functional significance due to the overuse of pauses in other sentence positions.

In contrast to the current findings for speakers with FAS, Berthier et al.'s (1991) findings on focus marking in FAS suggested a meaningful use of pauses for the purpose of information structuring. Although the authors did not specifically investigate the pausing structure and their relation to the focus structure of the sentence, the case descriptions suggest that pausing may have been employed to help indicate the position of the highlighted item. Specifically, of the four speakers investigated by Berthier et al. (1991), two speakers realised pauses before the target word, one speaker produced pauses after the accentuated word, whereas the remaining speaker displayed pauses before and after the highlighted element. According to the descriptions provided, these pausing patterns appeared to have been frequently observed in cases where speakers highlighted the correct item. Given the diverging patterns of Berthier et al.'s (1991) findings and those of the present study, it would seem worthwhile to pursue further studies on the potential functional use of pauses in FAS speech and disordered speech in general.

### 7.1.4 Function of intonation

The current discussion on the dimensions of intonation has hitherto identified a very similar phonological inventory of categories in FAS and healthy speech, along with a number of differences in distribution and implementation. In particular the latter seems to follow a different pattern in speakers with FAS, as the performances differed in every aspect investigated from those of their healthy counterparts, showing a higher incidence of accentuation, phrasing and pausing. This section discusses the results of the phonological and phonetic encoding of information status, i.e. givenness of referents in discourse, and addresses whether the observed differences in distribution and implementation had an impact on the speakers' ability to successfully signal this functional aspect of intonation.

**Phonological encoding of givenness**

The analysis of the phonological marking of information status revealed that speakers with FAS as well as control speakers marked new referents in discourse by assigning a pitch accent irrespective of the type of text style examined. However, a more varied pattern emerged for the marking of given referents, whereby two main observations were made. Firstly, de-accentuation patterns in healthy speech were strongly influenced by the type of text style, with scripted data yielding a higher rate of de-accentuation than unscripted data. Secondly, whilst the control group showed a strong tendency to de-accent given referents, particularly in the scripted data, the speakers with FAS only infrequently de-accented given items.

These findings suggest that in healthy speech the marking of given referents is subject to considerable variation, whereby the text style seemed to be one of the major determinants influencing whether given referents were primarily marked using de-accentuation or accentuation. In the scripted data, in particular in the SENT set, de-accentuation prevailed, whereas in the unscripted data a tendency towards accentuation was evident. However, although de-accentuation was generally the preferred option in the scripted data - the de-accentuation of given referents ranged between 60% and 93% - none of control speakers consistently de-accented given referents. The fact that even in the tightly controlled environment of the sentence reading task none of the healthy speakers showed complete de-accentuation implies that it may represent the expected pattern, but it is clearly not the only option available to speakers.

With less than 40% of given referents being de-accented, the average de-accentuation rate observed in the unscripted data sets of the present study was considerably lower than that of the scripted data sets. The relatively low de-accentuation rate supports findings by Bard and Aylett (1999), who investigated givenness in task-oriented dialogues and found that less than 20% of all given items were de-accented. With 75% of given entities being de-accented, Lehman (1977, as cited in Cruttenden, 2006) reported a much higher de-accentuation rate than Bard and Aylett (1999). In this case, however, it is not clear which kind of data Lehman analysed, but her results would correspond well to the de-accentuation rates obtained for the scripted data sets of the present study. By contrast, the present results clearly do not confirm findings from the study by Prince (1981), in which 96% to 100% of all given items in a dialogue situation were de-accented. In the current study, such consistency was not even observed in the strictly controlled sentence reading task, where only one of the ten speakers investigated (PMS) completely de-accented given referents in post-focal position.

The low de-accentuation rates observed for the unscripted datasets of the present study suggests that the phonological marking of givenness is likely to be influenced by other factors. According to Terken and Hirschberg (1994), for instance, de-accentuation is most likely if the given referent maintains the same surface position and grammatical role as the previously introduced new counterpart. A change in one of the two aspects would render de-accentuation less likely. A further factor of importance to the de-accentuation of given referents concerns the position of the given referent relative to the focused element. Given information in pre-focal position may be accented for rhythmical reasons (Baumann, et al., 2007; Chen, 2007; Gussenhoven, 2002a), whereas in post-focal position de-accentuation of given referents is expected. However, in unscripted speech the focus-background partitioning of an utterance is difficult to control as the position of the elements in focus is strongly influenced by the speaker's intention. In addition, the different levels of information structure are known to interact and focus can override information status if referents that are considered newsworthy are assigned a pitch accent, even though they are contextually given. In the present study, the only text style to be controlled for any of these factors was the sentence reading task, in which new and given referents were controlled for the position within the text. It is therefore possible that the factors mentioned above have contributed to the relatively low de-accentuation rate observed in the unscripted text styles.

In summary, the findings suggest that the marking of given referents by means of de-accentuation in healthy speech is influenced by a variety of factors and as a result does not appear to be as strong a constraint as has been postulated in the literature (among others Cruttenden, 2006; Ladd, 1980, 1996; von Heusinger, 1999). Accordingly, the widely held assumption of a binary manifestation of information status, indicated by the presence or absence of pitch accents, may reflect a broad tendency for scripted data, but cannot be considered an accurate representation of the notion of givenness in general.

The vast variation observed in healthy speech in relation to the phonological encoding by means of accentuation and de-accentuation, combined with the absence of any previous systematic research of givenness in FAS speech, means that the basis against which to compare the current FAS performances is limited and any interpretation is to be treated carefully. A relatively clear pattern that emerged from the phonological encoding results of the speakers with FAS is that speakers did employ intonation patterns to signal the information status of referents in discourse, but the use of accentuation and de-accentuation did not reflect the binary status of new and given information. Specifically, although the speakers with FAS showed accentuation rates for new referents in discourse that were comparable to those of the control speakers, this observation does not necessarily imply that only new information was highlighted. Across the board, speakers with FAS preferred accentuation over de-accentuation to indicate given information. That is to say, instead of the expected de-accentuation, the speakers with FAS mostly used full accents to mark given referents, irrespective of the type of text style examined. This is likely to be one of the major reasons for the higher overall number of pitch accents observed in the speakers with FAS. The fact that the low rate of de-accenting was present in all text styles investigated, implies that factors such as structural position and grammatical role, thought to impact on the manifestation of givenness in healthy speech, were not found to have a similar effect on FAS speech. The comparable de-accentuation performances across speaking styles in FAS means that whatever caused the low de-accentuation rate, it affected speech in general and not just single text styles. The fact that most referents were assigned a pitch accent, irrespective of their actual information status, indicates that at phonological level the ability to signal the givenness status of discourse referents by means of de-accentuation is restricted in FAS. Possible causes for the restricted use of de-accentuation are addressed in section 7.2.

Having established that in FAS the binary distinction of new and given information is not adequately reflected in the presence versus absence of pitch accents, it was explored whether the type of pitch accent might be a better indicator of information status than the dichotomy of accentuation versus de-accentuation, as was suggested in the literature (Baumann, 2006a, 2006b; Baumann & Hadelich, 2003; Baumann et al., 2007; Brazil et al., 1980; Grice, 2006; Grice & Baumann, 2007; Pierrehumbert & Hirschberg, 1990). Table 7.1 summarises the different types of information status investigated in the present study, along with the expected phonological categories and those that were actually employed by the different speaker groups. In order to prevent confoundings in the data with variables such as surface position and focus-background structure, only the highly controlled data of the sentence reading task were considered.

| information status | expected realisation | actual realisation | | |
|---|---|---|---|---|
| | | CON | FAS | PMS |
| new | **H*** (Pierrehumbert & Hirschberg, 1990)<br>**H*L** (Brazil et al., 1980) | H*<br>H*L<br>!H*L<br>L*H<br>--<br>no accent | H*<br>H*L<br>!H*L<br>L*H<br>--<br>-- | --<br>H*L<br>!H*L<br>L*H<br>L*HL<br>-- |
| given – pre-focal | **accent**<br>**no accent**<br>(Chen, 2007; Gussenhoven, 2002a) | H*<br>H*L<br>!H*L<br>L*H<br>L*<br>no accent | H*<br>H*L<br>!H*L<br>L*H<br>L*<br>no accent | --<br>H*L<br>--<br>L*H<br>L*<br>no accent |
| given – post-focal | **L***<br>**no accent**<br>(Pierrehumbert & Hirschberg, 1990;<br>Baumann and colleagues, 2003, 2006, 2007) | --<br>H*L<br>!H*L<br>L*<br>no accent | H*<br>H*L<br>!H*L<br>L*<br>no accent | --<br>--<br>--<br>--<br>no accent |

Table 7.1: Expected and actual realisation of information status for the control speakers (CON), the speakers with FAS (FAS) and the speaker with mild dysarthria (PMS)

What can be seen from the table is that a variety of pitch accents were employed to indicate the different types of information status, calling into question the assumption of a phonological category being specifically used to mark *newness* or *givenness*. New information is assumed to be indicated by H* (Baumann, 2006a, 2006b; Grice & Baumann, 2007; Pierrehumbert & Hirschberg, 1990) or H*L (Brazil et al., 1980), whereby the latter pitch accent is associated with British English and therefore more likely to occur in the present study. As is evident from the table, each speaker group used a range of different pitch accents to mark new information, including the postulated *newness* accents H* and H*L, but also rising patterns or complex rising-falling patterns in the case of the speaker with dysarthria (PMS), indicating a wide range of individual variation. Such highly speaker-specific preferences for particular pitch accents were already observed by Baumann (2005) and Baumann et al. (2006), which suggest that a high degree of variation in the intonational marking of new information appears to represent a more common phenomenon than is generally assumed.

A similarly rich use of pitch patterns arose for the marking of given referents in pre-focal position. As can be seen from the table, the different speaker groups employed various pitch patterns including accentuation and de-accentuation, whereby the control speakers and the speakers with FAS exhibited a slightly wider range than the speaker with dysarthria. In general, each group used pitch accents that were thought to indicate new information (H*L) as well as pitch accents that are considered to function as indicators of given information (L*).

According to Pierrehumbert and Hirschberg (1990) and Baumann and colleagues (Baumann, 2006a, 2006b; Grice, 2006; Grice & Baumann, 2007), post-focal givenness is indicated by pitch accent L* or de-accentuation. As discussed earlier, the latter was consistently employed by the speaker with dysarthria, who de-accented each given referent in that position (cf. table 7.1). The remaining two speaker groups employed a variety of phonological categories to mark post-focal given referents, including the expected low pitch accent L* and de-accentuation, but also full accents such as H*L.

In summary, based on the examination of the type of pitch accent employed to indicate information status, a number of important points can be established. It became clear that each information status was not just marked by a single specific pitch accent, but by a variety of phonological categories. In combination with the considerable overlap between the different types of information status in terms of the pitch accents employed, there is clearly too much variation as to be able to infer the nature of the information status from the phonological form employed. In other words, contrary to the claim made by Pierrehumbert and Hirschberg (1990), it appears unlikely that the phonological form of discourse referents as such can serve as a reliable indicator of different degrees of givenness, as even the binary distinction of new and given information investigated in this study was not consistently indicated by the same phonological category. In addition, the fact that the control speakers and the speakers with FAS employed by and large the same pitch accents to mark the different types of information status suggests that not the type of pitch accent, but the frequency of accentuation and de-accentuation is the deciding factor that tells the performances of these two speaker groups apart.

**Phonetic encoding of givenness**

In addition to the phonological marking, the phonetic encoding of information status was investigated to establish how the speakers with FAS employed duration, intensity and F0, i.e. the dynamic parameters known to play a role to the successful encoding of new and given referents.

The results of the phonetic analysis revealed that the control speakers employed all three parameters to signal information status, with new referents being significantly longer, louder and higher in pitch than the given referents in the same position. This result conforms with findings from studies investigating the phonetic marking of givenness (cf. chapter 1.4.2), which overwhelmingly reported a significant increase in duration, intensity and F0 of new target words compared to given target words (e.g. Baumann, Grice & Steindamm, 2006; Féry & Kügler, 2008; Fowler, 1988; Fowler & Housum, 1987; Kügler, 2008; Kügler & Genzel, submitted; Lieberman, 1963; Shields & Balota, 1991).

Although the speakers with FAS generally managed to reproduce the overall pattern of higher phonetic values in new compared to given referents found for the control speakers, the statistical analysis conducted to examine the magnitude of this effect highlights an important difference. For each parameter investigated, the percentage difference between new and given information was significantly smaller in the speakers with FAS than in the control speakers, indicating that - despite the same overall tendencies - the speakers with FAS were in fact less effective in distinguishing new and given information by means of duration, intensity and F0 than the control speakers.

The observed heightening of phonetic cues on new information in the present speakers, was subject to parameter-specific *positional effects*. For the control speakers, the percentage difference between new and given information increased across sentence positions for the parameters intensity and F0, whereas for the parameter duration this difference remained about the same. Whilst MFAS1 and MFAS3 mirrored the performances of the control speakers by displaying a percentage difference change across sentence positions that was within the control speakers' range, the performances of MFAS2 and PFAS differed from those of the remaining speakers. Specifically, MFAS2 showed a considerable increase of percentage difference across sentence positions for duration, whereas the patterns for F0 and intensity were comparable to those of the other participants (cf. appendix F9). PFAS, by contrast, showed the substantial increase of percentage difference not only for the parameter duration, but also for intensity and F0 (cf. figure 5.14 and appendix E10). The observed differences in these speakers with FAS pertaining to the magnitude of percentage difference suggests that they exploited the phonetic parameters to different degrees in order to distinguish between new referents and their given counterparts.

Further differences between FAS and control speakers were highlighted in the analyses of post-focal F0 lowering, which showed that the degree of F0 lowering following new information was significantly smaller in the speakers with FAS than in the control speakers. This restricted ability to suppress pitch range in post-focal position to the same extent as the control speakers implies that post-focal givenness in FAS was less likely to be indicated by complete de-accentuation. This has been observed in relation to the phonological encoding of givenness in FAS (cf. previous section), i.e. the phonetic measures confirm the greater presence of pitch accents, and thus the preference of accentuation over de-accentuation to mark given information in FAS speech. In this context it is also important to note that the less effective lowering of F0 in FAS speech to indicate given information in post-focal position appeared in the context of a linguistic pitch range that was significantly wider than that of the control speakers. Given that the pitch range as such was not restricted, the inability to lower F0 within that range points to a reduced ability in effectively controlling F0 movements.

In summary, the analysis of the phonetic encoding of givenness showed that speakers with FAS employed the same phonetic cues as control speakers to mark information status, but they clearly differed from that group in terms of the degree to which new and given information was distinguished. As a result of these differences, the phonetic encoding of information status was less pronounced in FAS, which mirrors findings observed in relation the phonological encoding of givenness. The perceptual implications of these findings are briefly assessed in the following section.

**Perceptual evaluation of the functional marking of information status**

Given the observed differences in the phonological and phonetic encoding of information status in the current FAS group, a further exploratory investigation was conducted to examine to what extent their performances impacted on the perception of givenness of discourse referents. For this purpose, the data were perceptually evaluated by the experimenter with a focus on de-accentuation. The evaluation therefore concentrated on the sentence reading task, in particular those sentences in which either target word T1 or T2 were to be highlighted as de-accentuation of the post-focally given referents was only expected in these two conditions.

The perceptual analysis revealed that the new and given referents in the sentences produced by the control speakers and PMS were consistently identified correctly, suggesting that the marking of information status was generally successful in these speakers. For the speakers with FAS a more heterogeneous pattern emerged. Whilst PFAS was equally successful in marking the information status of discourse referents as the control speakers and PMS, the remaining speakers performed less well: MFAS2 marked referents successfully in only 50% of the sentences; and for speakers MFAS1 and MFAS3 the correct information status of referents was identified in only 35% of the data. Importantly, the sentence position of the new and given referents was not found to have an effect on the successful identification of information status in any of these speakers. In those cases, where the information status of target words was not identified correctly, all target words were perceived as new information rather than the wrong target being highlighted. This finding reflects the general absence of de-accentuation in the data set.

The perceptual findings show that MFAS1 and MFAS3, who mirrored the phonetic performances of the control speakers, exhibited the lowest rate of successful identification, suggesting that a use of phonetic parameters similar to that of the control speakers does not necessarily translate into a successful marking of information status. By comparison, PFAS and MFAS2, i.e. those speakers who were found to exploit phonetic parameters differently, were more successful in signalling information status. In particular PFAS, who differed from the control group in her use of all three phonetic cues succeeded in marking givenness correctly throughout.

Overall, the results of the perceptual evaluation suggest that although new discourse referents generally stood out phonetically in the current speakers with FAS, in three of the four speakers the phonetic manipulation of these parameters was not sufficiently extensive to override the frequent accentuation of post-focal given referents. The one speaker, who succeeded in marking givenness appeared to have employed some form of compensatory strategy by deviating from the normal pattern of phonetic manipulation. It is outside the scope of this study to examine the exact details of such compensatory behaviour, however, this issue would benefit from a more extensive perceptual investigation into the relationship between the phonetic parameters and their relevance in signalling information status.

### 7.1.5 The role of text style in defining the typology of intonation

Situated between the conflicting demands of systematically investigating the nature of everyday speech on the one hand and the absence of control over these speech patterns on the other, research on prosody and intonation finds itself in the centre of an ongoing debate as to the type of corpus considered most appropriate to capture its true nature (Hirst & Di Cristo, 1998; Xu, 2010). Whilst the majority of work on prosody is based on laboratory speech, i.e. scripted speech, a shift in favour of spontaneous, i.e. unscripted speech, took place in the 1990s, spurred by researchers questioning to what extent findings from read speech can be generalised to more conversational situations. The controlled manipulation of factors, i.e. the very advantage that rendered scripted speech the preferred option to gain insights into the underlying mechanisms of speech production in the first place, has come under scrutiny because of the unnatural and planned nature of this speech style. However, spontaneous speech, which was deemed more appropriate to provide a realistic picture of every day speech, is not without its problems either, as the lack of control over certain factors renders it more difficult to detect the systematic patterns behind the prosodic phenomena investigated.

This ongoing debate is not only crucial for the investigation of prosody in healthy speech, but is also of great importance for disordered speech, since the nature of the speech corpus may impact on whether the features specific to a speech disorder are captured adequately or not. By using scripted as well as unscripted data, the current study intended to assess the influence of the different text styles on the shape of the four different dimensions of intonation and thus on the typological account of intonation in FAS speech. Analysing both types of data allowed to systematically assess each dimension and to compare its manifestation across text styles, that way overcoming the issues raised by the above debate.

The analysis and subsequent discussion of the four dimensions of intonation has shown that the type of text style had an influence on the make-up of the different dimensions, as systematic differences between scripted and unscripted data were observed for all four dimensions. In the following, the key differences between scripted and unscripted text styles observed in the present study are summarised for each intonation dimension.

**Inventory:** In both speaker groups, the use of pitch accents and boundary tones was more varied in the unscripted data than in the scripted data, therefore yielding a richer categorical inventory for the unscripted text styles.

**Distribution:** The frequency distribution of some of the categorical elements differed between scripted and unscripted text styles. In the speakers with FAS, the use of pitch accent L*H rose considerably in the unscripted data sets, whereas the same was observed for the high boundary tone H% in the performances of the control speakers.

**Implementation:** Differences between scripted and unscripted data sets in relation to the implementation of intonation patterns were predominantly observed for phrasing, with the scripted materials resulting in the elicitation of longer intonation phrases than the unscripted data.

**Function:** In scripted speech, de-accentuation of given information dominated the picture, whereas accentuation prevailed in the unscripted data sets. This shift from de-accentuation to accentuation, however, was only observed for the control speakers; the speakers with FAS displayed stable (de-)accentuation patterns.

