RECEPTIVE AND EXPRESSIVE PROSODY OF INDIVIDUALS WITH ASPERGER SYNDROME

KATE KING

MSpEd, BAppSc (SpPath)

Thesis submitted in fulfilment of the requirements for the Degree of Doctor of Philosophy

Department of Speech Pathology and Audiology

School of Medicine

Faculty of Health Science

Flinders University

Adelaide, South Australia

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ABSTRACT

Effective communication requires understanding of other people's use of prosody (intonation, stress and rhythm) as well as the ability to produce appropriate prosody. Expressive prosody in autism spectrum disorders (ASD) is often described as unusual and limited research has been conducted. Difficulties with receptive prosody are often assumed, acoustic analysis has rarely been utilized to determine prosodic characteristics and the majority of studies have involved small sample sizes. The cause of the dysprosody is currently thought to result from the social and cognitive impairments associated with ASD. However, impaired motor abilities have also been determined in the speech of individuals with ASD, so could be a concomitant cause of the prosodic disturbance.

This study sought evidence of impaired speech production processing in the prosody of participants with Asperger syndrome (ASP), one of the autism spectrum disorders. ASP (n=58) were diagnosed through Autism SA. To gain a broader knowledge of prosody in AS and to facilitate comparisons, understanding and expression of prosodic functions (including grammatical, pragmatic and affective prosody) and of reading tasks requiring application of typical English rhythm were assessed. Spontaneous speech was also examined. Results of perceptual analysis and of acoustic analysis which included intensity (loudness), minimum, maximum and average pitch, pitch range and duration were compared with the results for control participants (CP). CP (n=50) did not have a diagnosis of ASD, language disorder or intellectual disability and were matched by age, gender and educational status to the ASP.

With one exception (understanding of pragmatic prosody) ASP understood all domains of prosody as well as CP, however, clear evidence of a consistent deficit in prosodic production was found. ASP produced significantly more errors than their matched CP with pragmatic, affective and grammatical prosodic functions producing statistically significantly differences. The ASP were also less able than the CP to apply typical English rhythm. Acoustic analysis of spontaneous speech samples did not reveal significant differences, but statistically significant results were found in the reading condition, with the ASP using a higher mean minimum pitch and longer durations than the CP. Pitch difficulties and longer durations are indicative of speech motor impairment. Speech production difficulties were also observed in the high incidence of residual articulation substitutions and the increased speech dysfluencies made by the ASP.

Overall, the result that receptive prosody was virtually intact while production across both linguistic and non-linguistic domains was significantly poorer for ASP than for CP indicates that speech motor functioning is likely to underpin the prosodic disturbance in Asperger syndrome. This research involves a larger number of subjects than all previous studies internationally and includes receptive and expressive prosody as well as acoustic analysis, therefore adding considerably to the limited information available on prosody in ASD. As motor difficulties have been shown to affect prosody in ASP, intervention should include amelioration of expressive prosody issues and should not concentrate solely on social/emotional factors.

DECLARATION

Receptive and Expressive Prosody of individuals with Asperger syndrome

I certify that this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text.

Name: …………………………………….

Signature: …………………………………….

Date: …………………………………….

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LIST OF COMMONLY USED ABBREVIATIONS

ASD	Autism spectrum disorder
AS	Asperger syndrome
HFA	High functioning autism
PDDNOS	Pervasive developmental disorder not otherwise specified
CP	Control participants
PEPS-C	Profiling Elements of Prosodic Systems – Children
TD	Typically developing
CA	Chronological age
Hz	Hertz
dB	decibels
fMRI	Functional Magnetic Resonance Imaging

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CHAPTER 1 INTRODUCTION

Autism and Asperger Syndrome (AS) are part of what are commonly called Autism Spectrum Disorders (ASD). These disorders are classified as pervasive developmental disorders in the Diagnostic and Statistical Manual, Fourth Edition - Text Revised (DSM IV-TR) (American Psychological Association (APA), 2000), which remains one of the most commonly used diagnostic tools for autism and AS in Australia and internationally. The social difficulties and the resistance to change/repetitive activities which are characteristic of ASD are the same for both autism and AS. However, while language disorder is prevalent in autism, at this point in time a clinically significant general delay in language precludes a diagnosis of AS. Nevertheless, it is generally accepted that individuals with AS often have communication difficulties related to semantics (language meaning), pragmatics (the social use of language) (Baron-Cohen, 1988; Bishop, 1989) and prosody (intonation, stress and rhythm) (Grossman, Bemis, Plesa-Skwerer & Tager-Flusberg, 2010; McCann, Peppe, Gibbon, O'Hare & Rutherford, 2008).

Common understanding suggests that the cognitive and social impairments in ASD are concomitant causes of the communication difficulties in this population (Jordan, 1993; Prizant & Wetherby, 1989; Tanguay, 2000), and it is often assumed that their impaired prosody is related to social and cognitive impairments (Rutherford, Baron-Cohen & Wheelwright, 2002). There is abundant evidence that many people with ASD lack understanding of how other people may think, feel and act (Baron-Cohen, 1989; Golan, Baron-Cohen, Hill & Rutherford, 2007) but perhaps it is not only the social disabilities of this group of individuals that impinge upon their communication abilities. Could impaired motor abilities also contribute to the communication difficulties, including prosody, in this population?

The poor motor skills of people with ASD are cited as a possible difficulty in most internationally recognized diagnostic tools for AS including the DSMIV-TR (APA, 2000) and the ICD 10 (World Health Organization, 1990). Many individuals with AS have poor writing abilities and motor planning difficulties are also often cited as possible compounding difficulties in the communication of people with ASD (Wetherby, Prizant & Schuler, 2000). Research conducted twenty to thirty years ago (DeMeyer, 1976; Jones & Prior, 1985) found difficulties with gross and fine motor skills and motor planning in this population, while Manjiviona and Prior (1995) found that the majority of children with high-functioning autism and AS in their study displayed clinically significant gross and fine motor impairment. Nevertheless, it has only been in the last decade or so that consistent research has been conducted to explore these issues and when necessary in intervention, the inclusion of therapy to alleviate motor difficulties is still not always applied.