The patterns emerging from the analysis of the intonational dimensions suggest that both scripted as well as unscripted speech tasks have their merits and it appears advisable to investigate both text styles in order to obtain a comprehensive picture of the intonation component - in healthy as well as in disordered speech - for the following reasons. Firstly, whilst scripted data appeared to be more suited for the investigation of the functional aspect, i.e. the encoding of information status, unscripted text styles were more likely to provide a realistic picture of the actual inventory of categorical elements speakers have at their disposal. Secondly, the type of text style was clearly identified to have a role in defining the magnitude of performance differences between clinical and healthy speakers. Phrasing differences between speaker groups, for instance, were most pronounced in the scripted data, but the distance shrank considerably in the unscripted data. Therefore, analysing only one of the text styles could ultimately have distorted the manifestation of the intonation deficit in FAS speech.

In summary, the findings show that both types of data have their advantages, highlighting that for a comprehensive typological account of intonation in healthy speech in general, and in FAS speech in particular, the analysis of both scripted as well as unscripted text styles is indispensable (cf. section 8.4.1).

## 7.2 The nature of intonation in FAS

The holistic approach to analysing the intonation system in FAS revealed that some dimensions of intonation were unaffected, whereas others differed from the performances of the control speakers. Specifically, the rich pitch accent and boundary tone inventory employed by the speakers with FAS clearly suggests that the abstract phonological categories of intonation are retained, but changes in the distribution, implementation and functional use of these structural elements imply difficulties when instantiating them. Importantly, the analysis also revealed that the three dimensions affected by changes were not compromised to the same extent. Whilst the distribution of pitch accents and boundary tones differed for a few structural categories only, their implementation evidently varied in each aspect investigated, i.e. frequency of accentuation, phrasing and pausing, from that of the control speakers. At the functional level, the marking of new referents was comparable to that of the control speakers, but difficulties arose in relation to given referents, reflected in both encoding strategies. As a consequence of the difficulties experienced, the speakers with FAS were generally less efficient in using intonation to mark information status.

The discerning pattern that emerged from the dimensional analysis clearly allowed the identification of retained and affected levels of intonation in FAS, thereby providing evidence that the AM approach combined with the dimensional analysis can contribute considerably to determining the level of intonational differences between healthy speech and disordered speech (Mennen et al., 2008). The results of the present study indicate that in FAS, the implementation of the structural categories, i.e. the precise realisation of the abstract tonal structure, differs from that of healthy speakers, but not the abstract phonological representation of these categories as such. Support for this finding comes from the study by Moen et al. (2007), which investigated the prosodic patterns of a Norwegian speaker with FAS in whom a reduced ability to vary the dynamic parameters led to problems in differentiating between the two types of Norwegian pitch accents. In the absence of any phonological substitutions, Moen et al. (2007) concluded that the deviant accent production was the result of difficulties in articulating, i.e. implementing, the accent patterns rather than a reflection of phonological issues. The same pattern, i.e. preserved phonological categories, but deviating realisation of these elements, was observed by Mennen et al. (2008) in two speakers with hypokinetic dysarthria. Given the similarities across studies in terms of retained phonological representations, and difficulties in instantiating them, it appears worthwhile to investigate the possibility that this pattern could represent a general feature of the intonation component in speech disorders.

In the case of FAS, the present data strongly suggest that none of the intonational changes seen at the level of distribution, implementation and function represent a primary deficit or core impairment of intonation, but are secondary to compensatory mechanisms and adaptations that were established by speakers in order to cope with the actual speech impairment (Miller et al., 2006). The fact that the three dimensions were not equally affected further implies that the observed intonational changes may not be the result of a single underlying mechanism, but were brought about in a variety of ways. In the following, the three dimensions in question and the potential underlying causes for their disturbance are discussed in greater detail.

**Distribution**: As discussed earlier, the changes to the distributional patterns between speakers with FAS and healthy control speakers were limited to a few structural elements including pitch accent L*H and boundary tone H% (cf. section 7.1.2), i.e. those categories that are known to act as continuation markers. The higher use of both elements in the speakers with FAS was therefore interpreted as a compensatory strategy intended to signal that there is more information to come. By frequently employing continuation markers, the speakers were thought to compensate for other manifestations of speech difficulties in FAS speech such as slower speech rate, halting speech and long pauses. In other words, the distributional differences observed in the speakers with FAS most likely represented a compensatory tactic that was adopted to deal with the observed fluency issues.

**Implementation**: The fact that the speakers with FAS differed from the control speakers in every aspect of implementation examined, i.e. frequency of accentuation, phrasing and pausing, clearly signifies problems when instantiating intonation patterns. The most likely reason for the observed intonational changes at this level are issues with phonatory and respiratory support as evidenced in the restrictions observed in some of the maximum performance tests, in particular the phonation time, which was on average about half of those of the control speakers. As a result of the restrictions, speakers with FAS ran out of breath more quickly and had to take breaths more often, resulting in a higher number of pauses, which in turn may have triggered the division of utterances into smaller phrasing units.

In addition to that, the higher frequency of accentuation observed in the speakers with FAS was likely to have resulted partly from the changes seen in the phrasing pattern. Due to the division of sentences into smaller units it was often the case that discourse referents were separated from the preceding or following referent by phrase boundaries. Yet, following current intonation theories, every intonation phrase requires to bear at least one pitch accent (Pierrehumbert, 1980). Given that referents which were originally positioned in the same intonation phrase now formed a separate phrase, they were automatically assigned a pitch accent for reasons of intonational well-formedness, irrespective of their original informational status. Thus, the rule that every intonation phrase requires at least one pitch accent overrode the strong de-accentuation constraint operating in English. This may explain why the speakers with FAS often assigned a full pitch accent to post-focal given referents instead of de-accenting them. In summary, the changes observed regarding the phrasing and pausing of intonation structures appeared to be a direct result of the physiological constraints experienced by the speakers with FAS in relation to their breath support. The higher frequency of accentuation and the related absence of de-accentuation, in turn, seemed to at least partly originate from the changes in the phrasal component and hence constitute a secondary phenomenon.

**Function**: As already argued in the previous section, there is strong evidence that the shorter phrases observed in the speakers with FAS indirectly impacted on the functional use of intonation in the marking of information status. More specifically, the phrase-structural changes brought about an increase in the frequency of accentuation as intonation rules disallowed the de-accentuation of post-focal given referents if they formed an intonation phrase on their own. As a result, accentuation as such did not necessarily reflect the newness status of an element, but changes to the phrasal structure of utterances. At the same time, the phrase structural limitations constrained the way intonation could be used to mark the givenness status of referents. Similar to the marking of newness, it appears that it was not the encoding of givenness per se that was affected in the speakers with FAS, but the accentedness of referents as an indicator of information status. In this light, the difficulties in marking given referents by means of de-accentuation are to be interpreted as a direct consequence of the structural changes seen at the level of prosodic phrasing.

Although the changes in the functional use of intonation partly appear to be an artefact of phrase length, the latter cannot entirely account for the general inability to reduce prominences in the speakers with FAS, as speakers occasionally realised sentences as one intonation phrase, but still did not consistently de-accent the expected target words. This observation suggests that the mechanism of prominence reduction does not work properly in FAS. Instead, the impairment is most likely a direct result of the reduced ability to control phonetic parameters as evidenced in the respiratory-phonatory screening, where speakers with FAS exhibited more difficulties in gradually manipulating F0 and intensity. Further evidence that the control over the parameter F0 was affected in the current speakers with FAS, and not F0 variation as such comes from the pitch range analyses, which showed a significantly higher span for the speakers with FAS than for the control speakers. In other words, the restricted ability to reduce prominences was not an artefact of an overall reduction in the ability to vary F0, but the result of limitations in exerting control over it. Importantly, restrictions in controlling and manipulating dynamic parameters are a typical feature of dysarthric conditions, suggesting a link between the latter and FAS (cf. section 7.3).

In summary, it appears that none of the surfacing intonational changes observed at the levels of distribution, implementation and function are a direct reflection of an underlying intonation impairment in FAS. Rather, the changes observed represent a combination of compensatory strategies as well as primary and secondary manifestations of physiological limitations affecting speech support systems such as respiration and phonation. More specifically, the observed distributional changes appeared to constitute compensatory mechanisms to indicate continuation, whereas the phrasing and pausing changes at the level of implementation were likely to be a direct reflection of physiological constraints. The changes in the phrasal structuring, in turn, were found to have a knock-on effect on the frequency of accentuation as well as the functional use of intonation, that way demonstrating the extent to which the different dimensions of intonation are interrelated. Based on these findings and in contrast to the widely held view in the literature (e.g. Blumstein et al., 1987; Blumstein & Kurowski, 2006), the present study agrees with Verhoeven and Mariën (2002, 2004, 2010), who argue that the intonational changes in FAS are not necessarily the result of a primary prosodic disturbance. Instead, they are a manifestation of physical deficits that affect the control over the phonetic features as well as compensatory tactics to cope with the restricted ability.

Based on these findings, a model was devised to account for the relationship between the different aspects of intonation and to outline how intonation might be realised in FAS (figure 7.1). It should be noted that this model is a suggestion based purely on the findings of the present study and may be redefined and elaborated on the basis of further research.

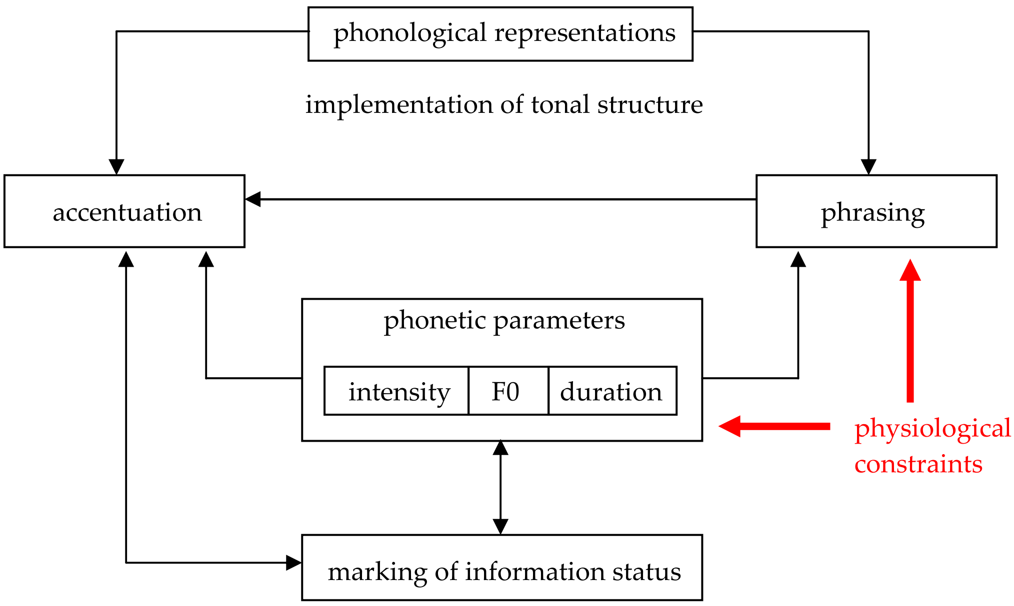


Figure 7.1: Model of intonation realisation with level of breakdown in FAS

The proposed model assumes a direct link between the abstract phonological representations, i.e. pitch accents and boundary tones, and their implementation in terms of accentuation and phrasing, which are connected via a unidirectional link. Whilst both phrasing and accentuation are directly linked to the phonetic means of implementation, the connection of both aspects to the function of intonation in marking information status is less straightforward. Here, the present data only suggest a direct link to accentuation, whereas phrasing only indirectly impacts on the marking of information structure, with accentuation serving a mediating role. On the basis of the present findings, it is further suggested that both encoding strategies employed to mark information status, i.e. phonetic encoding, which in the model is represented by the phonetic parameters, and the phonological encoding, i.e. the accentuation, are directly linked to the function of intonation in the marking of information status. In addition, the findings of the present study suggest that physiological restrictions might have impacted directly on a speaker's performance. Specifically, the present data indicate that the phrasing of utterances as well as the phonetic attributes in FAS speech are influenced by physiological constraints.

Having established the nature of the intonation deficit in the current speakers with FAS, the following section elucidates to what extent the present findings support the various theories put forward to account for deviant intonation patterns in FAS speech.

## 7.3 The nature of FAS

In the literature, a number of explanations have been suggested in order to account for the constellation of segmental and suprasegmental characteristics of speech in FAS (cf. chapter 3.4). Deviant intonation patterns were most frequently considered to be the result of an underlying disturbance of speech prosody (Blumstein et al., 1987; Blumstein & Kurowski, 2006; Kurowski et al., 1996) or a mild form of apraxia of speech (e.g. Ackermann et al., 1993; Coelho & Robb, 2001; Mariën et al., 2006, 2009; Miller et al., 2006; Varley et al., 2006; Varley & Whiteside, 2001; Whiteside & Varley, 1998) or the manifestation of a speech planning deficit (Graff-Radford et al., 1986)[24]. In the following sections, the present study revisits these approaches to demonstrate that none of the three explanations suggested could readily be substantiated by the present data on intonation. Instead, a different position will be taken that entertains the idea of a close relationship between FAS and dysarthric conditions to account for the intonational changes observed in the speakers with FAS.

The above discussion has revealed that the abstract phonological representations, i.e pitch accents and boundary tones, were preserved in each of the four speakers with FAS investigated in the present study. At the same time, intonational changes at the level of distribution, implementation and function occurred in all four individuals. Importantly, though, the intonational alterations observed in FAS speech did not represent a primary intonation deficit, but appeared to be a combination of physiological constraints and compensatory mechanisms that follow from the actual speech impairment, which happened to surface as intonation deficit. With the phonological representations in place, this finding implies that the observed intonational changes - at least in the speakers with FAS investigated in the present study - do not appear to be entirely accounted for by an underlying disturbance of linguistic speech prosody as posited by Blumstein and colleagues (Blumstein et al., 1987; Blumstein & Kurowski, 2006; Kurowski et al., 1996).

A second theory that is frequently put forward when considering the underlying nature of the observed speech changes is that FAS constitutes a mild speech-apraxic

[24] Graff-Radford et al. (1986) considered the long pauses and the inability to highlight the correct words to be a consequence of a planning deficit at sentence level. Given that accentuation reflects the phonological structure of intonation, the sentence level planning deficit was interpreted as a deficit at the level of phonological encoding. AoS, by contrast, is defined as a problem to programme and coordinate speech movements "which situates the likely breakdown at a stage of phonetic encoding or control" (Miller & Wambaugh, 2011).

condition. Aware of the potential involvement of apraxia in FAS speech, a screening based on Dabul's (2000) Apraxia Battery for Adults was administered as part of the main study to assess the presence of these features (cf. chapter 4.3.5.3 and 6.3.2). The screening consisted of three subtests, examining speakers' performances in relation to increasing word length, repeated trials and articulatory characteristics specific to Apraxia of Speech (AoS). The results of the screening revealed that of the three tested individuals with FAS, only MFAS1 exhibited some features, which could be attributed to AoS. MFAS2 and MFAS3 performed well in all subtests.

Despite the overall classification of no or mild impairment only, it is important to note that all three speakers displayed some form of consonantal or vocalic variation in relation to the last subtest, i.e. the subtest assessing articulatory characteristics specific to AoS. Notably, they presented with a similar range of AoS features, which centred around vowel changes, voicing errors and problems of initiating speech. More specifically, of the 15 AoS features described by Dabul (2000), only four were observed in the speakers' performances, which means that FAS speech, if at all, only features a restricted range of characteristics commonly seen in AoS. In this context, it is further important to point out that the few changes that were observed did not conform entirely to the variations typically seen or expected in AoS. For instance, none of the consonantal or vocalic changes in FAS speech were phonemic in nature. In addition, the schwa-additions observed in the speech of MFAS1 were restricted to word-initial positions and did not occur between syllables or in consonant clusters, as often witnessed in AoS. These findings show that although features typically seen in AoS were present in FAS speech, their manifestation and distribution followed different patterns.

Having established the presence of subtle but crucial differences in the speech characteristics between FAS and AoS, there is a potential that the performances of the speakers and the way they completed the screening tasks were influenced by external factors. For instance, it may be possible that some of the variation observed in the subtest that assessed increasing word length could be a direct result of the task design. In an attempt to be as precise as possible, the speakers may have hyperarticulated some of the words which, for example, led to the velarisation of /h/. Furthermore, it remains open whether the difficulties in initiating speech observed in MFAS1 were a consequence of the potential involvement of AoS or residues of the aphasic component. Setting aside the issues with interpreting some of the screening results, it is apparent that the speakers with FAS featured some of the characteristics typically associated with AoS. Looking at the bigger picture though, with the exception of MFAS1, the speech-apraxic features were far too few to clearly establish the presence of AoS in the current participants with FAS.

Yet another position was taken by Graff-Radford et al. (1986), who assumed a speech planning deficit at sentence level to be the primary reason for the observed intonation changes in their speakers with FAS. The authors' conclusion was based on the observation that the speakers experienced marked difficulties in focus-marking specific words in a sentence. Not only did they frequently fail to highlight the target word in question, they also produced unexpected and at times long pauses between words. However, there are two arguments that speak against a deficit in speech planning to be the primary cause for the difficulties observed in the marking of information status in the speakers with FAS investigated in the present study.

Firstly, although the current data showed that the speakers with FAS were able to produce the sentences of the reading task in one intonation phrase, they displayed variation as to the successful de-accentuation of post-focal given referents in these sentences. Whilst in some sentences given information was successfully de-accented, which shows that the speakers successfully planned the phonological structure of the intended utterance as well as succeeded in implementing the phonetic plan, in others they failed to do so. This is exemplified in figures 7.2 and 7.3, where MFAS3, despite producing both sentences as one intonation phrase, only de-accented the given target words in post-focal position in the sentence displayed in 7.2. This fluctuation in performances is not compatible with the assumption of a breakdown in speech planning in FAS, as speakers - albeit infrequently - were able to de-accent given information and hence were able to plan and implement the intonational structure of a sentence. The irregularities in de-accenting post-focal given referents are therefore more likely to be the result of physiological restrictions as outlined above or general cognitive factors known to affect speech planning and production processes in speakers with neurological impairments. The latter includes difficulties such as processing information load caused by working memory problems or deficits in the short term memory buffer storing the phonetic motor execution plans (e.g. Baddeley, 1986; Baddeley & Hitch, 1974; Ravizza, McCormick, Schlerf, Justus, Ivry & Fiez, 2006; Vallar & Shallice, 1990). Consequently, the problems in de-accenting given referents observed in the speakers with FAS are more likely to be an execution problem rather than a purely higher order speech planning deficit.

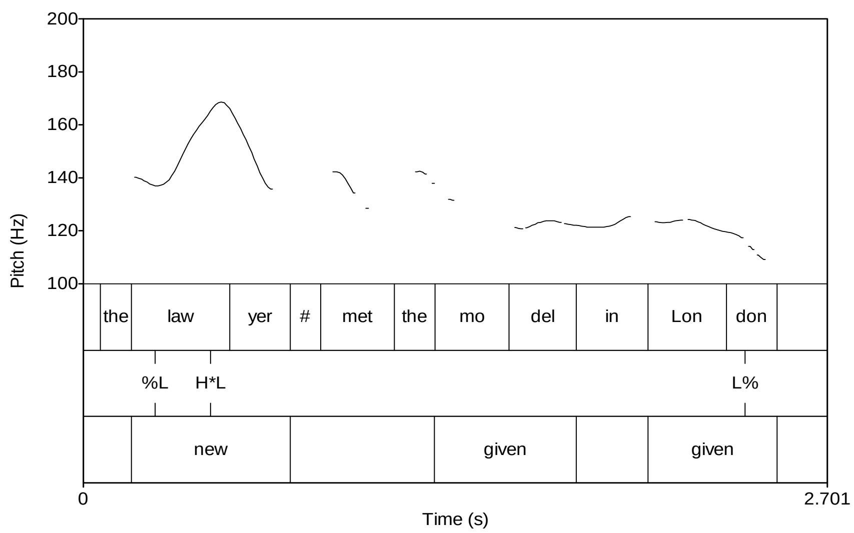


Figure 7.2: Sentence "The lawyer met the model in London" produced by MFAS3 with successful de-accentuation of post-focal target words, following the question "Who met the model in London?" (tier 1: syllable-by-syllable transcription; tier 2: phonological labelling; tier 3: information status of target words)

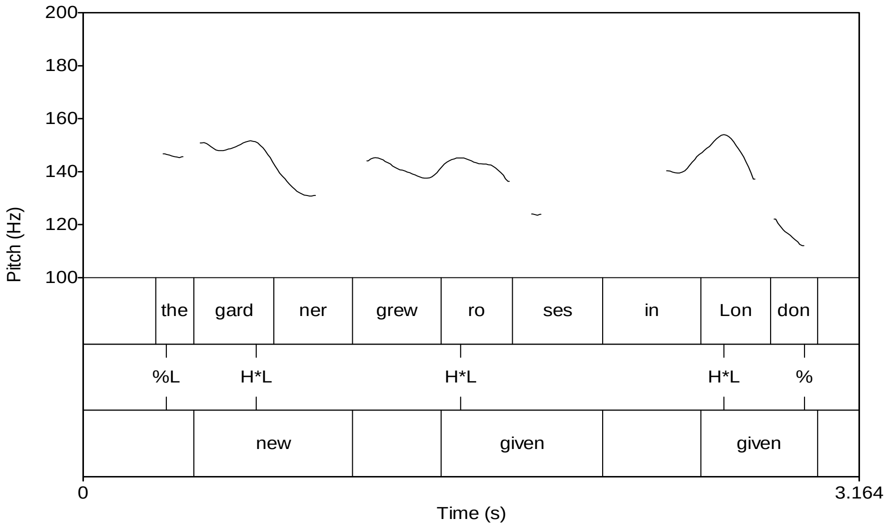


Figure 7.3: Sentence "The gardener grew roses in London" produced by MFAS3 without de-accentuation of post-focal target words, following the question "Who grew roses in London?" (tier 1: syllable-by-syllable transcription; tier 2: phonological labelling; tier 3: information status of target words)

Secondly, there is some further evidence in the form of phrasal downstep that in terms of prosodic planning the speakers with FAS investigated here planned at least one intonation phrase ahead. Specifically, it was observed that in many sentences, which were produced using more than one intonation phrase, phrasal downstep (Gussenhoven, 2004), i.e. the register lowering of an intonation phrase in relation to the preceding one, was present. Figure 7.4 exemplifies this lowering of F0 register of the second IP, showing that F0 was successfully scaled over both intonation phrases of the sentence. Consequently, the size of the prosodic planning window available to the speakers with FAS stretched over at least a couple of intonation phrases. These findings conform with findings from Krivokapić (2007a, 2007b, 2010) who investigated speech planning and phrase length of prosodic units in healthy speech and found that speakers were able to prosodically plan speech production at least one intonation phrase ahead. The presence of phrasal downstep in the current data therefore implies that the speakers with FAS were able to successfully plan a number of prosodic units. This finding in combination with the above mentioned variation in implementing the de-accentuation of given referents suggest that prosodic speech planning as such is relatively unlikely to be affected in FAS.

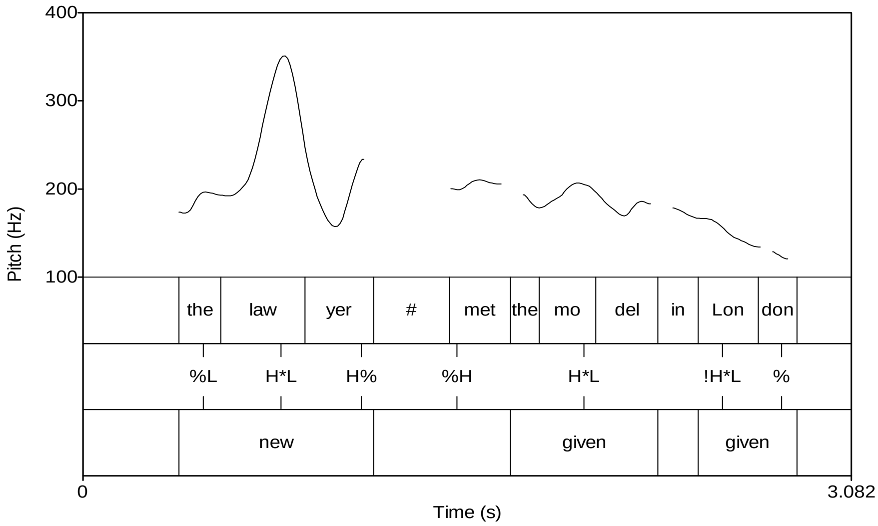


Figure 7.4: Sentence "The lawyer met the model in London" produced by PFAS showing phrasal downstep of the second IP in relation to the preceding one, following the question "Who met the model in London?" (tier 1: syllable-by-syllable transcription; tier 2: phonological labelling; tier 3: information status of target words)

As hypothesised earlier on, the most likely factor impacting on the intonation performances of the speakers investigated in the present study are the physiological constraints often seen in and therefore associated with dysarthric conditions. More specifically, the present data have revealed that breath support as well as breath control appear to be an issue in FAS speech, reflected in the respiratory and phonatory restrictions observed in the dysarthria screening. The conducted screening identified a number of aspects that were problematic for the speakers with FAS. In terms of respiration, for instance, they struggled to count to 20 in one breath. In terms of phonation, maximum performance tests showed that the phonation duration times in the speakers with FAS were on average shorter than those of the control speakers. In addition, problems were evident in varying pitch and loudness in a smooth as well as in a stepwise fashion. The observed difficulties in respiratory and phonatory support were also reflected in the self report provided by the speakers, with each speaker reporting problems with breath support such as running out of breath more quickly than previously.

Issues with the respiratory and phonatory speech support systems were already identified by previous case studies to have a major role in FAS. Gurd et al. (1988), for instance, reported that their speaker with FAS experienced difficulties with phonation, reflected in frequent pausing. Moen et al. (2007) observed difficulties in FAS to vary F0 appropriately at word as well as utterance level, which they used as a basis to argue for the presence of a dysarthric condition. Dysarthria has been defined as a motor speech disorder, where problems with muscular control result in incoordination, and slowness affecting articulation and prosody (e.g. Darley et al., 1975; Kent, 2000). On a more general note, dysarthria was identified to be one of the disorders that frequently accompany FAS (e.g. Aronson, 1980; Berthier et al., 1991; Dankovičová et al., 2001; Coelho & Robb, 2001; Schiff, Alexander, Naeser & Galaburda, 1983; Whitty, 1964). Given the frequent co-occurence of FAS and dysarthria, it stands to reason that the manifestation of the different speech characteristics in FAS are to some degree shaped by the dysarthric condition, without necessarily arriving at the conclusion that FAS represents a mild form of dysarthria. It is therefore possible that the intonational performances of the speakers with FAS investigated in the present study were affected by the presence of dysarthric speech symptoms, with additional involvement of apraxic problems in the case of MFAS1.

## 7.4 Contribution of intonation to foreign accentedness

Although care should be taken when trying to directly relate or equate changes in speech production to the perception of a foreign accent in FAS, there is a potential that some of the intonational features observed in the present study could have contributed to the impression of foreignness. One of the major differences between the speakers with FAS and the examined control speakers concerns the generally greater use of pitch accents in FAS, which is partly caused by the lower incidence of de-accentuation of given referents and partly the result of highlighting additional words such as the verb. Interestingly, the very same accentuation patterns constitute key features of the so-called rich pitch accent languages, a subcategory of intonation languages, which is primarily characterised by high-frequent pitch accenting on almost every content word of the utterance (Hellmuth, personal communication). In these languages, the frequent pitch accents are often resistant to de-accentuation, suggesting that pitch accenting is less of an indicator of the pragmatic organisation of discourse, but rather involved in segmenting speech and indicating prominence at the level of word (Jun, 2005). Higher pitch accentuation is attested in a number of languages, one of which is Italian, which was often identified to be the native language of the speakers with FAS investigated in the present study. Importantly, Italian not only features pitch accents on almost every content word, but it is also known to indicate discourse function by syntactic means rather than intonational ones such as de-accentuation (Cruttenden, 2006; Ladd, 1996; Swerts, et al., 2002). It is a well-established fact that de-accentuation of given referents is not a cognitive universal (Cruttenden, 2006). Whilst in Germanic languages, such as English and German, de-accentuation constitutes a means of intonationally marking information structure, this is clearly not the case for Romance languages, such as Italian or French (cf. section 2.5.2; Phonological encoding of givenness). As a consequence, Italian or French second language (L2) learners of English are likely to experience difficulties in applying the de-accentuation constraint in an appropriate manner to express givenness. Based on the intonation system of their native language, they would be expected to produce full accents on given referents instead. The assumed strong resemblance between the accentuation patterns of Italian and French L2 learners of English and the speakers with FAS, along with the shared restricted ability in signalling the pragmatic function of intonation, may go some way in explaining how the observed changes in intonation could contribute to the listeners' categorisation of FAS speech as sounding foreign.

## 7.5 Summary

This chapter integrated and discussed the findings of chapters 5 and 6 with the aim of demonstrating the importance of investigating the intonation component in FAS in a systematic way. The research discussion of the different dimensions of intonation has successfully elucidated the level of impairment in FAS speech, showing that abstract phonological representations are retained, whereas the distribution, implementation and function of intonation follow different patterns in FAS. These conclusions served as a basis to hypothesise about the underlying nature of FAS and to speculate how the observed intonational changes, in particular the higher frequency of accentuation, can contribute to the perception of foreignness in speakers. Specifically, it was demonstrated that none of the intonational changes represented a core impairment, but were secondary or compensatory manifestations masking the physiological origin of the surface intonation deficit. Based on the present data, it was argued that the physiological restrictions, which impacted on the intonation realisation in FAS, bore similarities to those associated with dysarthria.

# 8 CONCLUSIONS

This final chapter critically reviews the major research findings with the aim of highlighting the contributions of the present study to our understanding of the nature of intonation in FAS. An overview of the thesis is presented in section 8.1, followed by a brief summary of the major findings of this thesis (8.2). The next two sections present a critical reflection on the significant contributions of the findings to the field of research (8.3) and consider their theoretical and practical implications (8.4). In section 8.5, the potential limitations of the current study are explored, before the chapter concludes with recommendations for further research (8.6).

## 8.1 Overview of the thesis

The main aim of this thesis was to gain insights into the nature of intonation in FAS by systematically investigating the different dimensions of intonation (Ladd, 1996), i.e. phonological inventory, distribution, phonetic implementation and function and to examine their interplay. Specifically, this explorative study tried to determine the level of intonation impairment as well as its nature in terms of primary and secondary manifestations of the deficit in order to get a precise picture of the intonational system in FAS and to further our understanding of the principles which underlie intonation realisation in FAS. To achieve this goal, the speech of four individuals with FAS was elicited using different scripted and unscripted text styles and compared to the performances of four healthy gender-, age- and dialect-matched control speakers.

The context of the study was set out in chapters 2 and 3. Chapter 2 laid the groundwork for the thesis, defining the term *intonation* as it has been used in this study and described it in terms of phonology, phonetics and function. Regarding the latter, special attention was paid to the marking of information status of referents in discourse, i.e. the intonational function that was of particular interest in this study. This chapter also presented the model of AM theory (Ladd, 1996) as the theoretical framework within which data were annotated and analysed. Starting from the discussion on the modelling of intonation in disordered speech, the third chapter presented information about the speech disorder foreign accent syndrome, whereby emphasis was laid on a discussion of previous and current intonation research. It was realised from this discussion that there is a rhetoric-reality-gap between the unequivocal presence and relevance of intonational changes in FAS speech and the efforts undertaken to examine their exact manifestations and underlying nature. In chapter 4, the materials, the transcription system and annotation procedures were described, whereas in chapter 5 and 6 the results of the preliminary study and main study were presented. The results of the different case studies were integrated and discussed in relation to the main goal in chapter 7. Results indicated that not all dimensions of intonation in FAS featured changes and those that did could be attributed to different underlying causes, providing a useful insight into the level and nature of the intonational impairment. In the next section of this chapter the major findings of the thesis are summarised, followed by a discussion of the contributions and implications of the findings for theory and practice.

## 8.2 Summary of major findings of the thesis

Based on the findings and the research discussion of this investigation, which set out to accomplish the above mentioned goal of systematically describing the intonation component in FAS, four major findings could be established.

Firstly, the extensive corpus analysis in relation to the four dimensions of intonation (Ladd, 1996) has identified retained as well as affected levels in FAS, therefore providing evidence that a systematic analysis approach can contribute substantially to determining the level of the intonation deficit. Specifically, it was found that the inventory of categorical elements appeared to be preserved in FAS, whereas the intonational changes observed at the level of distribution, implementation and function suggest that speakers experienced difficulties when trying to instantiate the structural categories. It was further found that the three dimensions that featured intonational changes were not affected to the same degree. Whilst distributional changes were observed for a few structural elements only, at the level of implementation aspects of accentuation, phrasing and pausing were equally affected. Restrictions were also observed regarding the functional use of intonation in the marking of information status, where the givenness constraint - in particular in the scripted data sets - was frequently overruled in favour of accentuation. As a consequence of the difficulties with the mechanism of prominence reduction, the speakers with FAS were less successful in signalling effectively the information status of referents in discourse. These findings highlight that for a comprehensive analysis of the intonation component in FAS, and in disordered speech in general, all four levels of intonation should be examined.

Secondly, the analysis of the various scripted and unscripted data sets has revealed that the manifestations of the different dimensions of intonation are influenced by the nature of the respective text style. Here, the most important finding concerned the fact that unscripted data seemed to provide a more realistic picture of the categorical inventory speakers have at their disposal, whilst scripted data was more effective in assessing the functional use of intonation. This finding underlines the importance of using a variety of task types for a comprehensive assessment of disordered intonation.

Thirdly, the present study has revealed that none of the intonational changes observed at the levels of distribution, implementation and function reflect a core impairment of the intonation component in FAS, but that they constitute a combination of primary and secondary effects of physiological changes as well as compensatory mechanisms that are in place to cope with the actual speech impairment. This finding shows that the intonational changes observed in the speakers with FAS are not necessarily the direct result of an underlying disturbance of speech prosody as has been frequently postulated in the literature.

Fourthly, the thesis argues that the respiratory and phonatory issues that were observed to constrain speech in FAS bear strong similarities to restrictions typically associated with dysarthria. This finding suggests that the physiological restrictions resulting in the surfacing intonational changes in FAS might be of dysarthric nature.

The main conclusion to be drawn from these findings is that in FAS the underlying representation of intonation as such is unaffected, but physiological restrictions along with compensatory strategies impact on the realisation of intonation contours. More importantly, the intonational changes observed in relation to the dimensions in question manifested in the different speakers with FAS in a very similar way. Despite the different dialectal backgrounds and the different medical histories, the same levels and the same aspects of intonation were affected in each speaker. Not only did all speakers show an increased use of continuation contours, they further presented with the same tendencies in terms of a higher frequency of accentuation, a higher number of pauses as well as shorter intonation phrases. What is more, all four speakers with FAS exhibited difficulties with the mechanism of prominence reduction, resulting in similar patterns pertaining to the marking of information status. Variation in speakers' performances was only observed in relation to the degree to which the intonational changes occurred, with some speakers displaying, e.g. a shorter mean length of phrases than others. In all, given the strong similarities across speakers there is a potential that the pattern presented here in terms of the affected levels might reflect a universal picture of the intonation component in FAS.

Despite the obvious commonalities regarding the realisation of intonation patterns across speakers, the data of the present study further highlights the importance of assessing performances individually as the underlying mechanisms causing the intonational changes possibly differed between speakers. Specifically, whilst dysarthric influences represent the most likely option to account for the observed intonational changes in speakers MFAS2 and MFAS3, the intonation patterns of MFAS1 might actually reflect the impact of a mild form of AoS - according to the screening tests conducted. In other words, this thesis provides evidence that in FAS different underlying causes can surface and manifest as similar intonation difficulties. Overall, looking beyond the individual differences and variations, the speakers with FAS investigated here share such a significant number of intonational features to warrant generalisations from this study as to the intonation system in FAS.

In summary, the major findings of this thesis can be summarised as follows:

- Given the successful identification of the level of intonational impairment in FAS, a holistic approach to analysing intonation should be adopted in any research aimed at furthering knowledge on the intonation system in disordered speech.
- The type of text style has a role in defining the different dimensions of intonation and needs to be considered accordingly when analysing disordered intonation.
- Surface intonation changes are not necessarily a direct manifestation of an underlying intonation disturbance.
- Performances of the speakers with FAS are to be analysed individually to allow assumptions regarding the underlying nature of the deficit.

## 8.3 Significant contributions of the thesis

This thesis has proved important for a number of reasons, making significant contributions to our understanding of the nature of intonation in FAS and to theory-led research in the field of clinical linguistics.

Firstly, by systematically investigating the different dimensions of intonation, detailed information on the internal organisation of the intonation system in FAS could be obtained, that way taking the ongoing debate about the nature of intonation in FAS further. The thesis demonstrated that a dimensional analysis of intonation can help to identify the level of intonation impairment in FAS. In addition, it was shown that a systematic analysis of the intonation system allows one to differentiate between core impairments and compensatory strategies (Miller et al., 2006).

Secondly, the research of this thesis adds to the small but growing body of research that has successfully applied the AM approach of intonational analysis (Ladd, 1996) to disordered speech. Analysing the intonation patterns of speakers with FAS within a well-recognised framework of intonational analysis is a step towards establishing the use of such theory-led models in the investigation of intonation in disordered speech. A wider use of established theoretical frameworks will provide the necessary basis on which to compare the performances of different populations and speaker groups. Applying the AM approach to disordered intonation is also a move towards bridging the gap between the research fields of clinical linguistics and theoretical linguistics to further theory and practice.

## 8.4 Implications of findings

The findings of the present study have implications for the field of clinical practice as well as for the theory of intonational phonology. In the following, the relevance of the different findings for each area is elucidated in greater detail.

### 8.4.1 Relevance of findings for clinical practice

Regarding the clinical management of intonation deficits the findings of the present study have the potential to inform assessment and intervention in FAS and related speech and language disorders. In relation to the assessment of intonation disorders, the present results highlight the role of text styles for the evaluation of the different dimensions of intonation; in terms of clinical management, findings emphasise the importance of differentiating between primary and secondary intonation deficits.

By investigating the different dimensions of intonation in FAS using a variety of scripted and unscripted text styles, the relevance of the method of elicitation on defining the nature of each dimension of intonation became apparent. Unscripted text styles may provide a more accurate picture of the structural inventory and its distribution, but seem less practical or suitable to fully capture the functional use of intonation, i.e. the marking of information status. The latter was more effectively reflected by the scripted text styles. Although the findings are derived from an investigation of intonation in speakers with FAS and their respective healthy control speakers, the same tendencies across speaker groups strongly suggest that this pattern may hold for other speech and language disorders as well.

Whilst the assessment of the different dimensions of intonation generally proved to be context-sensitive, there were a number of intonation features in FAS speech such as higher pitch accent use and shorter intonation phrases that occurred across speaking styles. The presence of such universal tendencies suggests that the purpose of an intonation assessment has a role in determining which text style is most appropriate to elicit the data. Specifically, if the main focus of the assessment is on obtaining a broad picture of how intonation difficulties manifest themselves in the speech of an individual, the analysis of one text style - be it scripted or unscripted - should be sufficient to yield an overview of the intonational characteristics, as they are likely to be reflected in all text styles. On the other hand, if the focus of the assessment is on a specific aspect of intonation, such as function or distribution of structural elements, the choice of speaking style becomes relevant to the intonational analysis. In other words, the focus of an assessment determines which and how many text styles are required to be assessed in order to yield reliable and robust information on a speaker's intonation component.