Dawson (1998) states that motor planning and fine motor coordination difficulties are common in children with ASD, while Gillberg and Billstedt (2000) agree, stating that developmental coordination disorder, clumsiness, abnormal gait and catatonic features are relatively common in AS. Five of the six most severely motor impaired children in the Green et al (2002) study, which assessed manual dexterity, ball skills and static and dynamic balance, came from the group of children with AS and all participants with AS met the criteria for a diagnosis of motor impairment. Research regarding the poor imitation and oral motor skills in ASD has also implicated motor impairment (Peppe, McCann, Gibbon, O'Hare, & Rutherford, 2007; Wetherby et al, 2000). Bennetto (1999) found support for the role of dyspraxia (motor planning difficulty) in the poor body imitation skills of children with autism. The possibility that dyspraxia and/or dysarthria is evident in ASD has received increased attention over the past decade (Anzalone & Williamson, 2000; Dziuk et al, 2007; Rogers, Hepburn, Stackhouse & Wehner, 2003; Shriberg, Paul, Black & van Santen, 2011).

Although quite broad, the American Speech-language-Hearing Association (ASHA, 2007) describes childhood apraxia of speech (CAS) as

> "a neurological childhood (pediatric) speech sound disorder in which the precision and consistency of movements underlying speech are impaired in the absence of neuromuscular deficits (e.g., abnormal reflexes, abnormal tone). CAS may occur as a result of known neurological impairment, in association with complex neurobehavioural disorders of known or unkown origin, or as an idiopathic neurogenic speech sound disorder. The core impairment in planning and/or programming spatiotemporal parameters of movement sequences results in errors in speech sound production and prosody" (p.2).

Kent (2004) describes the dysarthrias as

> "a group of neurological disorders that reflect disturbances in the strength, speed, range, tone, steadiness, timing, or accuracy of movements necessary for prosodically normal, efficient and intelligible speech. They result from central or peripheral nervous system conditions that adversely affect

respiratory, phonatory, resonatory, or articulatory speech movements" (p.126).

Having worked directly with individuals with ASD for over twenty years, I have witnessed many cases of motor difficulties in this population. Some of the difficulties observed include motor planning difficulties displayed by obvious attempts to copy oral movements but inability to do so, inability to point to specific items upon request despite actually looking at the appropriate item and attempting to say words but only being able to produce the first one or two sounds. Delayed gross, fine, oral and verbal imitation abilities were also apparent. Parental reports have confirmed this, with most parents reporting that their children did not point, clap hands or wave at an expected age, and many did not babble. Clinical experience, knowledge of the impaired imitation skills and the recent increased research and knowledge of motor planning difficulties in ASD led to an interest in pursuing the possibility that motor difficulties may contribute to the poor prosodic abilities of individuals with ASD. To reduce the influences of possible problems associated with intellectual disability and delayed language, individuals with AS were chosen specifically for this project.

1.1 PROSODY

As Pragmatics (social use of language), which are known to be a problem in AS (Baron-Cohen, 1988; Loveland, Landry, Hughes, Hall, & McEvoy, 1988; Paul, 2007; Rapin & Dunn 2003), are facilitated by prosodic signals, for example directing turn taking in conversation, differentiating types of discourse units, and indicating whether literal or non-literal meanings are intended (Sidtis & Van Lancker Sidtis, 2003), one may expect that in ASD prosody may also be affected.

Prosody refers to the intonation, stress and rhythm of speech. By contouring words, prosodic information provides perceptual cues which help listeners to segment and interpret the flow of speech (Baltaxe, 1984). Effective communication requires understanding of other people's use of prosody as well as the ability to produce appropriate prosody. Misunderstanding the prosodic signals of other people may leave a listener confused, while the use of atypical prosody can make a speaker sound different from other people, may contribute to a person's lack of acceptance by others and may lead to the speaker being misunderstood.

Prosody is reflected in a range of communicative functions including grammatical prosody which can be used to differentiate sentence types and indicate phrase boundaries, pragmatic prosody which distinguishes between topics and signals new information (particularly the use of contrastive stress) and affective prosody which denotes emotional aspects of linguistic communication (Baltaxe & Simmons, 1985; McCann & Peppe, 2003; Shriberg, Paul, McSweeney & Klin, 2001). The acoustic characteristics used to establish these functions are fundamental frequency (pitch), amplitude (loudness) and duration (timing, pauses, rhythm) (Baltaxe, 1981; Peppe, Cleland, Gibbon, O'Hare & Martinez Castilla, 2011). (Chapter 2 provides further information regarding communicative functions and acoustic correlates).

1.2 PROSODY RESEARCH IN ASD

Abnormal prosody is often referred to in articles about ASD, however, although ranging over 40 years, prosody research in ASD is limited and there is still little consensus about the nature of the prosodic difficulties in this population. The predominant realm of published research involves perceptual analysis of expressive prosody with only a handful of studies using acoustic analysis. As individuals with ASD are known to have difficulties with emotional reciprocity, it is generally thought that pragmatic and affective prosodic functions are more affected than grammatical prosodic functions in AS and research has generally focused on the expression of these areas. Difficulties with comprehension of prosody have been assumed, but while research in this area is increasing steadily, information remains limited and results have often conflicted.

Early research implicated mis-assignment of stress as problematic in ASD (Baltaxe, 1984; Baltaxe & Guthrie, 1987; Simmons & Baltaxe, 1975) and poor understanding and use of contrastive stress and affective prosody continue to be among the most consistent findings of prosody in ASD, particularly in individuals with autism and high functioning autism (HFA) (Fine, Bartolucci, Ginsberg, & Szatmari, 1991; McCann & Peppe, 2003; Shriberg et al, 2001). Nevertheless, more recently the use of grammatical prosody has also been found to be impaired (Peppe et al, 2011).

Perceptual judgment has dominated analysis of data with less than a dozen projects utilizing acoustic analysis and all but one including less than a dozen individuals with ASD. Children with autism have shown longer durations and variability in total utterance duration in a number of studies (Bagshaw, 1978; Baltaxe, 1981; Fosnot &

Jun, 1999). English is a stress-timed language and Baltaxe (1981) claimed that rhythmic patterning in English is central to speech programming. Wider or narrower ranges of pitch have also been found in children with autism, although results have not always been significant statistically (Baltaxe, Simmons & Zee, 1984; Fosnot & Jun, 1999; Unger, 2006).