The current investigation has further yielded important findings in relation to the manifestation of intonation in FAS that could direct intervention strategies in these individuals. More precisely, the findings revealed that not all aspects of intonation are affected to the same extent. Whilst the phonological level of intonation in FAS was comparable to that of healthy speakers, the implementation and distribution of intonational elements seemed to follow different patterns, ultimately impacting on the functional use of these elements. The differences in the implementation of intonation structures manifested themselves in the phrasing as well as the accentuation patterns, whereby on closer inspection the higher frequency of accentuation and absence of de-accentuation were partly a direct consequence of the changes seen in the phrasal component. These findings show that surface intonational changes are not always a direct manifestation of an underlying intonation deficit, but can constitute secondary phenomena or compensatory tactics. This is an import point to consider in view of possible management strategies in individuals with FAS, as in such cases a direct focus on accenting to improve the pragmatic function of intonation may not yield the desired results of increasing the effectiveness of communication.

Based on the findings of the speakers with FAS described in the present study it may be most effective for intervention to focus on the speech support systems of respiration and phonation to influence the realisation of intonation in FAS. An improved breath support may trigger the production of longer utterances, which in turn may positively impact on the phrasing and accentuation patterns of the affected speakers. In terms of the WHO's ICF, this intervention strategy would address the level of body function and structures (voice and speech functions), with the potential to indirectly influence the foreign or altered accent by changing the frequency of the perceived accentuation. However, as outlined in the literature review on FAS (cf. chapter 3), it is important to keep in mind that the emergence of the foreign or altered accent is considered to be the result of a constellation of segmental as well as suprasegmental features. Given the research focus of this study, only features of intonation, i.e. a suprasegmental feature, were investigated. Consequently, the clinical recommendations pertaining to the relevance of the speech support systems of respiration and phonation refer to the intonation component of FAS only, and should not be generalised to the wider clinical picture of FAS. However, there is a potential that changes to the intonation component may positively impact on the perceived foreign or altered accent, influencing the speaker's well-being and participation in social life. As discussed earlier, intervention is strongly indicated in this client group given the psychosocial consequences the change in accent can bring about. The complexity of neurological condition, speech disorder and psychosocial challenges arising as a result of the change in accent further advocates a holistic approach to intervention that encompasses all levels of ICF. However, in light of the fact that speakers with FAS are intelligible and therefore often considered to have minimal communication concerns it remains to be seen whether the needs of individuals with FAS can be met in a stretched health care system.

### 8.4.2 Relevance of findings for the theory of intonational phonology

Apart from the clinical relevance just outlined, the present study also has implications for the theoretical construct of intonational phonology as it highlights the importance of the phonological level of analysis. Although several authors (in particular Arvaniti, 2007; Kügler & Genzel, submitted; Ladd, 1996, 2008) have outlined the relevance of the phonological level, phonetic approaches to analysing linguistic concepts of intonation still prevail in the current research landscape. However, the behavioural findings of the present study clearly support the view that for a comprehensive picture of the intonation component, and the function of intonation in particular, both phonology and phonetics are to be investigated.

This conclusion is based on the diverging observations made in relation to the phonological and phonetic encoding strategies of both speaker groups. If each encoding pattern were interpreted on its own, it would lead to different conclusions as to the functionality of intonation in FAS speech. The results of the phonetic analyses revealed that, in terms of the marking of information status, speakers with FAS exhibited by and large the same tendencies as the control speakers. In both speaker groups, new information was longer, louder and higher in pitch than given information, which led to the conclusion that in terms of the phonetic encoding of information status speakers with FAS follow the same principles as healthy speakers. That is, from a purely phonetic perspective, the marking information status in FAS appears to be retained to some extent.

However, this interpretation changes if the phonological results are taken into account, as in terms of the phonological encoding of givenness, clear differences between speaker groups emerged. Whilst the control speakers generally preferred de-accentuation over accentuation when marking given referents, the speakers with FAS exhibited the opposite pattern. That is to say, speakers with FAS did not effectively signal new and given information by categorical means, i.e. the presence and absence of pitch accents, but largely relied on gradient means, if at all. This finding points to differences between speakers with FAS and healthy control speakers in the use of the categorical elements and it highlights the relevance of the phonological level for the description of intonation and its functions.

In sum, the analysis of intonation from a speech disordered perspective has provided clear evidence for the relevance of the phonological level of intonation realisation, calling into question the strong association of acoustic parameters and function in current approaches to analysing intonation. Based on these findings it can be concluded that intonation in general, and disordered intonation in particular, is best analysed in a framework that accounts for both, the phonology *and* the phonetics of intonation.

## 8.5 Limitations of the study

The findings of the thesis are limited by a variety of issues including aspects that are related to the analysis of disordered speech in general, but also aspects that are specific to the conduct of the present study. The former includes considerations pertaining to the validity and generalisability of the results, whereas the latter refers to issues relating to the transcription system used to annotate the data as well as the limited potential the explorative data offers in terms of further detailed phonetic analyses.

One general issue that may have impacted on the validity of the results concerns the fact that the speech recordings, and thus the intonational analysis, only reflect the speakers' performances of a single testing date. As a result, the data can only present an extract of the speakers' intonation abilities, which ultimately may not reflect their actual abilities. This is of particular relevance when investigating disordered speech where cognitive skills such as concentration and receptiveness can be affected and hence impact on the speakers' performances. However, this is an issue that commonly arises pertaining to the data collection of clinical speech. In order to gain more robust clinical results, it would therefore be desirable to test participants a number of times, that way retrieving multiple baselines.

Another important point to consider when interpreting the results of the present study is the variety of dialects that were investigated due to the rare nature of FAS. As outlined earlier, this issue was addressed by choosing the IViE transcription system to annotate the data and, more importantly, by dialectally matching the control speakers. Despite the limits the dialectal variation poses in terms of the comparability and generalisability of the findings, it is important to highlight that a number of patterns that emerged were common to all clinical speakers. For instance, the much lower de-accentuation rate was present in all four speakers with FAS, as were the shorter phrasing units, allowing the conclusion that some of the patterns seen in the clinical speakers may represent general features associated with FAS, which occur regardless of the type of dialect spoken.

An issue, which is more closely related to the present study, that could potentially be regarded as a limitation concerns certain aspects inherent to the IViE transcription system. As detailed earlier, the use of IViE was motivated by the fact that it constitutes an annotation system which has already successfully been employed to transcribe disordered intonation data, while at the same time allowing comparisons of different dialects of British English. Consequently, IViE appeared to represent the best option available to annotate the present data. However, during the conduct of the study, it became apparent that some features of the transcription system turned out to be problematic for the data analysis. Although attempts were made to minimise the impact of these aspects, it is still probable that they influenced the way intonation patterns were transcribed.

Firstly, during the process of annotating the clinical data it became evident that the current set of pitch accents offered by IViE did not always suffice to adequately describe disordered intonation, as there were instances where e.g. the label !H* would have been the most appropriate. However, as the aim of the study was to analyse intonation in FAS within an established framework rather than to develop a pitch accent inventory of FAS speech, the use of and/or development of additional labels was avoided. In addition to that, extending the set of labels was thought to have implications for the generalisability of results across speakers and studies.

Secondly, by not specifying the difference between stressed syllable and accented syllable, the IViE transcription guidelines left some room for the interpretation as to what constitutes a prominence (Grabe, 2001). As a result, uncertainty remained pertaining to the assignment of pitch accents to stressed and accented syllables. This became especially apparent when consensus was sought as part of inter-rater agreement discussions. The lack of a clear definition of prominence may account for some of the disparity observed in the reliability measures.

The fact that the elicited clinical data did not permit detailed scaling and alignment measures constitutes a further aspect that might be considered a limitation of the present study. As pointed out previously, the investigation of the different dimensions of intonation using established theoretical frameworks was largely explorative in nature and, although there were some expectations as to how speakers with FAS may realise intonation, by and large performance patterns could not be anticipated. As a consequence, the SENT set was designed based on knowledge gained from investigating intonation in healthy speech. Originally, the materials of the sentence reading task were developed to investigate the linguistic marking of information status of referents, that way elucidating a linguistic notion of intonation, but it was hoped that they could also form the basis for extensive phonetic analyses. While this would have been possible for data elicited from the control speakers - as anticipated they produced the sentences usually as one intonation phrase - this was not the case for the speakers with FAS, where many sentences were divided into more than one intonation phrase. As a result, the size of the different phrasing units as well as the number of pitch accents per phrase varied considerably, hindering the comparability of patterns. In addition, the more frequent use of pitch accents led to tonal crowding which is known to impact on alignment patterns. In summary, accentuation and phrasing patterns differed too widely across speakers with FAS and across speaker groups to allow a meaningful phonetic analysis of alignment and scaling patterns in this study. However, taking the findings of the present study into account, detailed phonetic measures in terms of scaling and alignment would be worth considering in subsequent research studies on intonation in FAS (cf. section 8.6).

Although the limitations detailed above are related to broader issues of data analysis as well as more specific aspects that arose during the conduct of this study, it is important to note that many of the limitations are at least partly the result of this study being explorative in nature. In addition, transcribing intonation is an intricate matter and the issues faced when analysing disordered speech pose challenges in providing an accurate picture of intonation realisation. However, the robust intra- and inter-reliability measures highlight the fact that the conclusions drawn from the current results have strong validity. In addition, many of the present results were in line with previous research, thus underlining the comparability of the current measures with those of other studies.

## 8.6 Recommendations for future research

The present study has set a basis for further work aimed at enhancing our understanding of intonation realisation in disordered speech in general and FAS in particular. The recommendations for future research specifically centre around the broader application of the AM approach to establish a recognised theoretical framework of intonational analysis within the realm of disordered speech, additional perceptual and phonetic analyses of FAS speech and the potential of the current findings for intervention programmes.

Firstly, it is recommended that the AM framework along with the four different dimensions of intonation (Ladd, 1996) be applied to more FAS case studies to validate the findings of the present study and to confirm the major determinants that were identified to have a role in the intonation realisation in FAS speech. In this context it would also be worthwhile to explore the dimensions of intonation across language families, e.g. West Germanic languages versus Romance languages, to gauge the functional-linguistic relevance of intonation in different languages. Conducting comparative studies that are based on the same theoretical framework has the potential to provide a better understanding of how language-specific intonational differences impact on the functional realisation of intonation in FAS speech, and to ascertain whether the intonation patterns observed in this thesis are universal to FAS speech.

At the same time, it is recommended that the AM framework be applied to speech and language disorders other than FAS to establish the use of acknowledged theoretical frameworks of intonational analysis within the area of disordered intonation in general. This step would not just extend the knowledge base about intonation in disordered speech, but also open up a path for integrating the analysis and interpretation of the phonological level of intonation into the research landscape on disordered intonation, which is currently heavily dominated by phonetic approaches. The analysis of intonation in other speech and language disorders would further allow investigation of a larger sample of speakers who share the same dialectal background, thereby providing the opportunity to conduct more thorough statistical analyses and consequently obtain more robust quantitative findings to add to the existing qualitative body of work.

Secondly, it would be useful to explore further in what ways the phonological and phonetic findings correlate with the perceived function of intonation, in order to assess to what extent the intonational changes of the different dimensions impact on the communicative function of intonation in FAS speech. Based on a more detailed and comprehensive analysis, it would be possible to identify the specific cues which listeners use to identify the position of the new, i.e. highlighted, element in discourse and to assess whether their perception is in any way related to the cues speakers with FAS were found to employ. This knowledge, in turn, might help to expand our understanding of how different phonological and phonetic cues interact to influence the perception of intonation, and thus the efficacy of communication.

Thirdly, as outlined earlier on, there is a clear potential for future studies to investigate scaling and alignment patterns in speakers with FAS in order to get finer-grained phonetic information. More detailed knowledge on these phonetic features would provide deeper insights into the timing abilities and their influence on the intonational patterns in speakers with FAS. An investigation of these features could take the findings of the present study into account, designing materials so as to reduce the likelihood of extensive variation by avoiding tonal crowding and a division of sentences into smaller units. That way, a purposeful analysis of the alignment and scaling patterns in speakers with FAS would be warranted.

Finally, most studies investigating intonation patterns in disordered speech like this one focus on identifying the underlying nature of intonational changes. However, very few intervention studies exist that actually test these findings. It is therefore suggested that future studies take the findings of the present study as a point of departure to look at the potential of developing intervention programmes in order to test whether defining the nature of intonation difficulties in FAS and other speech and language disorders can be directly translated into a successful clinical intervention programme.

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# APPENDICES

## Appendix A: The constituents of the prosodic hierarchy

**Syllable:** The *syllable* represents the prosodic unit that structures the sequence of segments. It is the domain of a variety of segmental phenomena such as final devoicing and aspiration. In addition, it is known to be the phonological domain of stress and tone assignment.

**Foot**: The prosodic constituent *foot* consists of a stressed syllable and associated unstressed syllables and is instrumental in defining the stress patterns of languages. The inventory of possible feet is small, with iambic (stress pattern: unstressed stressed) and trochaic (stress pattern: stressed unstressed) feet representing the most common stress patterns (Hayes, 1995).

**Phonological Word**: In general, the *phonological word* comprises one or several feet, and often corresponds to the actual grammatic word.

**Phonological Phrase**: The *phonological phrase* is usually syntactically defined, with boundaries tending to correspond to those of syntactic phrases.

**Intonation Phrase**: An *intonation phrase* generally consists of one or several phonological phrases. At this level of the prosodic hierarchy, the association of tune and text is regulated, whereby different texts can be realised with the same intonation pattern and vice versa. A change in the tune structure does not alter the meaning of a text, but the context in which it is acceptable.

**Utteranc**e: The *utterance* represents the largest unit within which prosodic relations can be defined and usually comprises one or more intonation phrases.

# Appendix B: Materials

## B1 Sentence set

NB: New referents are underlined.

| question | answer |
|---|---|
| **1 The gardener grew roses in London.** | |
| I´ve heard that you have been to the staff garden party yesterday. Have you learned anything new about somebody? | The gardener grew roses in London. |
| Who grew roses in London? | The gardener grew roses in London. |
| What did the gardener grow in London? | The gardener grew roses in London. |
| Where did the gardener grow roses? | The gardener grew roses in London. |
| **2 The landlord owned dwellings in Reading.** | |
| Yesterday you were speaking with our neighbour. I could see that you were having quite a nice chat. What was she telling you? | The landlord owned dwellings in Reading. |
| Who owned dwellings in Reading? | The landlord owned dwellings in Reading. |
| What did the landlord own in Reading? | The landlord owned dwellings in Reading. |
| Where did the landlord own dwellings? | The landlord owned dwellings in Reading. |
| **3 The diva made a movie in Berlin.** | |
| Yesterday there was a big press conference releasing the latest celebrity news. What was the most thrilling bit? | The diva made a movie in Berlin. |
| Who made a movie in Berlin? | The diva made a movie in Berlin. |
| What did the diva make in Berlin? | The diva made a movie in Berlin. |
| Where did the diva make a movie? | The diva made a movie in Berlin. |
| **4 The lawyer met the model in London.** | |
| Rumour has it that Weaver & Partners have got quite an important client. What do you know about that? | The lawyer met the model in London. |
| Who met the model in London? | The lawyer met the model in London. |
| Whom did the lawyer meet in London? | The lawyer met the model in London. |
| Where did the lawyer meet the model? | The lawyer met the model in London. |
| **5 The widow bought a villa in Berlin.** | |
| Hewindon Terrace 7 is under offer. Do you know why? | The widow bought a villa in Berlin. |
| Who bought a villa in Berlin? | The widow bought a villa in Berlin. |
| What did the widow buy in Berlin? | The widow bought a villa in Berlin. |
| Where did the widow buy a villa? | The widow bought a villa in Berlin. |

## B2 Reading passage

I was reading in front of the library when I saw Manny. That usually means trouble. He's rather absent-minded. He came over to me so we talked.

He began, "I can't think what's the easiest way to the zoo from here.
Actually you know, I reckon, but I can't remember."

"Well, start from the wine bar", I said.

"Which wine bar?" Manny asked.

"The Jolly Vine", I answered.

He asked where it was. I told him it was near the Meadow Inn.

"No, no, that's over there between the swimming bath and the garden centre", Manny said.

I said, "Isn't that the Drum and Monkey? Wait a minute, I think you are right. Well, why not go via the river lane?"

"Too long", he said. "Really, I could do with a lift. Have you got a car?" I told him I hadn't, but the thirty-one bus went near there. At this Manny finally gave up with me and said he was off to the leisure centre to play tennis instead.

## B3 Pictures

## B4 Revised sentence set

NB: New referents are underlined.

| question | answer |
|---|---|
| **1 The landlord owned dwellings in Reading.** | |
| Yesterday you were speaking to our neighbour. I could see that you were having quite a nice chat. What was she telling you? | The landlord owned dwellings in Reading. |
| Who owned dwellings in Reading? | The landlord owned dwellings in Reading. |
| What did the landlord own in Reading? | The landlord owned dwellings in Reading. |
| Where did the landlord own dwellings? | The landlord owned dwellings in Reading. |
| **2 The diva made a movie in Venice.** | |
| Yesterday there was a big press conference releasing the latest celebrity news. What was the most thrilling bit? | The diva made a movie in Venice. |
| Who made a movie in Venice? | The diva made a movie in Venice. |
| What did the diva make in Venice? | The diva made a movie in Venice. |
| Where did the diva make a movie? | The diva made a movie in Venice. |
| **3 The lawyer met the model in London.** | |
| Rumour has it that Weaver & Partners have got quite an important client. What do you know about that? | The lawyer met the model in London. |
| Who met the model in London? | The lawyer met the model in London. |
| Whom did the lawyer meet in London? | The lawyer met the model in London. |
| Where did the lawyer meet the model? | The lawyer met the model in London. |
| **4 The widow bought a villa in Ealing.** | |
| 7 Castle Terrace is under offer. Do you know why? | The widow bought a villa in Ealing. |
| Who bought a villa in Ealing? | The widow bought a villa in Ealing. |
| What did the widow buy in Ealing? | The widow bought a villa in Ealing. |
| Where did the widow buy a villa? | The widow bought a villa in Ealing. |
| **5 The model wrote her memoirs in Lima** | |
| I saw you reading that article about celebrities and books in the newspaper. Was there anything worth knowing? | The model wrote her memoirs in Lima. |
| Who wrote her memoirs in Lima? | The model wrote her memoirs in Lima. |
| What did the model write in Lima? | The model wrote her memoirs in Lima. |
| Where did the model write her memoirs? | The model wrote her memoirs in Lima. |
| **6 The gardener grew roses in London.** | |
| I´ve heard that you have been to the staff garden party yesterday. Have you learned anything new | The gardener grew roses in London. |

| | |
|---|---|
| about somebody? | |
| Who grew roses in London? | The gardener grew roses in London. |
| What did the gardener grow in London? | The gardener grew roses in London. |
| Where did the gardener grow roses? | The gardener grew roses in London. |
| **7 The minister made money in London.** | |
| There was no time to read the newspapers today. Anything worth knowing? | The minister made money in London. |
| Who made money in London? | The minister made money in London. |
| What did the minister make in London? | The minister made money in London. |
| Where did the minister make money? | The minister made money in London. |
| **8 The milliner got a memo from Mona.** | |
| Did you notice anything when you were buying your hat? | The milliner got a memo from Mona. |
| Who got a memo from Mona? | The milliner got a memo from Mona. |
| What did the milliner get from Mona? | The milliner got a memo from Mona. |
| Who did the milliner get a memo from? | The milliner got a memo from Mona. |
| **9 The murderer met his lover in Venice.** | |
| You went to that trial, didn't you. What did you hear there? | The murderer met his lover in Venice. |
| Who met his lover in Venice? | The murderer met his lover in Venice. |
| Who did the murderer meet in Venice? | The murderer met his lover in Venice. |
| Where did the murderer meet his lover? | The murderer met his lover in Venice. |
| **10 The minister had a nanny from Norway.** | |
| I saw you with all the executive's wives. Any gossip? | The minister had a nanny from Norway. |
| Who had a nanny from Norway? | The minister had a nanny from Norway. |
| What did the minister have from Norway? | The minister had a nanny from Norway. |
| Where (did you say) had the minister a nanny from? | The minister had a nanny from Norway. |

**B5 Revised reading passage**

NB: New referents are underlined; given referents are in italics.