1.3 OBJECTIVES

The main objective of this research was to determine whether evidence of speech production problems could be detected in the prosody of individuals with AS. As information regarding the use and understanding of prosody in ASD and AS particularly is limited and as results have often conflicted, additional information is needed. Additional information could also provide a guide to intervention with individuals with AS. Small numbers of research participants (most involving less than 12 participants) have been involved in the majority of previous research. Therefore, this research was also designed to further the available information regarding prosody in ASD by comparing the receptive and expressive prosody of a large group of individuals with AS with that of a large group of control participants (CP) to determine whether the prosody of the participants with AS is impaired across both receptive and expressive areas. As only a handful of studies have used acoustic analysis of data, this research also sought to increase knowledge of the acoustic characteristics of the prosody of the group with AS and to see if their acoustic characteristics differ from those of the CP. This was achieved by comparing the pitch range, average pitch, minimum pitch, maximum pitch, intensity and duration used by the two groups.

This chapter has provided an overview of the study of the use and understanding of prosody in AS. The following chapter will describe AS, prosody and prosody research in ASD in further detail and will indicate the questions and hypotheses related to the study.

CHAPTER 2 LITERATURE REVIEW

Prosody in Autism Spectrum Disorder (ASD) has been deemed to be problematic since autism was first described and the assumption that these difficulties exist in ASD is now generally accepted. Current thinking places the cause of this dysprosody primarily in the social and cognitive impairments which are often associated with the disorder. However, these impairments have not been proven to be the sole basis of the prosody problems in ASD. Evidence of motor difficulties in ASD has been accumulating over several decades and has been shown to affect the communication abilities of this population. Motor difficulties as a cause of unusual prosody have also been suggested. The current research was conducted to discern whether evidence of speech motor difficulties could be found in the prosody of individuals with ASD. As information regarding prosody in ASD is limited, assessment of the use and understanding of prosody and the acoustic characteristics of prosody in ASD was also imperative. To limit the effect of language and intellectual difficulties, individuals with Asperger Syndrome (AS) were chosen for this study.

As described in the DSM IV-TR (American Psychiatric Association (APA), 2000) AS is a pervasive developmental disorder and is classified as one of the autism spectrum disorders. The term autism, coined in 1943 by American psychiatrist Leo Kanner, is derived from the Greek word ‘autos’, meaning alone. Although revised by Rutter (1971) and his colleagues, the symptoms described by Kanner are still accepted predominantly. Around the time that Kanner was describing people with autism, an Austrian psychiatrist, Hans Asperger was also working with a similar population of individuals. However, due to the Second World War, the two men did not communicate regarding their ideas. Hans Asperger's research was not recognized generally until Lorna Wing's 1981 English translation and it was not until 1993 that AS was specified individually in the ICD 10 (World Health Organization) and 1994 in the DSM IV (APA). When the DSM V is released in 2013, AS will no longer be a separate entity, but will be incorporated into the general heading of Autism Spectrum Disorder.

Currently, the DSM IV-TR (APA, 2000) specifies that people diagnosed with autism must present with qualitative impairments in social interaction and communication, and with restricted, repetitive patterns of interests, activities or behaviours, which may include stereotypical motor mannerisms. People diagnosed with AS must present with the same qualitative social impairments and restricted, repetitive patterns of interests, activities or behaviours, however, diagnostic criteria stipulate that there must not be a clinically significant general delay in language or in cognitive development although development in both areas is often idiosyncratic. While some people suggest that a mild intellectual disability may be associated with AS, most people with the disorder have average intellectual abilities, while some may have above average intelligence (Prior & Tonge, 1990). The communication difficulties associated with autism primarily involve specific language disorders. However, the severity of the disorder is broad, as it may include a complete absence of speech and language, echolalia, repetitive speech, grammatical errors, syntactic problems, impaired abilities in the use of language for social discourse (pragmatics) and prosodic difficulties. In contrast, while the early development of speech and language skills tends not to be delayed in people with AS they may have semantic language difficulties and their language is characterized, predominantly, by pragmatic difficulties, which remain throughout life (Frith, 1989; Minshew, Goldstein & Siegel, 1995).

As pragmatics are facilitated by prosodic signals (Sidtis & Van Lancker Sidtis, 2003) and as it is known that pragmatics are impaired in AS, one may expect individuals with AS to have prosodic difficulties as well. Prosody refers to the pitch, loudness and rhythm of speech, and it serves a variety of communicative functions (please refer below for further information). A number of acoustic characteristics are used to fulfil the various communicative functions of prosody including fundamental frequency (pitch) measured in hertz (Hz), amplitude (loudness/intensity) measured in decibels (dB), and duration (timing, pauses, rhythm). Crystal (2009) suggests that prosody "is central to the analysis of speech, and one ignores it at one's peril" (p.257).

Effective communicators must be able to use a range of prosodic features (expressive prosody) and to interpret the prosody of other people (understanding of prosody). Listeners who have poor understanding of prosody may become confused by conversations and may have concomitant delayed expressive prosody. Speech which has poor prosody can be difficult to understand, can be an impediment to social acceptance, can lead to the perception that the speaker is different and may lead to the speaker being misunderstood.

Sidtis and Van Lancker Sidtis (2003) state that there is a lot of individual variation of prosody in typical speakers and that the ranges of typical prosody are not well described or understood. They also suggest that complications in interpreting prosody may arise due to the difficulties of discerning multiple acoustic cues, as what the ear hears as speech melody may in fact be an element of intensity or timing. Difficulties with fluency can also confound problems with duration and while some authors discuss pitch range, others refer to average pitch predominantly. Additionally, many different names are used in the literature of prosody research. In the United Kingdom the term prosody is used, while the term supra-segmentals is common in the USA to mean the same thing. Sentence stress is also called sentence accent at times. Couper-Kulen (1986) defines intonation as speech melody, Mackay (1987) suggests that intonation only plays a role at the sentence level and is the fundamental frequency of the voice (pitch), while Peppe (2009) states that the terms prosody or intonation are now often used to refer to stress, rhythm and pitch, with 'intonation' being used primarily by theorists.

Given the variations in conceptualization and terminology above, it is not surprising that the specific prosodic characteristics in AS have not been readily determined and that results of research have often conflicted (McCann & Peppe, 2003). The differences may also be exacerbated by the fact that most studies have included less than twelve participants and research populations have varied, with individuals with autism, high functioning autism (HFA) and AS being studied and compared. As many projects have revealed that a number of people on the autism spectrum have not shown any difficulties with pragmatics or with prosody, the possibility of sub-groups within the spectrum has also been mooted.

2.1 THE DEVELOPMENT OF PROSODY

Many authors stress the importance of prosody in the acquisition of language, stating that the perception of prosodic features precedes the development of language understanding and the ability to produce words (Gerken & McGregor, 1998; Simmons & Baltaxe, 1975; Tager-Flusberg, 1989; Van Lancker, Cornelius, & Kreiman, 1989). Within their first year, the vocalizations of typically developing children include prosodic features which reflect their language environment (Tager-Flusberg, 1989). 'Motherese', a term given to the exaggerated use of prosody (including pitch, duration and loudness), is often used by carers when interacting with young children, and Gerken and McGregor (1998) state that infants prefer this child directed speech to adult directed speech because of the high pitch and wide pitch range used. Van Lancker et al suggest that research regarding the use of motherese has shown that well before being able to say their first word, typically developing children are able to understand and produce subtle prosodic nuances of speech, to provide linguistic as well as paralinguistic information. It is believed that prosody facilitates organization of the understanding and production of speech by providing cues which enable speech to be framed into units. This has been referred to as 'prosodic bootstrapping' (Morgan & Demuth, 1966, cited in McCann et al, 2008).

Baltaxe and Simmons (1985) asserted that studies of developing prosody provided support for the idea that affective prosody is used exclusively at the pre-linguistic level, with linguistic prosody evolving from this initial development. By the end of the second year, children are able to use prosody to convey pragmatic as well as affective information (Tager-Flusberg, 1989). The ability to control pitch, tone and timing continues to develop (Tager-Flusberg), with Baltaxe, Simmons and Zee (1984) and Tager-Flusberg stating that prosody may not be achieved fully until puberty. Baltaxe et al emphasized the interdependence of knowledge of other language levels with prosody and Tager-Flusberg implied that full mastery of stress and rhythm is important for semantic and syntactic interpretation.

2.2 FUNCTIONS OF PROSODY

Prosody serves a variety of communicative functions including grammatical, affective and pragmatic, although these categories are not always exclusive. Additionally, some authors combine affective and pragmatic prosody into one category, affective/pragmatic prosody (Shriberg et al, 2001).

2.2.1 GRAMMATICAL PROSODY

Grammatical prosody is language specific and relates to the cues used to indicate syntactic information, including -

- word stress, which can be used to differentiate word classes, e.g. nouns, 'He gave his mother a beautiful <u>pre</u>sent', or verbs, 'He will pre<u>sent</u> his findings at the meeting'
- pitch patterns, which can be used to denote sentence types in the absence of syntactic cues, e.g. falling pitch for statements suggesting finality and that a speaker may be finished speaking, and rising pitch for questions indicating that a response may be required
- pauses, which can be used to indicate phrase boundaries, e.g. 'chocolate cake and milk', compared with 'chocolate, cake and milk' (Peppe, McCann, Gibbon, O'Hare & Rutherford, 2006).

Difficulties understanding grammatical prosody may result in a person not realizing that a speaker has finished, not responding to questions and not understanding syntactic groups. A person with expressive grammatical prosody problems may not relay appropriate linguistic information to listeners, leading to his/her communication being misunderstood or its meaning being difficult to interpret. If problems with grammatical prosody are caused by lack of underlying grammatical competence, both receptive and expressive grammatical prosody difficulties would be expected.

2.2.2 AFFECTIVE PROSODY

Affective prosody denotes the emotional meanings and mood of communication. It relates to the registers used by speakers and how those registers are perceived by listeners. Peppe (2009) states that, in general, people associate a wider pitch range in a speaker with greater emotional involvement.

Difficulties understanding affective prosody may lead a listener to appear aloof and uncaring, while expressive difficulties may mean that the feelings of the speaker may be misinterpreted or ignored.

2.2.3 PRAGMATIC PROSODY

Pragmatic prosody is used to distinguish what the speaker believes to be the important information to impart to the listener by providing the location of information focus to distinguish between topic and comment, and to signal new information in an utterance. All sentences contain stresses, with the stressed or accented words being the carriers of information.

An utterance is considered to be in ‘broad’ focus if all parts of the utterance are equally important, and it will contain default sentence stress, which usually occurs on the accent-bearing syllable of the last lexical item (McCann & Peppe, 2003), e.g. ‘I bought a chair at the shop’, would have emphasis on ‘shop’. This default sentence stress (which may also be called primary sentence stress) does not occur in the presence of contrastive stress (Baltaxe & Guthrie, 1987). Contrastive stress is used to differentiate topic, the shared background knowledge between speakers and listeners which is not stressed, and comment, the new information to be imparted to listeners which is stressed (Baltaxe, 1984). An utterance is considered to be in ‘narrow’ focus when a particular aspect of the utterance is considered to be more important than another. Contrastive stress is then utilized to distinguish the salient information, with stress being placed on the accent-bearing syllable of the most important word (McCann & Peppe, 2003). For example, in reply to the question ‘Did you buy the red chair or the black chair at the shop? the answer, ‘I bought the red chair’, would have emphasis on ‘red’. McCann and Peppe state that studies have shown that by three years of age typically developing children use contrastive stress appropriately for imparting new information.

People who have difficulties understanding contrastive stress may miss important aspects of communicative interactions, while those who do not use stress appropriately may confuse their listeners and not impart the most salient information.

2.3 PROSODY RESEARCH IN AUTISM SPECTRUM DISORDERS (ASD)

The speech of people with ASD may include monotonous tone, unusual pitch, excessive volume, poor voice quality, and unusual stress patterns (Shriberg et al, 2001). These characteristics often contribute to other people's impressions that people with the disorder are different, and it is often assumed that these particular speech characteristics result from the social and cognitive impairments associated with ASD (Jordan, 1993; Prizant & Wetherby, 1989).

Poor expressive prosody in ASD is generally recognized (Baltaxe & Simmons, 1985; McCann et al, 2008; Paul et al, 2005a) and it is also commonly thought that affective and pragmatic prosody are the predominant areas of difficulty in ASD. Paul, Augustyn, Klin, and Volkmar (2005a) suggest that this hypothesis is not unreasonable, given that in ASD grammatical and morphological abilities are stronger than pragmatic skills and that to date, prosodic research has most commonly identified pragmatic/affective prosodic functions as areas of deficit. However, there is still a paucity of research in this area and results do not always concur (McCann, et al, 2008).