You wish to know all about my <u>grandfather.</u> Well, he is the best *grandfather* in the world.

He is <u>ninety</u> years old. I think that *ninety* is quite an age. Yet he still thinks as swiftly as ever.

He used to be a <u>lawyer</u>. And, of course, he was the best *lawyer* in town.

He dresses himself in a blue <u>coat</u> with white <u>buttons</u>. I love this *coat* and when I was younger I used to count the *buttons*.

A long <u>beard</u> clings to his chin. I know granny doesn't like the *beard*, but he prefers it that way.

When he speaks, his <u>voice</u> is now a bit cracked. But I remember the impressive *voice* he had when talking to his clients.

Every day, he plays skillfully and with zest upon a small <u>organ</u>. I like to hear him playing the *organ*.

He slowly takes a short <u>walk</u> in the open <u>air</u> each day. My granny often joins him on the *walk* because she likes the fresh *air*.
Unless it's <u>winter</u>; because it can be quite icy round here in *winter*.

Every day he looks after his <u>roses</u>. He has been growing *roses* in his <u>garden</u> for 40 years now. When I visit him we usually sit in the *garden* and have a chat.

We often talk about <u>London</u>, because he used to work in *London*. Weren't it for the <u>weather</u> it would be the best city in the world. But when it comes to nice *weather* he much prefers Venice.

## Appendix C: Screening tests

### C1 Phonation-Respiration Screening – Protocol Sheets

**A RESPIRATION**

**1. at rest**

**1) observe participant**

observations (e.g. in/exhalation not smooth or shallow, marked interruptions)

______________________________________________

______________________________________________

____________________________________________

**2. in speech**

**2) Please count to 20 as quickly as possible.**
(don't worry about articulation)

number of breaths: attempt 1: __ attempt 2: __ attempt 3: __

**3) Please count to 20 with normal pace.** (as you would normally speak)

number of breaths: attempt 1: __ attempt 2: __ attempt 3: __

**B PHONATION**

**1. duration**

**4) Please take a deep breath and say /a/ for as long as possible.**

duration (in sec): attempt 1: __ attempt 2: __ attempt 3: __

observations (e.g. husky, breaks in phonation?)

______________________________________________

______________________________________________

____________________________________________

**5) Please take a deep breath and say /z/ as long as possible.**

duration (in sec): attempt 1: __ attempt 2: __ attempt 3: __

observations (husky, breaks in phonation?)

______________________________________________

______________________________________________

____________________________________________

**6) Please take a deep breath and say /s/ for as long as possible.**

duration (in sec): attempt 1: __ attempt 2: __ attempt 3: __

observations

______________________________________________________________________
______________________________________________________________________
__________________________________________________________________

**2. loudness**

**7) Please count to 5 decreasing the volume on each number.**
(i.e. start with a very loud voice and end in a whisper)

attempt 1: __ attempt 2: __ attempt 3: __

observations

______________________________________________________________________
______________________________________________________________________
__________________________________________________________________

**8) Please count to 5 increasing the volume on each number.**
(i.e. start in a whisper and end with a very loud voice)

attempt 1: __ attempt 2: __ attempt 3: __

observations

______________________________________________________________________
______________________________________________________________________
__________________________________________________________________

**C PROSODY**

**1. intonation**

**9) Please say /a/** (starting as low as you can and ending as high as you can)

attempt 1: __ attempt 2: __ attempt 3: __

observations (e.g. pitch breaks? Uneven progression?)

______________________________________________________________________
______________________________________________________________________
__________________________________________________________________

**10) Please hum several times increasing the pitch each time.**
(i.e. start low and end high)

attempt 1: __ attempt 2: __ attempt 3: __

observations (e.g. pitch breaks? Uneven progression?)

______________________________________________________________________
______________________________________________________________________
___________________________________________________________________

**11) Please hum several times decreasing the pitch each time.**
(i.e. start high and end low)

attempt 1: __ attempt 2: __ attempt 3: __

observations (e.g. pitch breaks? Uneven progression?)

______________________________________________________________________
______________________________________________________________________
___________________________________________________________________

**12) Please say the words as a question or a statement.**
(questions are indicated by a question marks, statement with a period) 2x

| | | | |
|---|---|---|---|
| Hello? | __ | Hello. | __ |
| Today? | __ | Today. | __ |
| Monday? | __ | Monday. | __ |
| Sunday? | __ | Sunday. | __ |
| London? | __ | London. | __ |

observations (e.g. use of clear phonation?)

______________________________________________________________________
______________________________________________________________________
___________________________________________________________________

**D ADDITIONAL INFORMATION**

Any hearing problems? Hearing aids?

______________________________________________________________________
____________________________________________________________________

Do you need glasses, problems related to vision since incident?

______________________________________________________________________
____________________________________________________________________

Do you feel that your mood sometimes affects the way you speak?

______________________________________________________________________
____________________________________________________________________

Any medication?

______________________________________________________________________
____________________________________________________________________

## C2 Phonation-Respiration Screening – Analysis Sheets

| **A RESPIRATION** | | | Rating | R/A |
|---|---|---|---|---|
| **1. at rest** | | | | |
| **2. in speech** | | | | |
| **1-20 F** | | | | |
| **1-20 N** | | | | |
| **CONV** | | | | |
| | | RESPIRATION overall | | |
| **B PHONATION** | | | | |
| **1. duration (in seconds)** | | | | |
| **/a/** | | | | |
| **/z/** | | | | |
| **/s/** | | | | |
| | | duration overall | | |
| **2. loudness (in steps)** | | | | |
| **1-5 ↓** | | | | |
| **1-5 ↑** | | | | |
| **CONV** | | | | |
| | | loudness overall | | |
| | | PHONATION overall | | |
| **C PROSODY** | | | | |
| **1. intonation (in Hertz)** | | | | |
| **/a/ ↑** | | | | |
| **1-5 ↑** | | | | |
| **1-5 ↓** | | | | |
| **Q/A** | | | | |
| **CONV** | | | | |
| | | INTONATION overall | | |

R = retained; A = affected

## C3 Respiration-Phonation Screening – rating criteria

### A RESPIRATION

- **at rest**

1 – no difficulty
2 – inhalation or exhalation not smooth
3 – marked interruptions
4 – little control over rate of inspiration and expiration

- **1-20 F**

1 – no abnormality
2 – very occasional breaks in fluency (one extra break)
3 – up to four breaths to complete task
4 – seven breaths, shallow and marked difficulty

- **1-20 N**

1 – no abnormality
2 – very occasional breaks in fluency
3 – up to four breaths to complete task
4 – seven breaths, shallow and marked difficulty

- **CONV**

1 – no abnormality
2 – very occasional breaks in fluency due to poor respiratory control
3 – speak quickly because of poor respiratory control, voice may fade
4 – breath shallow, only a few words are managed

### B PHONATION - duration

- **/a/**

1 – 15 seconds
2 – 10 seconds
3 – 5 to 10 seconds, breaks in phonation
4 – 3 to 5 seconds

- **/s/**

1 – 15 seconds
2 – 10 seconds
3 – 5 to 10 seconds, breaks in phonation
4 – 3 to 5 seconds

- **/z/**

1 – 15 seconds
2 – 10 seconds
3 – 5 to 10 seconds
4 – 3 to 5 seconds

**B PHONATION – loudness**

- **1-5 ↓**

1 – no abnormality
2 – minimal difficulty, occasional numbers sound similar
3 – changes in volume but noticeably uneven progression
4 – only limited change in volume

- **1-5 ↑**

1 – no abnormality
2 – minimal difficulty, occasional numbers sound similar
3 – changes in volume but noticeably uneven progression
4 – only limited change in volume

- **CONV**

1 – no abnormality
2 – slight huskiness or occasional inappropriate use of volume or pitch
3 – voice deteriorates with length of passage or frequent modulation
4 – consistent impairment of voice quality, volume or pitch

**C PROSODY – intonation**

- **/a/**

1 – no abnormality
2 – good, but some difficulty – e.g. limited range
3 – some changes, but uneven progression
4 – minimal change in pitch

- **1-5 ↑**

1 – no abnormality
2 – good, but some difficulty – e.g. pitch breaks
3 – four distinct pitch changes
4 – minimal change in pitch

- **1-5 ↓**

1 – no abnormality
2 – good, but some difficulty – e.g. pitch breaks
3 – four distinct pitch changes
4 – minimal change in pitch

- **Q/A**

1 – no difficulty
2 – some difficulty
3 – marked difficulty
4 – almost no control

- **CONV**

1 – no abnormality
2 – slight huskiness or occasional inappropriate use of volume or pitch
3 – voice deteriorates with length of passage or frequent modulation
4 – consistent impairment of voice quality, volume or pitch

## C4 Screening of Apraxia of Speech – Protocol Sheets

### 1. Increasing Word Length

Instructions:
Now I would like you to read some words. Please read each word only once.

Scoring:
2 – correct, no struggle, no articulatory error
1 – self corrects, delays, visible or audible searching, articulatory errors

Average the scores for each column, subtract the three-syllable average from the one-syllable average to obtain the Deterioration in Performance Score

| 1 syllable | score |
|---|---|
| thick | |
| zip | |
| jab | |
| please | |
| love | |
| hard | |
| jig | |
| strength | |
| hope | |
| soft | |
| average | |

| 2 syllables | score |
|---|---|
| thicken | |
| zipper | |
| jabber | |
| pleasing | |
| loving | |
| harden | |
| jiggle | |
| strengthen | |
| hopeful | |
| soften | |
| average | |

| 3 syllables | score |
|---|---|
| thickening | |
| zippering | |
| jabbering | |
| pleasingly | |
| lovingly | |
| hardening | |
| jiggling | |
| strengthening | |
| hopefully | |
| softening | |
| average | |

### 2. Repeated Trials Tests

Instructions:
I am going to say a word. Please say it three times. Let's try it. Elephant.

Scoring:
Count the number of errors in each production (substitutions, distortions, additions, omissions) and place that number on the appropriate line.
Compare trial 1 and 3 and score – if 1 contained fewer errors than 3; + if 3 contained fewer errors than 1; or 0 if there was no change. Total the number to get a total amount of change score.

| | Trial 1 | Trial 2 | Trial 3 | Trials 1 and 3 compared |
|---|---|---|---|---|
| ashtray | | | | |
| living room | | | | |
| newspaper | | | | |

| | | | | |
|---|---|---|---|---|
| banana | | | | |
| cigarette | | | | |
| potatoes | | | | |
| butterfly | | | | |
| coffeepot | | | | |
| typewriter | | | | |
| refrigerator | | | | |
| | | | **score** | |

### 3. Inventory of Articulation Characteristics of Apraxia

| | **Y** | **N** |
|---|---|---|
| 1. The participant exhibits phonemic anticipatory errors | | |
| 2. The participant exhibits phonemic perseverative errors | | |
| 3. The participant exhibits phonemic transposition errors | | |
| 4. The participant exhibits phonemic voicing errors | | |
| 5. The participant exhibits phonemic vowel errors | | |
| 6. The participant exhibits visible/audible searching | | |
| 7. The participant exhibits numerous and varied off-target attempts at the word | | |
| 8. The participant's errors are highly inconsistent | | |
| 9. The participant's errors increase as phonemic sequence increases | | |
| 10. The participant exhibits fewer errors in automatic speech | | |
| 11. The participant exhibits marked difficulty initiating speech | | |
| 12. The participant intrudes a schwa sound between syllables or in consonant clusters | | |
| 13. The participant exhibits abnormal prosodic features | | |
| 14. The participant exhibits awareness of errors, and inability to correct them | | |
| 15. The participant exhibits a receptive-expressive gap | | |
| | | |

## C5 Screening of Apraxia of Speech – Analysis Sheets

| **A increasing word length** | | | | | | | class |
|---|---|---|---|---|---|---|---|
| **Syll average** | **20** | | | | | | |
| 1-syll average | | | | | | | |
| 2-syll average | | | | | | | |
| 3-syll average | | | | | | | |
| Deterioration of performance score (1-3) | | | | | **Raw score** | | |
| **Classification of errors**<br>- | | | | | | | |
| **B repeated test trials** | | | | | | | |
| | **Trial 1** | **Trial 2** | **Trial 3** | | | | |
| **1** | | | | | | | |
| **2** | | | | | | | |
| **3** | | | | | | | |
| **4** | | | | | | | |
| **5** | | | | | | | |
| **6** | | | | | | | |
| **7** | | | | | | | |
| **8** | | | | | | | |
| **9** | | | | | | | |
| **10** | | | | | | | |
| | | | | | | | |
| number of + **minus** number of - = | | | | | | | |
| variability | | | | | | | |
| 30 **minus** number of words with errors | | | | | **Raw score** | | |
| **Classification of errors**<br>- | | | | | | | |
| **C inventory of articulation characteristics of apraxia** | | | | | | | |
| **Number of yes** | | | | | **Raw score** | | none |
| **Classification of errors**<br>- | | | | | | | |

## C6 Screening of Apraxia of Speech – Cutoff Scores

A increasing word length

| | |
|---|---|
| 0-1 | none |
| 2-4 | mild |
| 5-7 | moderate |

B repeated test trials

| | |
|---|---|
| 28-30 | none |
| 16-27 | mild |
| 5-15 | moderate |

C inventory of articulation characteristics of apraxia

| | |
|---|---|
| 5+ | highly indicative of apraxia |

## Appendix D: Instructions

### D1 Instructions reading passage

Please read through the passage. When you have finished, I will ask you to read it aloud.

### D2 Instructions picture description task

Please have a look at the four pictures in front of you. Please tell me everything you see going on in these pictures.

### D3 Instructions coffee description task

Please explain to me how you would make a cup of coffee or tea. Please give a detailed description, starting from thinking about wanting to make a cup till you drink it.

### D4 Instructions sentence reading task

All you need to do is read out a couple of sentences in a relaxed and natural way.

The sentences will be presented on slides – switch from one slide to the next by pressing the return button.

There will be question-answer pairs on the slides.

In order to become familiar with them we will start with a few practise question-answer pairs.

When you click the button you will see <u>and</u> hear a question. When you click again you will see the answer. Please read out the answer.

There are also a few slides which have only answers. Please read out the answer.

Take a short break whenever you want.

## Appendix E: Detailed results of the preliminary study

**E1**a Number of structural categories (i.e. raw frequency of pitch accents and boundary tones) per speaker and text style

| | pitch accents | | | | boundary tones | | | |
|---|---|---|---|---|---|---|---|---|
| | **SENT** | **PASS** | **PICT** | **MONO** | **SENT** | **PASS** | **PICT** | **MONO** |
| **PC1** | 36 | 48 | 61 | 45 | 32 | 64 | 76 | 56 |
| **PC2** | 33 | 54 | 74 | 68 | 30 | 74 | 88 | 92 |
| **PFAS** | 68 | 77 | 28 | 60 | 84 | 100 | 34 | 78 |
| **PMS** | 46 | 52 | 50 | 63 | 40 | 66 | 50 | 80 |
| Text style no. | 183 | 231 | 213 | 236 | 186 | 304 | 248 | 306 |
| Total no. | 863 | | | | 1044 | | | |

**E1**b Number of new and given referents per speaker and text style

| | SENT | | PASS | | PICT | | MONO | |
|---|---|---|---|---|---|---|---|---|
| | **new** | **given** | **new** | **given** | **new** | **given** | **new** | **given** |
| **PC1** | 26 | 22 | 18 | 1 | 23 | 13 | 20 | 10 |
| **PC2** | 23 | 16 | 23 | 1 | 17 | 27 | 25 | 23 |
| **PFAS** | 30 | 30 | 25 | 1 | 8 | 6 | 15 | 10 |
| **PMS** | 30 | 30 | 23 | 1 | 15 | 15 | 15 | 17 |
| Total no. | 109 | 98 | 89 | (4)* | 63 | 61 | 75 | 60 |

*not included in analysis

**E2** Distribution of pitch accents per speaker and text style in percentages (%)

| | H*L | !H*L | L*H | H* | L* | L*HL |
|---|---|---|---|---|---|---|
| | | | **SENT** | | | |
| **PC1** | 69 | 6 | 3 | 19 | 3 | 0 |
| **PC2** | 85 | 12 | 0 | 3 | 0 | 0 |
| **PFAS** | 72 | 12 | 0 | 15 | 1 | 0 |
| **PMS** | 70 | 2 | 11 | 0 | 2 | 15 |
| | | | **PASS** | | | |
| **PC1** | 56 | 13 | 8 | 21 | 2 | 0 |
| **PC2** | 63 | 19 | 7 | 9 | 2 | 0 |
| **PFAS** | 48 | 18 | 19 | 12 | 0 | 3 |
| **PMS** | 38 | 23 | 23 | 12 | 4 | 0 |
| | | | **PICT** | | | |
| **PC1** | 34 | 25 | 25 | 15 | 1 | 0 |
| **PC2** | 46 | 31 | 18 | 5 | 0 | 0 |
| **PFAS** | 25 | 36 | 14 | 21 | 0 | 4 |
| **PMS** | 48 | 20 | 22 | 6 | 4 | 0 |
| | | | **MONO** | | | |
| **PC1** | 40 | 27 | 18 | 13 | 2 | 0 |
| **PC2** | 56 | 16 | 24 | 4 | 0 | 0 |
| **PFAS** | 47 | 23 | 22 | 8 | 0 | 0 |
| **PMS** | 48 | 11 | 33 | 3 | 2 | 3 |

**E3** Distribution of boundary tones per speaker and text style in percentages (%)

| | %L | %H | L% | H% | % | %L | %H | L% | H% | % |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | **SENT** | | | | | **PASS** | | |
| **PC1** | 100 | 0 | 38 | 0 | 62 | 53 | 47 | 3 | 0 | 97 |
| **PC2** | 87 | 13 | 0 | 0 | 100 | 59 | 41 | 14 | 2 | 84 |
| **PFAS** | 64 | 36 | 10 | 36 | 54 | 42 | 58 | 4 | 24 | 72 |
| **PMS** | 100 | 0 | 0 | 0 | 100 | 48 | 52 | 21 | 21 | 58 |
| | | | **PICT** | | | | | **MONO** | | |
| **PC1** | 71 | 29 | 18 | 8 | 74 | 36 | 64 | 18 | 7 | 75 |
| **PC2** | 77 | 23 | 11 | 23 | 66 | 61 | 39 | 7 | 21 | 72 |
| **PFAS** | 41 | 59 | 18 | 35 | 47 | 49 | 51 | 13 | 21 | 66 |
| **PMS** | 56 | 44 | 7 | 47 | 72 | 70 | 30 | 10 | 25 | 65 |

**E4** Frequency patterns of phrase length (1 to 3 syllables, 4 to 6 syllables and longer than 6 syllables) per speaker and text style in percentages (%)

| | SENT | | | PASS | | | PICT | | | MONO | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1-3** | **4-6** | **>6** | **1-3** | **4-6** | **>6** | **1-3** | **4-6** | **>6** | **1-3** | **4-6** | **>6** |
| **PC1** | 0 | 0 | 100 | 28 | 41 | 31 | 8 | 50 | 42 | 15 | 35 | 50 |
| **PC2** | 13 | 0 | 86 | 35 | 38 | 27 | 18 | 39 | 43 | 13 | 41 | 46 |
| **PFAS** | 50 | 24 | 26 | 55 | 31 | 14 | 41 | 35 | 24 | 28 | 49 | 23 |
| **PMS** | 0 | 0 | 100 | 21 | 42 | 37 | 16 | 48 | 36 | 28 | 25 | 47 |