Although for over forty years prosodic problems associated with autism and AS have been mentioned in research literature, less than fifty research articles are available currently. The majority of studies involves less than twenty subjects and relies upon the judgment of listeners to analyze the data, with only eleven studies using acoustic analysis. Research reflects the knowledge and practice of the time, with the 1970s relying on expressive prosody in autism, receptive prosody being included by the mid 1980s, and high functioning autism and AS being introduced in the early 2000s. Participant numbers also tended to increase over this time, and the use of acoustic analysis has been steady, albeit restricted, over the years. Stress is the most extensively covered area of prosody to be researched (Peppe, McCann, Gibbon, O'Hare & Rutherford, 2006). Although early research was limited and small sample sizes were involved generally, many of the early studies resulted in pioneering work. Results of more recent studies involving larger numbers of research participants have generally reflected the results of earlier research. Recent reports have also tended to combine examination of receptive and expressive prosody.

2.3.1 EXPRESSION OF PROSODY IN ASD

One of the earliest studies regarding prosodic features was reported by Goldfarb, Braunstein and Lorge at a symposium on Childhood Schizophrenia held in 1955. Using the trained listening judgment of an experienced speech pathologist the speech characteristics of 12 children with schizophrenia and 6 children with reactive behaviour disorders were compared. Using current diagnostic criteria, most of the children with schizophrenia would probably now be diagnosed with ASD. Repeated observations and recordings of the children's spontaneous speech were collected over the period of approximately one year. No significant differences were found between the two groups for voice quality. However insufficient volume changes and pitch problems including excessively high pitch levels, narrow pitch ranges and pitch falls on inappropriate syllables or words were found in the children with schizophrenia. Additionally, insufficiency of stress or incorrect placement of stress, and timing difficulties including prolongation of sounds, syllables or words, and hesitations were reported. Sound and syllable repetitions were also noted. Goldfarb and his colleagues commented that

> "The peculiarities are of insufficient, or incorrect, or distorted intonation patterns. Intonation insufficiency is sometimes linked with pitch insufficiency. When it is so linked the rises and falls in speech melody, although appropriate in range, are narrower than normally expected changes. Where the pitch should drop, for example, it often does not. A flat, unfinished quality is produced. This is what has been referred to commonly as a monotone" (p.548).

Although definitions were not clear and judgment was by one person only with no statistics provided, at the time the study was ground-breaking.

Goldfarb and his colleagues later developed a prosodic rating scale and in 1972 reported on the comparison of the prosodic features of 25 children diagnosed with childhood schizophrenia with a control group of 25 typically developing children who were matched by age, gender, race and religious background (Goldfarb, Goldfarb, Braunstein, & Scholl, 1972). Again, the listener judgments of a speech pathologist were used to determine a number of prosodic variables. Similar to the results of Goldfarb et al (1955) as well as articulation, voice and language difficulties, a trend towards opposite extremes particularly with regard to pitch and rate, unusually long prolongations of sound, incorrect emphasis, and faults stemming from excessive variability were observed. However, no evidence of a single pattern of errors was found. Goldfarb et al (1972) concluded that "This sounds very much as though the fundamental deficiency is a failure at many points in the control and regulation of speech and communication" (p.232).

Over a 20 year span Baltaxe, alone and with other colleagues, conducted a range of studies of prosody in children with autism. The earliest paper (Simmons & Baltaxe, 1975) examined the expressive prosody, expressive linguistic elements and musical abilities of seven adolescents (aged 14 – 21 years) with autism. Using the criteria cited by Goldfarb et al (1972) they found that the most frequent and characteristic feature was dysfluency, and four of the seven subjects had prosody deficits in areas that included pitch, volume, rhythm, stress and intonation. However, that means that three children did not have any difficulties and this difference could not be accounted for by age or IQ scores. Despite the small numbers in the study, the authors concluded that the two distinct groups were indicative of heterogeneity within ASD.

The aim of Baltaxe's study in 1984 was to compare the ability of seven children with autism, seven typically developing (TD) children and seven children described as aphasic, aged 4 to 12 years, to use contrastive stress to express pragmatic function. The TD children were much younger and their scores on the Peabody Picture Vocabulary Test significantly higher than the other two groups, but only Mean Length of Utterance was used to match the groups. The task involved the children responding to yes/no questions that were counterfactual to the manipulation of toys presented to them, e.g. the child was shown a toy dog sleeping in a bed and asked "Is the baby sleeping in the bed?" An appropriate response to this question would place contrastive stress on the subject of the sentence, e.g. 'It's a <u>dog</u> not a baby' or 'The <u>dog</u>'s sleeping in the bed'. Responses were elicited for contrastive stress in subject, verb and object (SVO) positions and were judged perceptually. The children with autism had the lowest number of correct responses overall and mis-assigned stress to function words that don't usually bear stress. Additionally, 39.4% of their incorrect responses were simultaneous assignment of sentence stress to more than 1 element of their utterances. The other two groups did not do this at all, suggesting to the author that the children with autism used disordered assignment of stress.

Using data from the same children as in Baltaxe's 1984 study, Baltaxe and Guthrie (1987) used listener judgement to examine differences in the use of default (primary) sentence stress. Toy manipulation facilitated descriptions of a play situation with children being asked 'What's this?' As all elements of the expected Subject Verb Object (SVO) responses were considered to carry an equal information load, it was anticipated that stress would be placed on the object (which is consistent with primary/default stress in SVO utterances), e.g. 'Mike is eating a <u>cookie</u>'. However, all groups mis-assigned stress to the subject predominantly, (i.e. <u>Mike</u> is eating a cookie). Baltaxe and Guthrie speculated that these results may have been developmentally determined as "subject position takes on specific significance for young children, who in their egocentric stage of development consider themselves as the controlling force in their environment" (p.267).

Other researchers joined the quest to determine the use of functional prosodic characteristics in ASD, with examination of pragmatic prosody (specifically contrastive stress) and grammatical phrase boundaries predominating.

McCaleb and Prizant (1985), who investigated the ability of four children with autism to encode new and old information through the use of contrastive stress, also found that they used contrastive stress in an atypical manner. The children stressed old information as often as new information when the pragmatic context required the focus to be on new information.

In a study involving larger numbers of participants than previous research, Fine et al (1991) compared the patterns of intonation of 23 people with AS and 19 high-functioning people with autism (HFA) aged 8-18, with 34 psychiatric outpatients. This was one of the first studies of prosody to define individuals with AS. Assignment of stress and the use of tone boundaries in a ten minute sample of spontaneous speech were judged appropriate or inappropriate by a research assistant. The HFA participants used sentence stress placement at the tone boundary (grammatical prosody) successfully, but tended to place stress on function words rather than content words, like the participants in Baltaxe's 1984 research. However, unlike the participants in Baltaxe and Guthrie's (1987) study they were also able to use default stress appropriately. The participants with AS performed as well as the control participants.

By comparing grammatical pauses (at phrase boundaries) and non-grammatical pauses (within phrases) in the speech of 10 children with autism, 10 TD children and 10 children with intellectual disability, Thurber and Tager-Flusberg (1993) investigated the hypothesis that children with autism produce non-grammatical pauses more frequently than the other groups. Thurber and Tager-Flusberg suggested that it is commonly believed that the frequency of pauses is indicative of cognitive load, with an increased use of non-grammatical pauses occurring in tasks which are cognitively demanding. The hypothesis was not confirmed, as the children with autism actually used non-grammatical pauses less frequently than the two other groups. They also used grammatical pausing similarly to the two other groups, confirming the results of Fine et al (1991). However, despite the good results of the children with autism, the authors suggested that the findings indicated a reduced cognitive load for these children, which they attributed to their reduced communicative investment in the interaction.

Shriberg et al (2001) also used a larger cohort of participants, which included 15 people with HFA and 15 people with AS. Speech and prosody profiles were constructed from their conversational speech and were compared with the profiles for 53 typically developing males. The age range of the subjects was 10 to 50 years. They found that 40% of the HFA individuals and 66% of the AS participants had inappropriate or non-fluent phrasing in more than 20% of their utterances, although the sound, syllable and word repetitions errors made suggested stuttering problems rather than phrasing difficulties per se. Utterances of longer length produced increased phrasing errors, which the authors stated may have been influenced by increased resource needs from both speech motor control and social demands. Phrase and sentence level stress was more problematic than word stress. Unlike Fine et al (1991) who did not find contrastive stress difficulties in people with AS, Shriberg et al noted small, but significant mis-assignments of contrastive stress in both the HFA and AS groups although the HFA participants used appropriate stress in 77.3% of their utterances while 86.5% of the utterances of the participants with AS contained appropriate stress. Shriberg et al suggested that the stress difficulties could reflect perceptual-motor deficits in coordinating components of the speech signal. However, they felt that if this was the case, grammatical and pragmatic errors would be found, whereas they state that only pragmatic difficulties were discerned in this study. They hypothesized that it is the pragmatic and affective prosodic areas which are primarily affected in ASD.

2.3.1.1 Echolalia

Prosody has also been researched in children with autism who are echolalic. Echolalia, the repeating of words previously heard, can be classified as immediate, delayed or mitigated. Immediate echolalia occurs when an utterance is repeated exactly, immediately after it has been spoken, while if a previously heard utterance is repeated exactly at a later time, it is called delayed echolalia. Mitigated echolalia occurs when a child manipulates words of a previously heard utterance and is an indication that a child is trying to communicate intentionally, although he or she may not have the requisite language skills to generate his or her own language. Although repetition can mean that a child lacks understanding, Prizant and Wetherby (1987) stated that “many individuals with autism use immediate and delayed echolalia to purposefully communicate their intentions” (p.475) and suggested that careful observations of children can determine whether they are trying to communicate with intent and that this intent may be reflected in subtle changes in prosody.

An early publication relating to prosody and ASD (Pronovost, Wakstein, & Wakstein, 1966) relied upon listener judgment of the prosodic features of the echoed speech of 14 children diagnosed as ‘atypical or autistic’. All children were observed in informal and clinical environments over a period of two years. Eight of the children, whose vocal utterances were limited to non-linguistic sounds, reflexive sounds, and single or reduplicated vocalizations, were allocated to the ‘vocalization group’. Findings indicated that the vocalization group used prolonged, monotonous vocalizations with many high pitched sounds, intensity levels which ranged from whispers to excessively loud, and voice quality which varied extensively. A 'talking group' included the remaining six children who were almost entirely echolalic. These children were able to produce some intelligible sounds and words which were imitative or suggestive of speech, however, they also used jargon and other non-linguistic sounds. The wide variations in pitch, intensity, duration and quality identified in the 'vocalization group', were also apparent in the speech and non-speech vocalizations of the 'talking group'. As the 'talking group' did not copy the rhythm or intonation of the adult stimuli the authors suggested that prosody was compromised in these children. However, the possibility exists that the children chose to change the rhythm and intonation.

Paccia and Curcio (1982) also examined echolalia in the speech of five 'autistic-like' children (aged 7-17 years approximately) to determine the frequency of their use of imitative and contrastive prosody. The fundamental frequency contours of their echolalic responses were analyzed in the context of yes/no questions. Judgment was made by the shape of utterance final contours, with rising contours judged as imitative and falling contours considered to be contrastive. As the children used the contrastive prosody, the authors interpreted their restructuring of prosody as mitigated echolalia which they suggested indicated a degree of comprehension. However, as falling contours are also indicative of primary/default intonation, one may query whether the children were aware of and/or had control over production of contrasting pitch patterns.

Conversely, Local and Wootton (1996) described the types of echolalia (prosodically echolalic or prosodically contrastive) displayed by an 11 year old child with severe autism. The child echoed back exactly what he had heard rather than restructuring the prosody (i.e. he used prosodically echolalic responses). Despite this, his utterances were interpreted as communicative because the authors suggested that he chose to repeat the utterances, as repetition is often successful for him when he is trying to communicate. Regardless of whether the child's communication was intentional or not, he did not display the ability to use appropriate prosody.

While the above studies have identified expressive prosodic difficulties in ASD, despite a lack of research, it has often been assumed that individuals with the disorder also have difficulties understanding prosody.

2.3.2 UNDERSTANDING OF PROSODY IN ASD

Obtaining information about understanding of prosody (receptive prosody) as well as prosody use (expressive prosody) provides a broader perspective and understanding of prosody in general and allows comparisons between the two areas. Assessment of receptive prosody in ASD is as limited as expressive prosody research and like expressive prosody has involved small numbers of participants primarily, with most studies involving less than twenty participants.