**E5** Accentuation of new and given referents per speaker and text style in percentages (%)

| | new | | | | given | | | |
|---|---|---|---|---|---|---|---|---|
| | **SENT** | **PASS** | **PICT** | **MONO** | **SENT** | **PASS** | **PICT** | **MONO** |
| **PC1** | 100 | 89 | 100 | 90 | 20 | - | 77 | 60 |
| **PC2** | 100 | 91 | 94 | 96 | 20 | - | 81 | 57 |
| **PFAS** | 100 | 100 | 100 | 100 | 75 | - | 100 | 90 |
| **PMS** | 100 | 100 | 100 | 100 | 0 | - | 67 | 82 |

**E6** Pitch patterns of new referents per text style and speaker in percentages (%)

| | DEACC | H* | H*L | !H*L | L* | L*H | L*HL |
|---|---|---|---|---|---|---|---|
| | | | | **SENT** | | | |
| **PC1** | 0 | 27 | 73 | 0 | 0 | 0 | 0 |
| **PC2** | 0 | 0 | 91 | 9 | 0 | 0 | 0 |
| **PFAS** | 0 | 13 | 80 | 7 | 0 | 0 | 0 |
| **PMS** | 0 | 0 | 70 | 3 | 0 | 3 | 24 |
| | | | | **PASS** | | | |
| **PC1** | 11 | 6 | 56 | 22 | 0 | 5 | 0 |
| **PC2** | 9 | 4 | 52 | 34 | 0 | 0 | 0 |
| **PFAS** | 0 | 12 | 52 | 16 | 0 | 20 | 0 |
| **PMS** | 0 | 0 | 39 | 39 | 0 | 22 | 0 |
| | | | | **PICT** | | | |
| **PC1** | 0 | 17 | 39 | 22 | 0 | 22 | 0 |
| **PC2** | 6 | 6 | 35 | 29 | 0 | 24 | 0 |
| **PFAS** | 0 | 14 | 14 | 57 | 0 | 15 | 0 |
| **PMS** | 0 | 14 | 33 | 20 | 0 | 33 | 0 |
| | | | | **MONO** | | | |
| **PC1** | 10 | 5 | 60 | 20 | 0 | 5 | 0 |
| **PC2** | 4 | 0 | 48 | 20 | 0 | 28 | 0 |
| **PFAS** | 0 | 0 | 53 | 27 | 0 | 20 | 0 |
| **PMS** | 0 | 0 | 27 | 20 | 0 | 53 | 0 |

**E7** Pitch patterns of given referents in the sentence set per position and speaker in percentages (%)

| | DEACC | H* | H*L | !H*L | L* | L*H | L*HL |
|---|---|---|---|---|---|---|---|
| | | | | **Pre-focal position** | | | |
| **PC1** | 0 | 0 | 86 | 0 | 0 | 14 | 0 |
| **PC2** | 0 | 0 | 86 | 14 | 0 | 0 | 0 |
| **PFAS** | 7 | 13 | 80 | 0 | 0 | 0 | 0 |
| **PMS** | 0 | 0 | 73 | 0 | 7 | 20 | 0 |
| | | | | **Post-focal position** | | | |
| **PC1** | 80 | 0 | 0 | 13 | 7 | 0 | 0 |
| **PC2** | 78 | 0 | 11 | 11 | 0 | 0 | 0 |
| **PFAS** | 26 | 7 | 20 | 40 | 7 | 0 | 0 |
| **PMS** | 100 | 0 | 0 | 0 | 0 | 0 | 0 |

**E8** Pitch patterns of given referents in the unscripted data sets per speaker in percentages (%)

| | DEACC | H* | H*L | !H*L | L* | L*H | L*HL |
|---|---|---|---|---|---|---|---|
| | | | | **PICT** | | | |
| **PC1** | 24 | 8 | 38 | 15 | 7 | 7 | 0 |
| **PC2** | 19 | 4 | 37 | 22 | 3 | 15 | 0 |
| **PFAS** | 0 | 33 | 33 | 17 | 0 | 17 | 0 |
| **PMS** | 33 | 0 | 20 | 20 | 7 | 20 | 0 |
| | | | | **MONO** | | | |
| **PC1** | 40 | 10 | 10 | 30 | 10 | 0 | 0 |
| **PC2** | 44 | 0 | 26 | 17 | 0 | 13 | 0 |
| **PFAS** | 10 | 0 | 60 | 20 | 0 | 10 | 0 |
| **PMS** | 18 | 12 | 47 | 0 | 0 | 23 | 0 |

**E9** Means and standard deviations (SD) per parameter, information status and speaker for normalised data and raw data

*Normalised data*

| | initial | | | | medial | | | | final | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | new | | given | | new | | given | | new | | given | |
| | | | | | | duration | | | | | | |
| | mean | SD | mean | SD | mean | SD | mean | SD | mean | SD | mean | SD |
| PC1 | 0.26 | 1.11 | -0.32 | 1.20 | -0.27 | 0.59 | -0.71 | 0.38 | 0.77 | 0.81 | 0.27 | 0.81 |
| PC2 | -0.07 | 1.13 | -0.69 | 1.16 | 0.35 | 0.59 | -0.16 | 0.72 | 0.37 | 0.74 | 0.20 | 1.03 |
| PFAS | 0.43 | 0.98 | 0.77 | 0.99 | 0.17 | 0.60 | -0.17 | 0.63 | 0.02 | 0.83 | -1.23 | 0.43 |
| PMS | 0.28 | 1.11 | 0.00 | 0.86 | -0.24 | 0.94 | -0.40 | 0.98 | 0.67 | 0.56 | -0.32 | 0.96 |
| | | | | | | intensity | | | | | | |
| | mean | SD | mean | SD | mean | SD | mean | SD | mean | SD | mean | SD |
| PC1 | 0.88 | 0.60 | 0.14 | 0.58 | -0.53 | 0.44 | 1.01 | 0.69 | -0.17 | 0.42 | -1.33 | 0.67 |
| PC2 | 0.93 | 0.53 | 0.54 | 0.62 | -0.83 | 0.65 | 0.59 | 0.56 | 0.06 | 0.74 | -1.28 | 0.35 |
| PFAS | 0.58 | 0.40 | 0.42 | 0.58 | -0.01 | 0.99 | 0.72 | 0.42 | -0.17 | 0.65 | -1.54 | 0.61 |
| PMS | 0.95 | 0.59 | 0.53 | 0.94 | 0.18 | 0.74 | 0.25 | 0.43 | -0.68 | 0.62 | -1.22 | 0.59 |
| | | | | | | F0 | | | | | | |
| | mean | SD | mean | SD | mean | SD | mean | SD | mean | SD | mean | SD |
| PC1 | 1.03 | 0.77 | 0.86 | 0.49 | 0.27 | 0.56 | -0.34 | 0.80 | -0.56 | 0.35 | -1.26 | 0.27 |
| PC2 | 0.93 | 0.54 | 0.98 | 0.62 | 0.23 | 0.88 | -0.41 | 0.44 | -0.51 | 0.46 | -1.23 | 0.46 |
| PFAS | 0.56 | 0.50 | 0.74 | 0.23 | 0.55 | 0.92 | -0.30 | 0.63 | -0.06 | 0.90 | -1.49 | 0.28 |
| PMS | 0.83 | 0.62 | 0.21 | 0.39 | 0.42 | 0.85 | -0.76 | 0.48 | 0.53 | 1.07 | -1.22 | 0.12 |

*Raw data*

| | initial | | | | medial | | | | final | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | new | | given | | new | | given | | new | | given | |
| | **duration** | | | | | | | | | | | |
| | mean | SD | mean | SD | mean | SD | mean | SD | mean | SD | mean | SD |
| PC1 | 256.43 | 58.55 | 225.41 | 63.42 | 228.18 | 31.13 | 204.80 | 19.95 | 283.31 | 42.62 | 256.63 | 42.71 |
| PC2 | 198.02 | 40.92 | 175.34 | 41.96 | 213.07 | 21.32 | 194.72 | 26.19 | 213.63 | 26.64 | 207.52 | 37.36 |
| PFAS | 315.46 | 70.39 | 339.80 | 71.26 | 296.30 | 42.96 | 271.84 | 45.31 | 285.77 | 59.57 | 195.53 | 31.08 |
| PMS | 368.19 | 97.03 | 343.84 | 75.86 | 322.27 | 82.12 | 308.08 | 86.14 | 402.64 | 49.30 | 315.78 | 84.40 |
| | **intensity** | | | | | | | | | | | |
| | mean | SD | mean | SD | mean | SD | mean | SD | mean | SD | mean | SD |
| PC1 | 59.96 | 2.16 | 60.44 | 2.46 | 57.31 | 2.06 | 56.19 | 1.49 | 54.92 | 1.59 | 52.03 | 2.41 |
| PC2 | 53.37 | 2.70 | 51.66 | 2.84 | 51.45 | 3.12 | 49.00 | 3.73 | 44.50 | 3.26 | 42.25 | 1.77 |
| PFAS | 73.72 | 2.15 | 74.44 | 2.28 | 72.87 | 3.10 | 69.64 | 3.53 | 70.54 | 5.33 | 62.27 | 3.31 |
| PMS | 64.46 | 3.17 | 60.70 | 2.31 | 62.21 | 5.03 | 55.74 | 3.31 | 60.35 | 3.98 | 52.87 | 3.16 |
| | **F0** | | | | | | | | | | | |
| | mean | SD | mean | SD | mean | SD | mean | SD | mean | SD | mean | SD |
| PC1 | 262.32 | 37.30 | 254.17 | 23.98 | 225.53 | 27.14 | 195.81 | 38.64 | 184.95 | 16.73 | 151.00 | 13.23 |
| PC2 | 112.53 | 7.28 | 113.13 | 8.40 | 103.05 | 11.96 | 94.31 | 5.89 | 93.04 | 6.23 | 83.22 | 6.23 |
| PFAS | 292.90 | 31.10 | 303.98 | 14.25 | 292.22 | 57.62 | 239.33 | 39.68 | 253.88 | 56.54 | 164.71 | 17.67 |
| PMS | 132.16 | 17.43 | 114.68 | 10.95 | 120.50 | 24.03 | 87.16 | 13.56 | 123.88 | 30.17 | 74.15 | 3.28 |

**E10** Percentage differences between new and given referents per parameter, position and speaker

| | duration | | | intensity | | | F0 | | |
|---|---|---|---|---|---|---|---|---|---|
| | T1 | T2 | T3 | T1 | T2 | T3 | T2 | T2 | T3 |
| PC1 | 12.37 | 9.50 | 9.16 | -0.83 | 1.85 | 5.26 | 6.09 | 12.47 | 18.21 |
| PC2 | 10.90 | 8.72 | 3.23 | 3.06 | 4.74 | 4.94 | 1.88 | 7.37 | 10.54 |
| PFAS | -7.68 | 7.59 | 30.96 | -1.06 | 4.40 | 11.60 | 12.67 | 16.97 | 34.41 |
| PMS | 5.40 | 3.45 | 22.58 | 5.76 | 10.18 | 12.27 | 6.51 | 26.98 | 39.41 |

**E11** Pitch range measures of level and span per speaker and condition

| | level | | | | span | | | |
|---|---|---|---|---|---|---|---|---|
| | T1 new | T2 new | T3 new | all new | T1 new | T2 new | T3 new | all new |
| PC1 | 139.94 | 142.58 | 148.76 | 140.02 | 134.36 | 111.58 | 121.79 | 110.32 |
| PC2 | 69.88 | 69.48 | 68.83 | 69.80 | 45.30 | 43.10 | 45.52 | 41.26 |
| PFAS | 128.80 | 129.62 | 138.12 | 121.86 | 158.32 | 195.90 | 183.26 | 176.82 |
| PMS | 67.94 | 65.38 | 65.00 | 68.10 | 75.84 | 68.72 | 83.08 | 56.98 |

**E12** Means and standard deviations (SD) of the raw data and normalised F0 measures for the de-accentuation measures per speaker (Bi = boundary initial, H1 = F0 maximum on T1, H2 = F0 maximum on T2, H3 = F0 maximum on T3, FL = final low)

*Normalised data*

| | **Bi** | | **H1** | | **H2** | | **H3** | | **FL** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | **initial** | | | | | |
| | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** |
| **PC1** | -0.18 | 0.30 | 1.69 | 0.60 | -0.47 | 0.27 | -0.67 | 0.25 | -1.07 | 0.18 |
| **PC2** | 0.12 | 0.14 | 1.38 | 0.50 | -0.06 | 0.31 | -0.78 | 0.25 | -1.37 | 0.19 |
| **PFAS** | -0.46 | 0.18 | 0.90 | 0.51 | -0.16 | 0.22 | -0.73 | 0.17 | -1.24 | 0.06 |
| **PMS** | -0.41 | 0.10 | 1.62 | 0.54 | -0.67 | 0.10 | -0.74 | 0.13 | -0.95 | 0.09 |
| | | | | | **medial** | | | | | |
| | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** |
| **PC1** | -0.37 | 0.24 | 1.28 | 0.59 | 0.96 | 0.54 | -1.02 | 0.16 | -1.02 | 0.20 |
| **PC2** | 0.09 | 0.41 | 1.22 | 0.25 | 0.84 | 0.87 | -0.33 | 0.35 | -1.39 | 0.17 |
| **PFAS** | -0.24 | 0.30 | 1.15 | 0.19 | 1.42 | 0.85 | -0.78 | 0.29 | -1.23 | 0.20 |
| **PMS** | -0.14 | 0.22 | 0.43 | 0.34 | 1.18 | 0.98 | -0.74 | 0.09 | -1.03 | 0.09 |
| | | | | | **final** | | | | | |
| | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** |
| **PC1** | 0.12 | 0.34 | 1.28 | 0.38 | 0.62 | 0.78 | -0.26 | 0.38 | -0.89 | 0.19 |
| **PC2** | 0.01 | 0.30 | 1.29 | 0.67 | 0.29 | 0.32 | 0.12 | 0.34 | -1.43 | 0.08 |
| **PFAS** | -0.34 | 0.21 | 1.11 | 0.19 | 0.67 | 0.44 | 1.05 | 0.50 | -1.11 | 0.41 |
| **PMS** | -0.18 | 0.28 | 0.84 | 0.27 | 0.08 | 0.36 | 1.77 | 0.39 | -1.05 | 0.18 |

*Raw data*

| | Bi | | H1 | | H2 | | H3 | | FL | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | **initial** | | | | | |
| | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** |
| **PC1** | 183.08 | 14.35 | 274.30 | 29.00 | 169.34 | 12.94 | 159.32 | 12.38 | 139.94 | 8.83 |
| **PC2** | 94.38 | 2.35 | 115.18 | 8.28 | 91.46 | 5.04 | 79.50 | 4.17 | 69.88 | 3.12 |
| **PFAS** | 186.60 | 13.32 | 287.12 | 37.83 | 209.00 | 16.11 | 166.20 | 12.84 | 128.80 | 4.36 |
| **PMS** | 83.68 | 2.87 | 143.78 | 15.92 | 76.14 | 3.05 | 74.20 | 3.85 | 67.94 | 2.78 |
| | | | | | **medial** | | | | | |
| | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** |
| **PC1** | 173.82 | 11.72 | 254.16 | 28.54 | 238.54 | 26.29 | 142.68 | 7.65 | 142.58 | 9.76 |
| **PC2** | 93.90 | 6.72 | 112.58 | 4.16 | 106.32 | 14.30 | 86.94 | 5.70 | 69.48 | 2.86 |
| **PFAS** | 202.80 | 22.06 | 305.24 | 14.27 | 325.52 | 62.53 | 163.22 | 21.34 | 129.62 | 15.14 |
| **PMS** | 91.76 | 6.49 | 108.60 | 10.15 | 130.88 | 28.82 | 74.10 | 2.58 | 65.38 | 2.80 |
| | | | | | **final** | | | | | |
| | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** |
| **PC1** | 197.78 | 16.67 | 254.18 | 18.32 | 222.28 | 37.65 | 179.38 | 18.51 | 148.76 | 9.27 |
| **PC2** | 92.50 | 4.95 | 113.68 | 11.10 | 97.16 | 5.26 | 94.46 | 5.56 | 68.83 | 1.33 |
| **PFAS** | 195.04 | 15.67 | 302.72 | 14.11 | 269.66 | 32.40 | 297.94 | 36.78 | 138.12 | 30.32 |
| **PMS** | 90.56 | 8.21 | 120.76 | 7.92 | 98.18 | 10.75 | 148.08 | 11.59 | 65.00 | 5.34 |

## Appendix F: Detailed results of the main study

**F1**a Number of structural categories (i.e. raw frequency of pitch accents and boundary tones) per speaker, speaker group and text style (for each group means and standard deviations (SD) are displayed)

| | pitch accents | | | | boundary tones | | | |
|---|---|---|---|---|---|---|---|---|
| | **SENT** | **PASS** | **PICT** | **MONO** | **SENT** | **PASS** | **PICT** | **MONO** |
| **MC1** | 92 | 78 | 22 | 21 | 84 | 96 | 32 | 30 |
| **MC2** | 98 | 71 | 43 | 34 | 90 | 82 | 62 | 44 |
| **MC2** | 93 | 71 | 48 | 60 | 82 | 88 | 58 | 72 |
| **sum** | **283** | **220** | **113** | **115** | **256** | **266** | **152** | **146** |
| **mean** | **94.3** | **73.3** | **37.7** | **38.3** | **85.3** | **88.7** | **50.7** | **48.7** |
| **SD** | **3.2** | **4.0** | **13.8** | **19.9** | **4.2** | **7.0** | **16.3** | **21.4** |
| **MFAS1** | 119 | 89 | 42 | 27 | 102 | 106 | 50 | 32 |
| **MFAS2** | 125 | 89 | 52 | 49 | 112 | 110 | 70 | 56 |
| **MFAS3** | 116 | 85 | 30 | 30 | 166 | 100 | 34 | 44 |
| **sum** | **360** | **263** | **124** | **106** | **380** | **316** | **154** | **132** |
| **mean** | **120.0** | **87.7** | **41.3** | **35.3** | **126.7** | **105.3** | **51.3** | **44.0** |
| **SD** | **4.6** | **2.3** | **11.0** | **11.9** | **34.4** | **5.0** | **18.0** | **12.0** |
| Text style no. | 643 | 483 | 237 | 221 | 636 | 582 | 306 | 278 |
| Total no. | 1584 | | | | 1802 | | | |

**F1**b Number of new and given referents per speaker and text style

| | SENT | | PASS | | PICT | | MONO | |
|---|---|---|---|---|---|---|---|---|
| | **new** | **given** | **new** | **given** | **new** | **given** | **new** | **given** |
| **MC1** | 60 | 60 | 15 | 15 | 6 | 5 | 7 | 6 |
| **MC2** | 60 | 60 | 15 | 15 | 16 | 12 | 12 | 7 |
| **MC2** | 60 | 60 | 15 | 15 | 10 | 17 | 17 | 17 |
| **MFAS1** | 60 | 60 | 15 | 15 | 9 | 14 | 9 | 5 |
| **MFAS2** | 60 | 60 | 15 | 15 | 16 | 12 | 16 | 12 |
| **MFAS3** | 60 | 60 | 15 | 15 | 12 | 7 | 10 | 5 |
| Total no. | 360 | 360 | 90 | 90 | 69 | 67 | 71 | 52 |