Two studies have involved assessment of the listening preferences of children with autism in regard to various types of prosody. One study involving eight children with autism (mean age 5;7), eight TD children matched by chronological age (CA), eight TD children matched by mental age (MA) and eight developmentally delayed children matched by CA and MA (Frankel, Simmons & Richey, 1987) attempted to compare the relative intrinsic reward value of different types of prosody. ‘The Three Bears’ story was read with natural prosody, monotone (a constant fundamental frequency was maintained), staccato (all syllables were stressed with a staccato rhythm) and metronome (monotone and unstressed). Three seconds of the story was read and the children were required to pull a lever to hear more of the story. If the lever was pulled during the three seconds, the story continued with the same prosody. More frequent pulling of the lever was considered to show greater interest in the story or in the prosody being used. None of the four prosodic conditions revealed statistically significant differences between any of the groups. However, as the children with autism showed short-lived, but heightened interest in prosodic changes, it was concluded that they were able to perceive prosody.

The other study assessing children’s prosodic preferences was conducted by Lamers and Hall (2003) who determined to identify the prosodic preferences for three types of prosody including monotonous, conversational, and enthusiastic and to judge which type of prosody is most effective in instruction. No overall significant preference for prosody for either the 12 children with autism or the 11 TD children in their study was found, however the responses of children in both groups were considered to be better with the conversational and enthusiastic prosody than with monotonous prosody.

Given the social/affective difficulties associated with ASD, not surprisingly, much of the research involving understanding of the functions of prosody has related to understanding of affective prosody.

Using the premise that consonants and vowels carry linguistic meaning, while paralinguistic information is carried mainly by the melody of speech or prosody, Van Lancker et al (1989) assessed the ability to label four emotional intonations in speech through the ability to comprehend linguistic versus emotional meanings in speech. Participants included 28 children with autism, 19 children with schizophrenia and 33 TD children, who were required to listen to 20 stimuli, each of which contained 2 channels of information. One channel provided a linguistic meaning (carried by the vowel and consonants) which necessitated matching a word to line drawings of pictures, e.g. a boy walking a dog. The other channel provided an emotional meaning (carried in the intonation), which required the emotions to be matched with line drawings of a happy, sad, angry or surprised faces with the appropriate word written underneath. These tasks require the ability to switch between auditory and visual modes. As it became apparent during testing that there was delineation of understanding between children under and over eight years of age, two subgroups were formed in each research group. No statistically significant differences were found between the older children with autism and the older TD children on the linguistic task. Results for the emotional task revealed that the TD children over eight years were able to match the emotional stimuli, while those under eight years performed poorly on this task. No statistically significant differences were found between the younger TD children and the younger or older children with autism, but the older children with autism performed significantly worse than the older TD children on the emotional task. Van Lancker et al suggest that mental age (MA) did not contribute to the differences found, but that the differences may reflect difficulties with cross-modal tasks. Nevertheless, subgroups were formed according to a chronological age of eight years and all but three of the children with autism had a MA of less than eight. No MA was provided for the other participants.

A study by Boucher, Lewis and Collis (2000) involved four test situations with 19 children with autism (mean age 9 years 7 months), 19 children with Specific Language Impairment (SLI) (9 years) and 19 TD children (6 years 4 months). The TD children were included in experiments three and four only. No differences were found between children with autism and children with SLI in their ability to match a familiar voice with the appropriate face (experiment one), or to recognize a familiar voice (experiment two). In experiment three, which required discrimination of unfamiliar voices, children with autism or SLI did not show impairment when compared with the TD children. Experiment four consisted of two sections. The children were required, firstly, to name vocally expressed emotions, including happiness, sadness, disgust, fear, anger and surprise with the children with autism performing as well as the TD on this task. Secondly they were required to match vocally expressed emotions with pictures of faces expressing emotions, with the children with autism performing more poorly than the TD children. The children with autism performed better than the SLI children on both sections of experiment four. The authors concluded that the scores on both sections of this experiment were similar for the children with autism therefore they did not show evidence of cross-modal problems. However, the TD children did display higher scores for the matching task than they did for the naming task, therefore the possibility that the children with autism did display cross-modal problems remains.

Lindner and Rosen (2006) also chose to combine prosody with facial expressions. PPVT-III scores did not differ significantly for the 14 AS group members (all of whom were in the 5 to 16 years age range) and their 16 TD peers. Four emotions, happy, angry, sad and neutral were presented in auditory or visual format across five modalities, which included static facial expression, dynamic facial expression, prosody, verbal content, and combined modality. The AS group did not perform as well as the TD group on the static facial expression, dynamic facial expression and prosody tasks, with the results being statistically significant. However, the children with AS did not differ from TD children in their ability to decode emotions in the verbal content modality or the combined modality. The authors concluded that the children and adolescents with AS may have been relying on verbal cues as a compensatory strategy to understand emotion.

Facial electromyography (EMG) was used to determine responses to emotional information from faces and voices by Magnee, Gelder, van Engeland and Kemner (2007). Thirteen high-functioning adults with Pervasive Developmental Disorder (PDD) were compared with 13 neuro-typical adult control participants. Autism spectrum disorder (ASD) is also part of PDD, however, while the adults with PDD in this experiment have many of the features of ASD, their behaviours do not reach the criteria for this diagnosis. The zygomaticus major, the muscle which pulls the corners of the mouth into a smile, is commonly contracted in response to seeing happy faces, while ‘corrugator supercilii’ activity, which moves the brows into a frown, is increased in response to negative stimuli, including angry faces. Similar reactions also occur to vocally expressed affect (Magnee et al). Six stimulus categories were presented, including visual happy, visual fear, congruent audio visual

(AV) happy, congruent AV fear, incongruent audio happy/visual fear and incongruent audio fear/visual happy. Magnee et al were surprised to find that both groups displayed increased activation of the appropriate muscles in response to the stimuli, and in fact the PDD group smiled more in response to happy versus fear than the control group.

While studies of affect initially dominated prosodic research in ASD, the rise in the number of research projects being undertaken, combined with the development of tools to assess prosody, lead to a wider range of prosodic functions being assessed, with grammatical and pragmatic prosodic functions being included.