**F2** Distribution of pitch accents per speaker and text style in percentages (%)

| | L* | H* | H*L | !H*L | L*H | L*HL |
|---|---|---|---|---|---|---|
| | | | **SENT** | | | |
| **MC1** | 0 | 40 | 49 | 10 | 1 | 0 |
| **MC2** | 2 | 12 | 73 | 11 | 1 | 0 |
| **MC3** | 1 | 14 | 68 | 17 | 0 | 0 |
| **mean** | **1.0** | **22.2** | **63.4** | **12.7** | **0.7** | **0** |
| **MFAS1** | 0 | 18 | 32 | 7 | 43 | 0 |
| **MFAS2** | 0 | 22 | 62 | 10 | 6 | 1 |
| **MFAS3** | 0 | 16 | 78 | 6 | 0 | 0 |
| **mean** | **0** | **18.8** | **57.0** | **7.5** | **16.4** | **0.3** |
| | | | **PASS** | | | |
| **MC1** | 0 | 19 | 55 | 13 | 13 | 0 |
| **MC2** | 0 | 23 | 54 | 23 | 0 | 1 |
| **MC3** | 0 | 21 | 59 | 20 | 0 | 0 |
| **mean** | **0** | **20.9** | **55.9** | **18.4** | **4.3** | **0.5** |
| **MFAS1** | 0 | 26 | 24 | 11 | 39 | 0 |
| **MFAS2** | 0 | 28 | 44 | 21 | 6 | 1 |
| **MFAS3** | 0 | 33 | 54 | 11 | 1 | 1 |
| **mean** | **0** | **28.9** | **40.5** | **14.4** | **15.4** | **0.8** |
| | | | **PICT** | | | |
| **MC1** | 9 | 27 | 55 | 9 | 0 | 0 |
| **MC2** | 5 | 12 | 42 | 30 | 12 | 0 |
| **MC3** | 2 | 15 | 71 | 10 | 2 | 0 |
| **mean** | **5.3** | **17.8** | **55.8** | **16.6** | **4.6** | **0** |
| **MFAS1** | 5 | 24 | 19 | 5 | 48 | 0 |
| **MFAS2** | 2 | 25 | 63 | 4 | 4 | 2 |
| **MFAS3** | 7 | 23 | 37 | 10 | 23 | 0 |
| **mean** | **4.5** | **24.1** | **39.7** | **6.2** | **24.9** | **0.6** |
| | | | **MONO** | | | |
| **MC1** | 0 | 29 | 38 | 24 | 10 | 0 |
| **MC2** | 12 | 18 | 44 | 26 | 0 | 0 |
| **MC3** | 13 | 10 | 30 | 28 | 18 | 0 |
| **mean** | **8.4** | **18.7** | **37.4** | **26.2** | **9.3** | **0** |
| **MFAS1** | 7 | 19 | 33 | 11 | 30 | 0 |
| **MFAS2** | 13 | 10 | 30 | 28 | 18 | 0 |
| **MFAS3** | 0 | 37 | 30 | 3 | 30 | 0 |
| **mean** | **6.9** | **21.7** | **31.1** | **14.3** | **26.0** | **0** |

**F3** Distribution of boundary tones per speaker and text style in percentages (%)

| | %L | %H | L% | H% | % | %L | %H | L% | H% | % |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | **SENT** | | | | | **PASS** | | |
| **MC1** | 88 | 12 | 43 | 0 | 57 | 58 | 42 | 8 | 0 | 92 |
| **MC2** | 93 | 7 | 96 | 4 | 0 | 37 | 63 | 2 | 7 | 90 |
| **MC3** | 63 | 36 | 7 | 0 | 92 | 55 | 45 | 0 | 14 | 86 |
| **mean** | **81.3** | **18.3** | **48.7** | **1.3** | **49.6** | **50** | **50** | **4** | **7** | **89** |
| **MFAS1** | 96 | 4 | 0 | 16 | 84 | 64 | 36 | 0 | 15 | 85 |
| **MFAS2** | 71 | 29 | 0 | 29 | 71 | 64 | 36 | 0 | 38 | 62 |
| **MFAS3** | 89 | 11 | 2 | 22 | 76 | 64 | 36 | 0 | 24 | 76 |
| **mean** | **85.3** | **14.7** | **0.6** | **22.3** | **77** | **64** | **36** | **0** | **26** | **74** |
| | | | **PICT** | | | | | **MONO** | | |
| **MC1** | 44 | 56 | 6 | 38 | 56 | 73 | 27 | 20 | 27 | 53 |
| **MC2** | 58 | 42 | 0 | 45 | 55 | 36 | 64 | 0 | 18 | 82 |
| **MC3** | 66 | 34 | 17 | 24 | 59 | 72 | 28 | 3 | 14 | 83 |
| **mean** | **55.8** | **44.2** | **7.8** | **35.6** | **56.6** | **60.6** | **39.4** | **7.6** | **19.6** | **72.8** |
| **MFAS1** | 84 | 16 | 4 | 16 | 80 | 56 | 44 | 0 | 0 | 100 |
| **MFAS2** | 49 | 51 | 0 | 40 | 60 | 64 | 36 | 0 | 32 | 68 |
| **MFAS3** | 59 | 41 | 6 | 12 | 82 | 32 | 68 | 0 | 36 | 64 |
| **mean** | **63.8** | **36.2** | **3.3** | **22.6** | **74.1** | **50.8** | **49.2** | **0.0** | **22.8** | **77.2** |

**F4** Frequency patterns of phrase length (1 to 3 syllables, 4 to 6 syllables and longer than 6 syllables) per speaker and text style in percentages (%)

| | **SENT** | | | **PASS** | | | **PICT** | | | **MONO** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1-3** | **4-6** | **>6** | **1-3** | **4-6** | **>6** | **1-3** | **4-6** | **>6** | **1-3** | **4-6** | **>6** |
| **MC1** | 5 | 0 | 95 | 15 | 29 | 56 | 25 | 25 | 50 | 27 | 66 | 7 |
| **MC2** | 7 | 11 | 82 | 15 | 17 | 68 | 26 | 26 | 48 | 14 | 45 | 41 |
| **MC3** | 2 | 0 | 98 | 9 | 30 | 61 | 10 | 41 | 48 | 17 | 33 | 50 |
| **mean** | **4.7** | **3.7** | **91.7** | **13.0** | **25.3** | **61.7** | **20.3** | **30.7** | **48.7** | **19.3** | **48.0** | **32.7** |
| **MFAS1** | 14 | 16 | 71 | 17 | 38 | 45 | 20 | 40 | 40 | 25 | 37 | 38 |
| **MFAS2** | 23 | 13 | 64 | 24 | 31 | 45 | 23 | 51 | 26 | 7 | 50 | 43 |
| **MFAS3** | 41 | 30 | 29 | 16 | 38 | 46 | 24 | 24 | 52 | 32 | 50 | 18 |
| **mean** | **26.0** | **19.7** | **54.7** | **19.0** | **35.7** | **45.3** | **22.3** | **38.3** | **39.3** | **21.3** | **45.7** | **31.3** |

**F5** Accentuation of new and given referents per speaker and text styles in percentages (%)

| | new | | | | given | | | |
|---|---|---|---|---|---|---|---|---|
| | **SENT** | **PASS** | **PICT** | **MONO** | **SENT** | **PASS** | **PICT** | **MONO** |
| **MC1** | 100 | 100 | 100 | 100 | 7 | 40 | 60 | 83 |
| **MC2** | 100 | 93 | 94 | 100 | 30 | 40 | 58 | 42 |
| **MC3** | 100 | 100 | 90 | 100 | 10 | 13 | 65 | 65 |
| **mean** | **100** | **97.7** | **94.6** | **100** | **15.7** | **31.1** | **61.0** | **63.6** |
| **MFAS1** | 100 | 100 | 100 | 100 | 100 | 79 | 100 | 80 |
| **MFAS2** | 100 | 100 | 100 | 100 | 83 | 87 | 92 | 92 |
| **MFAS3** | 100 | 100 | 100 | 100 | 83 | 73 | 100 | 100 |
| **mean** | **100** | **100** | **100** | **100** | **88.7** | **79.5** | **97.2** | **90.6** |

**F6** Pitch patterns of new referents per text style and speaker in percentages (%)

| | DEACC | H* | H*L | !H*L | L* | L*H | L*HL |
|---|---|---|---|---|---|---|---|
| | | | | **SENT** | | | |
| **MC1** | 0 | 25 | 70 | 3 | 0 | 2 | 0 |
| **MC2** | 0 | 5 | 92 | 3 | 0 | 0 | 0 |
| **MC3** | 0 | 8 | 72 | 20 | 0 | 0 | 0 |
| **mean** | **0** | **12.8** | **77.8** | **8.9** | **0** | **0.6** | **0** |
| **MFAS1** | 0 | 20 | 43 | 0 | 0 | 37 | 0 |
| **MFAS2** | 0 | 17 | 80 | 2 | 0 | 2 | 0 |
| **MFAS3** | 0 | 12 | 87 | 2 | 0 | 0 | 0 |
| **mean** | **0** | **16.1** | **70.0** | **1.1** | **0** | **12.8** | **0** |
| | | | | **PASS** | | | |
| **MC1** | 0 | 7 | 60 | 20 | 0 | 13 | 0 |
| **MC2** | 7 | 13 | 53 | 27 | 0 | 0 | 0 |
| **MC3** | 0 | 7 | 47 | 47 | 0 | 0 | 0 |
| **mean** | **2.2** | **8.9** | **53.3** | **31.1** | **0** | **4.4** | **0** |
| **MFAS1** | 0 | 13 | 40 | 7 | 0 | 40 | 0 |
| **MFAS2** | 0 | 7 | 53 | 33 | 0 | 7 | 0 |
| **MFAS3** | 0 | 13 | 80 | 7 | 0 | 0 | 0 |
| **mean** | **0** | **11.1** | **57.8** | **15.6** | **0** | **15.6** | **0** |
| | | | | **PICT** | | | |
| **MC1** | 0 | 33 | 67 | 0 | 0 | 0 | 0 |
| **MC2** | 6 | 6 | 38 | 25 | 6 | 19 | 0 |
| **MC3** | 10 | 0 | 80 | 10 | 0 | 0 | 0 |
| **mean** | **5.4** | **13.2** | **61.4** | **11.7** | **2.1** | **6.3** | **0** |
| **MFAS1** | 0 | 11 | 0 | 11 | 11 | 67 | 0 |
| **MFAS2** | 0 | 13 | 75 | 6 | 0 | 0 | 6 |
| **MFAS3** | 0 | 17 | 33 | 8 | 0 | 42 | 0 |
| **mean** | **0** | **13.4** | **36.1** | **8.6** | **3.6** | **36.1** | **2.0** |
| | | | | **MONO** | | | |
| **MC1** | 0 | 0 | 71 | 29 | 0 | 0 | 0 |
| **MC2** | 0 | 17 | 50 | 25 | 8 | 0 | 0 |
| **MC3** | 0 | 12 | 18 | 41 | 0 | 29 | 0 |
| **mean** | **0** | **9.5** | **46.4** | **31.6** | **2.8** | **9.8** | **0** |
| **MFAS1** | 0 | 0 | 33 | 11 | 0 | 56 | 0 |
| **MFAS2** | 0 | 19 | 69 | 0 | 0 | 13 | 0 |
| **MFAS3** | 0 | 20 | 30 | 0 | 0 | 50 | 0 |
| **mean** | **0** | **12.9** | **44.0** | **3.7** | **0** | **39.4** | **0** |

**F7** Pitch patterns of given referents per speaker and text style in percentages (%)

| | DEACC | H* | H*L | !H*L | L* | L*H | L*HL |
|---|---|---|---|---|---|---|---|
| | | | | **SENT pre-focal** | | | |
| **MC1** | 0 | 73 | 10 | 17 | 0 | 0 | 0 |
| **MC2** | 3 | 30 | 53 | 3 | 7 | 3 | 0 |
| **MC3** | 0 | 27 | 67 | 7 | 0 | 0 | 0 |
| **mean** | **1.1** | **43.3** | **43.3** | **8.9** | **2.2** | **1.1** | **0** |
| **MFAS1** | 3 | 20 | 0 | 0 | 0 | 77 | 0 |
| **MFAS2** | 0 | 43 | 47 | 7 | 0 | 3 | 0 |
| **MFAS3** | 0 | 37 | 60 | 3 | 0 | 0 | 0 |
| **mean** | **1.1** | **33.3** | **35.6** | **3.3** | **0** | **26.7** | **0** |
| | | | | **SENT post-focal** | | | |
| **MC1** | 93 | 0 | 0 | 7 | 0 | 0 | 0 |
| **MC2** | 70 | 0 | 3 | 27 | 0 | 0 | 0 |
| **MC3** | 90 | 0 | 0 | 7 | 3 | 0 | 0 |
| **mean** | **84.4** | **0** | **1.1** | **13.3** | **1.1** | **0** | **0** |
| **MFAS1** | 0 | 13 | 40 | 27 | 0 | 20 | 0 |
| **MFAS2** | 17 | 3 | 50 | 30 | 0 | 0 | 0 |
| **MFAS3** | 17 | 3 | 63 | 17 | 0 | 0 | 0 |
| **mean** | **11.1** | **6.7** | **51.1** | **24.4** | **0** | **6.7** | **0** |
| | | | | **PASS** | | | |
| **MC1** | 60 | 7 | 20 | 13 | 0 | 0 | 0 |
| **MC2** | 60 | 0 | 13 | 27 | 0 | 0 | 0 |
| **MC3** | 87 | 7 | 0 | 7 | 0 | 0 | 0 |
| **mean** | **68.9** | **4.4** | **11.1** | **15.6** | **0** | **0** | **0** |
| **MFAS1** | 21 | 21 | 29 | 21 | 0 | 7 | 0 |
| **MFAS2** | 13 | 0 | 27 | 53 | 0 | 7 | 0 |
| **MFAS3** | 27 | 7 | 40 | 27 | 0 | 0 | 0 |
| **mean** | **20.5** | **9.4** | **31.8** | **33.8** | **0** | **4.6** | **0** |
| | | | | **PICT** | | | |
| **MC1** | 40 | 20 | 40 | 0 | 0 | 0 | 0 |
| **MC2** | 42 | 0 | 17 | 33 | 0 | 8 | 0 |
| **MC3** | 35 | 0 | 53 | 6 | 6 | 0 | 0 |
| **mean** | **39.0** | **6.7** | **36.5** | **13.1** | **2.0** | **2.8** | **0** |
| **MFAS1** | 0 | 36 | 14 | 7 | 0 | 36 | 0 |
| **MFAS2** | 8 | 8 | 67 | 0 | 0 | 17 | 0 |
| **MFAS3** | 0 | 29 | 29 | 0 | 14 | 29 | 0 |
| **mean** | **2.8** | **24.2** | **36.5** | **2.4** | **4.8** | **27.0** | **0** |
| | | | | **MONO** | | | |
| **MC1** | 17 | 50 | 17 | 17 | 0 | 0 | 0 |
| **MC2** | 57 | 0 | 14 | 14 | 14 | 0 | 0 |
| **MC3** | 35 | 6 | 29 | 24 | 0 | 6 | 0 |
| **mean** | **36.4** | **18.6** | **20.1** | **18.2** | **4.8** | **2.0** | **0** |
| **MFAS1** | 20 | 20 | 40 | 20 | 0 | 0 | 0 |
| **MFAS2** | 8 | 17 | 25 | 17 | 0 | 33 | 0 |
| **MFAS3** | 0 | 60 | 20 | 0 | 0 | 20 | 0 |
| **mean** | **9.4** | **32.2** | **28.3** | **12.2** | **0** | **17.8** | **0** |

**F8** Means and standard deviations (SD) per parameter, information status and speaker for normalised data and raw data

*Normalised data*

| | **initial** | | | | **medial** | | | | **final** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **new** | | **given** | | **new** | | **given** | | **new** | | **given** | |
| | **duration** | | | | | | | | | | | |
| | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** |
| **MC1** | 0.01 | 1.09 | -0.29 | 1.13 | 0.18 | 0.87 | -0.19 | 0.82 | 0.28 | 1.00 | 0.04 | 0.04 |
| **MC2** | 0.28 | 1.09 | -0.50 | 1.01 | 0.40 | 0.91 | -0.31 | 0.77 | 0.52 | 0.76 | -0.38 | 0.85 |
| **MC3** | 0.38 | 1.09 | -0.29 | 0.91 | 0.10 | 0.95 | -0.23 | 0.90 | 0.22 | 0.93 | -0.18 | 0.99 |
| **mean** | **0.22** | **1.09** | **-0.36** | **1.02** | **0.23** | **0.91** | **-0.25** | **0.83** | **0.34** | **0.90** | **-0.18** | **0.89** |
| **MFAS1** | 0.13 | 0.99 | -0.40 | 1.03 | 0.35 | 0.91 | -0.22 | 0.53 | 0.34 | 1.19 | -0.20 | 0.94 |
| **MFAS2** | 0.16 | 0.84 | 0.22 | 1.09 | -0.20 | 0.91 | -0.35 | 0.72 | 0.39 | 1.06 | -0.21 | 1.07 |
| **MFAS3** | 0.16 | 1.02 | -0.15 | 1.08 | -0.04 | 0.68 | -0.32 | 0.75 | 0.38 | 1.15 | -0.04 | 1.04 |
| **mean** | **0.15** | **0.95** | **-0.11** | **1.07** | **0.04** | **0.83** | **-0.30** | **0.67** | **0.37** | **1.13** | **-0.15** | **1.02** |
| | **intensity** | | | | | | | | | | | |
| | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** |
| **MC1** | 0.91 | 0.77 | 0.14 | 1.00 | 0.12 | 0.94 | -0.47 | 0.69 | 0.24 | 0.75 | -0.94 | 0.65 |
| **MC2** | 0.85 | 0.52 | 0.43 | 0.66 | 0.60 | 0.51 | -0.56 | 0.71 | 0.19 | 0.45 | -1.51 | 0.60 |
| **MC3** | 1.21 | 0.63 | 0.81 | 0.50 | 0.32 | 0.50 | -0.49 | 0.52 | -0.58 | 0.56 | -1.21 | 0.45 |
| **mean** | **0.99** | **0.64** | **0.46** | **0.72** | **0.35** | **0.65** | **-0.50** | **0.64** | **-0.05** | **0.59** | **-1.22** | **0.57** |
| **MFAS1** | 0.62 | 1.00 | 0.37 | 0.77 | 0.17 | 1.00 | -0.19 | 0.90 | -0.16 | 0.85 | -0.82 | 0.75 |
| **MFAS2** | 0.46 | 0.68 | 0.46 | 0.91 | 0.25 | 0.98 | -0.59 | 0.85 | -0.05 | 0.77 | -0.53 | 1.12 |
| **MFAS3** | 0.73 | 0.54 | 0.66 | 0.56 | -0.11 | 0.74 | -0.64 | 1.19 | -0.07 | 0.65 | -0.57 | 1.11 |
| **mean** | **0.60** | **0.74** | **0.50** | **0.74** | **0.11** | **0.91** | **-0.47** | **0.98** | **-0.09** | **0.76** | **-0.64** | **0.99** |
| | **F0** | | | | | | | | | | | |
| | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** |
| **MC1** | 1.28 | 0.39 | 0.81 | 0.47 | 0.18 | 0.50 | -0.53 | 0.53 | -0.30 | 0.33 | -1.46 | 0.31 |
| **MC2** | 0.93 | 0.65 | 0.64 | 0.63 | 0.39 | 0.79 | -0.70 | 0.66 | 0.10 | 0.45 | -1.35 | 0.36 |
| **MC3** | 1.13 | 0.74 | 1.19 | 0.66 | -0.14 | 0.33 | -0.59 | 0.45 | -0.49 | 0.30 | -1.10 | 0.25 |
| **mean** | **1.11** | **0.59** | **0.88** | **0.59** | **0.15** | **0.54** | **-0.61** | **0.55** | **-0.23** | **0.36** | **-1.30** | **0.30** |
| **MFAS1** | 0.75 | 0.58 | 1.11 | 0.37 | -0.11 | 0.58 | -0.54 | 0.60 | -0.03 | 0.75 | -1.18 | 0.84 |
| **MFAS2** | 0.85 | 0.87 | 0.81 | 0.74 | 0.13 | 0.70 | -0.78 | 0.57 | 0.01 | 0.53 | -1.02 | 0.70 |
| **MFAS3** | 0.91 | 0.62 | 0.76 | 0.62 | -0.04 | 0.62 | -0.74 | 0.86 | -0.04 | 0.71 | -0.85 | 0.93 |
| **mean** | **0.84** | **0.69** | **0.90** | **0.58** | **-0.01** | **0.63** | **-0.69** | **0.68** | **-0.02** | **0.67** | **-1.02** | **0.82** |

*Raw data*

| | initial | | | | medial | | | | final | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **new** | | **given** | | **new** | | **given** | | **new** | | **given** | |
| | | | | | | **duration** | | | | | | |
| | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** |
| **MC1** | 252.61 | 83.32 | 230.16 | 85.89 | 265.70 | 66.47 | 237.63 | 62.64 | 273.75 | 76.05 | 255.15 | 63.93 |
| **MC2** | 212.19 | 47.99 | 177.92 | 44.51 | 217.53 | 40.04 | 186.26 | 33.60 | 223.05 | 33.32 | 183.26 | 37.16 |
| **MC3** | 206.32 | 57.07 | 171.21 | 47.59 | 191.73 | 49.76 | 174.34 | 47.29 | 197.82 | 48.70 | 176.72 | 51.98 |
| **mean** | **223.71** | **62.79** | **193.09** | **59.33** | **224.99** | **52.09** | **199.41** | **47.84** | **231.54** | **52.69** | **205.04** | **51.02** |
| **MFAS1** | 439.14 | 100.03 | 386.24 | 103.86 | 461.47 | 91.90 | 404.35 | 53.36 | 460.27 | 119.74 | 406.24 | 94.47 |
| **MFAS2** | 322.02 | 79.73 | 328.16 | 104.12 | 288.07 | 86.90 | 273.50 | 68.54 | 344.50 | 100.69 | 286.88 | 101.85 |
| **MFAS3** | 303.53 | 65.00 | 283.28 | 69.32 | 290.57 | 43.51 | 272.57 | 48.29 | 317.32 | 73.66 | 290.56 | 66.74 |
| **mean** | **354.89** | **81.59** | **332.56** | **92.43** | **346.70** | **74.10** | **316.80** | **56.73** | **374.03** | **98.03** | **327.89** | **87.69** |
| | | | | | | **intensity** | | | | | | |
| | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** |
| **MC1** | 74.26 | 2.21 | 72.04 | 2.89 | 71.97 | 2.70 | 70.30 | 1.98 | 72.34 | 2.16 | 68.94 | 1.88 |
| **MC2** | 81.70 | 2.84 | 79.40 | 3.60 | 80.33 | 2.79 | 74.03 | 3.87 | 78.12 | 2.43 | 68.83 | 3.26 |
| **MC3** | 74.09 | 2.08 | 72.78 | 1.64 | 71.16 | 1.64 | 68.49 | 1.73 | 68.18 | 1.86 | 66.12 | 1.50 |
| **mean** | **76.68** | **2.37** | **74.74** | **2.71** | **74.49** | **2.38** | **70.94** | **2.52** | **72.88** | **2.15** | **67.96** | **2.21** |
| **MFAS1** | 74.91 | 3.24 | 74.07 | 2.51 | 73.44 | 3.25 | 72.27 | 2.92 | 72.37 | 2.77 | 70.20 | 2.43 |
| **MFAS2** | 80.34 | 2.71 | 80.36 | 3.64 | 79.51 | 3.94 | 76.14 | 3.39 | 78.30 | 3.08 | 76.36 | 4.50 |
| **MFAS3** | 74.78 | 1.21 | 74.63 | 1.25 | 72.91 | 1.67 | 71.70 | 2.67 | 72.99 | 1.46 | 71.86 | 2.49 |
| **mean** | **76.68** | **2.39** | **76.35** | **2.46** | **75.29** | **2.95** | **73.37** | **3.00** | **74.55** | **2.44** | **72.81** | **3.14** |
| | | | | | | **F0** | | | | | | |
| | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** |
| **MC1** | 243.63 | 9.74 | 231.80 | 11.93 | 216.02 | 12.67 | 198.16 | 13.34 | 203.89 | 8.39 | 174.79 | 7.74 |
| **MC2** | 144.91 | 15.63 | 138.10 | 15.07 | 131.95 | 18.94 | 105.97 | 15.74 | 125.03 | 10.70 | 90.30 | 8.55 |
| **MC3** | 113.45 | 6.43 | 113.92 | 5.74 | 102.37 | 2.91 | 98.36 | 3.92 | 99.27 | 2.61 | 93.95 | 2.15 |
| **mean** | **167.33** | **10.60** | **161.27** | **10.91** | **150.11** | **11.51** | **134.16** | **11.00** | **142.73** | **7.23** | **119.68** | **6.15** |
| **MFAS1** | 251.50 | 10.56 | 258.00 | 6.74 | 235.83 | 10.55 | 228.08 | 10.91 | 237.41 | 13.54 | 216.63 | 15.11 |
| **MFAS2** | 166.30 | 15.54 | 165.69 | 13.29 | 153.49 | 12.51 | 137.30 | 10.14 | 151.28 | 9.53 | 132.86 | 12.55 |
| **MFAS3** | 167.49 | 7.16 | 165.73 | 7.27 | 156.43 | 7.19 | 148.24 | 10.02 | 156.40 | 8.30 | 147.04 | 10.84 |
| **mean** | **195.10** | **11.09** | **196.47** | **9.10** | **181.91** | **10.08** | **171.21** | **10.36** | **181.69** | **10.45** | **165.51** | **12.83** |

**F9** Percentage differences between new and given referents per parameter, position and speaker

| | duration | | | intensity | | | F0 | | |
|---|---|---|---|---|---|---|---|---|---|
| | **T1** | **T2** | **T3** | **T1** | **T2** | **T3** | **T1** | **T2** | **T3** |
| **MC1** | 9.51 | 10.33 | 5.29 | 2.99 | 2.27 | 4.62 | 4.80 | 8.16 | 14.27 |
| **MC2** | 16.33 | 14.39 | 17.56 | 2.78 | 7.84 | 11.87 | 7.90 | 19.46 | 27.55 |
| **MC3** | 16.67 | 8.78 | 10.58 | 1.73 | 3.75 | 3.01 | 1.58 | 3.90 | 5.35 |
| **mean** | **14.17** | **11.17** | **11.14** | **2.50** | **4.62** | **6.50** | **4.76** | **10.51** | **15.73** |
| **MFAS1** | 12.23 | 10.62 | 10.32 | 1.06 | 1.53 | 2.93 | -0.83 | 3.21 | 8.61 |
| **MFAS2** | -0.83 | 3.95 | 16.74 | -0.07 | 4.13 | 2.47 | 8.99 | 10.40 | 11.98 |
| **MFAS3** | 6.87 | 5.62 | 8.01 | 0.19 | 1.64 | 1.55 | 5.59 | 5.09 | 5.74 |
| **mean** | **6.09** | **6.73** | **11.69** | **0.39** | **2.43** | **2.31** | **4.59** | **6.24** | **8.78** |

**F10** Pitch range measures of level and span per speaker and condition

| | level | | | | span | | | |
|---|---|---|---|---|---|---|---|---|
| | **T1 new** | **T2 new** | **T3 new** | **all new** | **T1 new** | **T2 new** | **T3 new** | **all new** |
| **MC1** | 149.78 | 150.25 | 149.94 | 152.04 | 95.41 | 81.38 | 83.41 | 90.20 |
| **MC2** | 72.00 | 71.86 | 82.23 | 81.51 | 81.65 | 77.91 | 60.72 | 55.14 |
| **MC3** | 89.85 | 88.80 | 91.20 | 91.74 | 18.67 | 24.13 | 23.71 | 26.64 |
| **mean** | **103.88** | **103.64** | **107.79** | **108.43** | **65.24** | **61.14** | **55.95** | **57.33** |
| **MFAS1** | 153.76 | 153.00 | 157.59 | 152.00 | 94.51 | 105.52 | 100.73 | 103.32 |
| **MFAS2** | 89.30 | 91.13 | 93.12 | 95.91 | 80.47 | 81.88 | 70.92 | 68.92 |
| **MFAS3** | 112.90 | 119.09 | 121.07 | 126.23 | 56.92 | 47.85 | 47.74 | 40.50 |
| **mean** | **118.65** | **121.07** | **123.93** | **124.71** | **77.30** | **78.42** | **73.13** | **70.91** |

**F11** Means and standard deviations (SD) of the raw data and normalised F0 measures for the de-accentuation measures per speaker (Bi = boundary initial, H1 = F0 maximum on T1, H2 = F0 maximum on T2, H3 = F0 maximum on T3, FL = final low)

*Normalised data*

| | **Bi** | | **H1** | | **H2** | | **H3** | | **FL** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | **initial** | | | | | |
| | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** |
| **MC1** | 0.00 | 0.35 | 1.66 | 0.34 | -0.17 | 0.31 | -0.63 | 0.26 | -1.39 | 0.18 |
| **MC2** | -0.36 | 0.23 | 1.60 | 0.57 | -0.38 | 0.34 | -0.41 | 0.13 | -1.22 | 0.21 |
| **MC3** | 0.24 | 0.72 | 0.91 | 0.43 | -0.48 | 0.26 | -0.57 | 0.20 | -1.02 | 0.33 |
| **mean** | **-0.04** | **0.43** | **1.39** | **0.45** | **-0.34** | **0.30** | **-0.54** | **0.20** | **-1.21** | **0.24** |
| **MFAS1** | -0.26 | 0.30 | 0.96 | 0.32 | 0.25 | 0.31 | 0.14 | 0.31 | -1.66 | 0.12 |
| **MFAS2** | -0.52 | 0.79 | 1.29 | 0.59 | -0.02 | 0.32 | 0.04 | 0.36 | -1.44 | 0.28 |
| **MFAS3** | -0.35 | 0.18 | 1.28 | 0.42 | -0.25 | 0.47 | -0.19 | 0.61 | -1.72 | 0.18 |
| **mean** | **-0.38** | **0.42** | **1.18** | **0.44** | **-0.01** | **0.37** | **0.00** | **0.43** | **-1.61** | **0.19** |
| | | | | | **medial** | | | | | |
| | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** |
| **MC1** | -0.26 | 0.39 | 1.18 | 0.35 | 0.95 | 0.26 | -0.55 | 0.22 | -1.37 | 0.07 |
| **MC2** | -0.43 | 0.36 | 1.00 | 0.60 | 1.40 | 0.44 | -0.77 | 0.30 | -1.23 | 0.14 |
| **MC3** | -0.39 | 1.62 | 1.36 | 0.56 | 0.37 | 0.28 | -0.63 | 0.24 | -1.13 | 0.24 |
| **mean** | **-0.36** | **0.79** | **1.18** | **0.50** | **0.91** | **0.33** | **-0.65** | **0.25** | **-1.24** | **0.15** |
| **MFAS1** | -0.38 | 0.34 | 1.24 | 0.15 | 0.77 | 0.20 | 0.02 | 0.50 | -1.68 | 0.21 |
| **MFAS2** | -0.42 | 0.30 | 1.25 | 0.43 | 0.91 | 0.32 | 0.04 | 0.49 | -1.38 | 0.22 |
| **MFAS3** | -0.32 | 0.17 | 1.06 | 0.32 | 0.75 | 0.42 | 0.37 | 0.36 | -1.40 | 0.65 |
| **mean** | **-0.37** | **0.27** | **1.18** | **0.30** | **0.81** | **0.31** | **0.14** | **0.45** | **-1.49** | **0.36** |
| | | | | | **final** | | | | | |
| | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** |
| **MC1** | -0.29 | 0.15 | 1.28 | 0.40 | 0.48 | 0.23 | 0.48 | 0.24 | -1.38 | 0.12 |
| **MC2** | -0.49 | 0.26 | 1.13 | 0.42 | 0.28 | 0.51 | 0.75 | 0.34 | -0.87 | 0.54 |
| **MC3** | 0.40 | 0.70 | 1.57 | 0.61 | 0.20 | 0.18 | 0.05 | 0.29 | -0.88 | 0.36 |
| **mean** | **-0.13** | **0.37** | **1.33** | **0.48** | **0.32** | **0.31** | **0.43** | **0.29** | **-1.04** | **0.34** |
| **MFAS1** | -0.35 | 0.20 | 1.21 | 0.21 | 0.54 | 0.21 | 0.75 | 0.32 | -1.55 | 0.09 |
| **MFAS2** | -0.57 | 0.15 | 1.07 | 0.46 | 0.41 | 0.20 | 0.65 | 0.38 | -1.31 | 0.50 |
| **MFAS3** | -0.20 | 0.27 | 1.10 | 0.44 | 0.55 | 0.18 | 0.62 | 0.51 | -1.29 | 0.61 |
| **mean** | **-0.37** | **0.21** | **1.13** | **0.37** | **0.50** | **0.20** | **0.67** | **0.40** | **-1.38** | **0.40** |

*Raw data*

| | Bi | | H1 | | H2 | | H3 | | FL | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | **initial** | | | | | |
| | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** |
| **MC1** | 193.31 | 10.85 | 245.19 | 10.59 | 187.90 | 9.80 | 173.56 | 8.28 | 149.78 | 5.78 |
| **MC2** | 97.04 | 6.61 | 153.65 | 16.41 | 96.44 | 9.72 | 95.62 | 3.68 | 72.00 | 5.96 |
| **MC3** | 102.07 | 6.93 | 108.52 | 4.16 | 95.08 | 2.53 | 94.21 | 1.93 | 89.85 | 3.22 |
| **mean** | **130.81** | **8.13** | **169.12** | **10.39** | **126.47** | **7.35** | **121.13** | **4.63** | **103.88** | **4.99** |
| **MFAS1** | 204.15 | 10.99 | 248.27 | 11.60 | 222.84 | 11.18 | 218.67 | 11.06 | 153.76 | 4.19 |
| **MFAS2** | 116.34 | 23.27 | 169.48 | 17.39 | 130.88 | 9.36 | 132.82 | 10.52 | 89.30 | 8.22 |
| **MFAS3** | 138.82 | 3.46 | 169.48 | 7.89 | 140.76 | 8.78 | 141.79 | 11.56 | 112.90 | 3.42 |
| **mean** | **153.10** | **12.57** | **195.74** | **12.29** | **164.83** | **9.77** | **164.43** | **11.05** | **118.65** | **5.28** |
| | | | | | **medial** | | | | | |
| | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** |
| **MC1** | 185.13 | 12.06 | 230.25 | 11.09 | 222.95 | 8.16 | 176.01 | 6.95 | 150.25 | 2.34 |
| **MC2** | 94.84 | 10.47 | 136.25 | 17.27 | 147.92 | 12.75 | 84.97 | 8.71 | 71.86 | 4.06 |
| **MC3** | 95.97 | 15.72 | 112.93 | 5.41 | 103.35 | 2.75 | 93.69 | 2.33 | 88.80 | 2.30 |
| **mean** | **125.31** | **12.75** | **159.81** | **11.26** | **158.07** | **7.89** | **118.22** | **6.00** | **103.64** | **2.90** |
| **MFAS1** | 200.03 | 12.23 | 258.52 | 5.53 | 241.35 | 7.25 | 214.58 | 18.06 | 153.00 | 7.49 |
| **MFAS2** | 119.22 | 8.82 | 168.38 | 12.61 | 158.27 | 9.31 | 132.89 | 14.29 | 91.13 | 6.39 |
| **MFAS3** | 139.34 | 3.27 | 165.32 | 6.08 | 159.48 | 7.89 | 152.28 | 6.80 | 119.09 | 12.24 |
| **mean** | **152.86** | **8.11** | **197.41** | **8.07** | **186.37** | **8.15** | **166.58** | **13.05** | **121.07** | **8.71** |
| | | | | | **final** | | | | | |
| | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** |
| **MC1** | 184.21 | 4.80 | 233.35 | 12.51 | 208.41 | 7.05 | 208.33 | 7.58 | 149.94 | 3.61 |
| **MC2** | 93.27 | 7.57 | 139.95 | 12.22 | 115.49 | 14.82 | 128.96 | 9.76 | 82.23 | 15.66 |
| **MC3** | 103.64 | 6.73 | 114.91 | 5.88 | 101.63 | 1.72 | 100.20 | 2.77 | 91.20 | 3.47 |
| **mean** | **127.04** | **6.37** | **162.74** | **10.20** | **141.84** | **7.86** | **145.83** | **6.70** | **107.79** | **7.58** |
| **MFAS1** | 201.24 | 7.35 | 257.47 | 7.72 | 233.32 | 7.63 | 240.73 | 11.51 | 157.59 | 3.26 |
| **MFAS2** | 114.92 | 4.31 | 162.99 | 13.40 | 143.72 | 5.95 | 150.56 | 11.22 | 93.12 | 14.57 |
| **MFAS3** | 141.62 | 5.11 | 166.13 | 8.27 | 155.71 | 3.46 | 157.06 | 9.56 | 121.07 | 11.41 |
| **mean** | **152.65** | **5.64** | **195.61** | **9.62** | **177.54** | **5.57** | **182.64** | **10.63** | **124.03** | **9.86** |

## Appendix G: Excerpt picture description

Orthographic transcription per phrase including number of pitch accents and syllables per phrase. Below the orthographic transcription, the phonological labels are provided.

PA = number of pitch accents in phrase (words that were assigned a pitch accent are highlighted)
syll = number of syllables in phrase

### MFAS1 - picture description

| text | PA | syll |
|---|---|---|
| 1 there's a cat on top of a chest of drawers | 2 | 11 |
| %L H* L*H % | | |
| 2 he's trying to push a bowl | 2 | 7 |
| %L L*H L*H % | | |
| 3 off the top of | 1 | 4 |
| %L L*H H% | | |
| 4 the chet od drawers | 1 | 5 |
| %H H*L % | | |
| 5 with some sort of liquid in it | 2 | 8 |
| %L L*H !H*L L% | | |
| 6 and the next picture | 1 | 5 |
| %L L*H % | | |
| 7 there's a man coming to the room | 2 | 8 |
| %L L*H L*H % | | |
| 8 and the cat is hiding behind the door | 3 | 10 |
| %L H* L*H L*H % | | |
| 9 and the bowl | 1 | 3 |
| %L L*H % | | |
| 10 as been broken | 1 | 4 |
| %L H*L % | | |
| 11 in the next picture | 1 | 5 |
| %L H*L % | | |
| 12 not a man | 1 | 3 |
| %H L* % | | |

| | | |
|---|---|---|
| 13 it's a a wee boy<br>%L L* % | 1 | 4 |
| 14 his mother came into the room<br>%L L*H L*H % | 2 | 8 |
| 15 and blames him<br>%L H* H* H% | 2 | 3 |
| 16 by the look of things<br>%H H*L H* % | 2 | 5 |
| 17 for breaking the bowl<br>%L H*L % | 1 | 5 |
| 18 the cat is still hiding behind the door<br>%L H* H* L*H % | 3 | 10 |
| 19 in the fourth picture<br>%L L*H H*L H% | 2 | 5 |
| 20 the cat is going out of the door<br>%L H* L*H L*H % | 3 | 9 |
| 21 and both the mother and the boy<br>%L L*H H* L*H % | 3 | 8 |
| 22 are looking<br>%L L*H H% | 1 | 3 |
| 23 towards the cat<br>%H H* % | 1 | 4 |
| 24 leaving<br>%L H*L % | 1 | 2 |
| 25 they're about to clean up the bowl<br>%L H*L !H*L % | 2 | 8 |