Jarvinen-Pasley, Peppe, King-Smith, and Heaton (2008) used the receptive subtests of a prosody assessment tool, Profiling Elements of Prosodic Systems – Children (PEPS-C) (Peppe & McCann, 2003). (Chapter three provides further information regarding the PEPS-C). The prosody of 21 children with AS/autism was compared with 21 children who were matched for CA, receptive vocabulary and non verbal IQ. 76% of the control group was typically developing, while the remainder had moderate learning difficulties. The PEPS-C assesses prosodic form, involving auditory-perceptual characteristics of prosody, "bottom-up processing where no meaning is involved" (Peppe, McCann & Gibbon, 2004, p.6) and cognitive function level prosodic abilities including affective, grammatical, and pragmatic functions, "top-down processing involving meaning" (Peppe et al, p.6). Although results for form tasks were superior to function task results for both groups, the overall performance of the children with autism was poorer than that of the control group. Apart from one function task, focus, which assesses contrastive stress, all control group participants achieved the competence level, which was set at 75%, for all tasks. Conversely, the children with AS/autism failed to achieve competency in any of the function tasks. Despite this, no significant differences were found between the groups for understanding of contrastive stress, unlike Paul (2005a) (referred to below) or for understanding of questions versus statements, which is in agreement with Paul (2005a) and Peppe, McCann, Gibbon, O'Hare and Rutherford (2007). Significant differences were found for understanding of affect (expressed vocally) and understanding of grammatical phrasing. Additionally, a difference between the groups on the form task requiring perception of phrase level prosody changes was also statistically significant. As understanding of the grammatical use of questions and statements is only assessed at the word level on the PEPS-C, a second experiment was conducted to assess this receptive ability at the sentence level. All control children but only 20 children with AS/autism were included in experiment two, which involved 24 sentences read with prosody indicating a statement or a question, e.g. 'He wants to leave now' (falling pitch) compared with 'He wants to leave now?' (rising pitch). As final words in statements of this type have falling pitch while prosodic question forms have rising pitch and usually have concomitant higher amplitude (loudness), the amplitude and duration of final words was equalized using PRAAT (Boersma, 2001), a computer software program enabling the analysis and synthesis of speech. Like word level understanding of questions and statements, in experiment two, sentence level understanding of statements and questions also failed to reach statistical significance. However, the control group was able to discriminate questions better than the AS/autism group, who had a bias towards judging stimuli as statements, particularly when longer stimuli were used.

A small pilot study by Paul, Augustyn, Klin, Volkmar, and Cohen (2000) is cited by McCann and Peppe (2003), although the latter state that limited information is available and no statistical results are reported. Three tasks were included in the study of 18 individuals with HFA (presumably children) and 10 TD children aged 12 to 18 years. The first two tasks assessed understanding of grammatical prosody, while the third task involved understanding of affective prosody. In the first task the children were asked to judge whether heard words (which were differentiated by stress) were nouns or verbs, e.g. <u>im</u>print (noun), versus im<u>print</u> (verb). The second task assessed the ability of the children to discern grammatical phrasing, e.g. ‘Paul, my friend, is here’ compared with ‘Paul, my friend is here’. Reportedly, the HFA group was less able than the TD group on both of these tasks. The third task assessed the children’s ability to understand utterances said in an ‘excited’ or ‘calm’ manner. Contrary to the findings of Rutherford et al (2002) both groups performed near ceiling level on this task. However, McCann and Peppe (2003) suggested that as the two stimulus emotions used are substantially different from each other, if more complex or subtle emotions had been used a difference might have been found between the groups.

Three tasks were also used to assess understanding of grammatical prosody in children with AS (Chevallier, Noveck, Happe & Wilson, 2009). Seventeen TD children were matched by CA and MA (using the British Picture Vocabulary Scales) to 15 children with AS in tasks one and two and to 17 children with AS in task three. Both groups of children performed similarly on pre-tests which were used to ensure that they did not have a disorder at the perceptual level. Like Paul et al’s (2000) study above, the first test assessed understanding of grammatical prosody at the word level, while the second assessed grammatical phrasing, e.g. ‘dragonfly and carrot’ compared with ‘dragon, fly and carrot’. However, unlike the children with HFA in Paul et al’s (2000) study, the children with AS performed as well on these tasks as the TD children. The third task was to differentiate statements, e.g. ‘This is a dog’, with what they called syntax condition questions, e.g. ‘Is this a dog?’ and prosody questions, e.g. ‘This is a dog?’ Both groups achieved ceiling responses for the statement condition and both question conditions. The prosody questions were more problematic for both groups and the performance of the AS children did not differ from the TD children. Therefore the authors concluded that the results support the view that in AS the perception of grammatical prosody is not compromised. However, the ceiling effect may have compromised these results.

As McCann and Peppe did not find any studies that covered both understanding and use of a range of prosodic skills when they wrote their review of prosody in ASD in 2003, they expressed concern that the relationship between understanding and use of prosody could not be investigated fully. They and their colleagues have since set out to rectify this situation.

2.3.3 STUDIES COMBINING USE AND UNDERSTANDING OF PROSODY IN ASD

Since McCann and Peppe’s (2003) review approximately seven research articles regarding use as well as understanding of prosody in ASD and involving larger numbers of participants have been published. Five of these papers were written by Peppe and her colleagues, who devised the previously mentioned prosody assessment tool the PEPS-C to assess both receptive and expressive prosody (Peppe & McCann, 2003). By investigating a broad range of prosodic abilities, using adequate numbers and using a narrow diagnosis of autism Peppe and her colleagues stated that they have tried to avoid the pitfalls of previous research.

Using the receptive and expressive subtests of the PEPS-C (Peppe & McCann, 2003), the same assessment tool which Jarvinen-Pasley et al (2008) used to assess receptive prosody, McCann et al (2005) assessed 31 children with HFA matched by MA, sex and socio-economic status with 72 TD children. In a brief account of results, it was stated that overall the children with HFA performed significantly poorer than the TD children, with particular difficulties understanding and using affective prosody. A French translation of the PEPS-C (Hesling et al, 2010), which included all subtests except the expressive imitation (form) tasks, revealed that receptively and expressively eight adults with HFA also performed poorer overall than adult control participants.

Peppe et al (2007) provided additional information regarding the receptive and expressive results of the PEPS-C for the children referred to above, and included an adult control group of 33 people aged 18 to 59 years. The adult group achieved near ceiling results for most subtests. Other results revealed significant differences between the HFA children and the TD children for all form subtests (bottom-up processing per Peppe et al, 2004), including perceiving differences between word-like and phrase-like sounds and imitating words and phrases with specific prosody. The authors state that although many children with autism are able to repeat parts of their favourite videos using the exact words and accent, the lack of ability of the children with HFA to imitate prosody on the PEPS-C provides evidence of problems with motor imitation. As was expected, significant differences were also found for understanding and use of affective prosody and for the ability to use contrastive stress, which the authors concluded supports the findings of Baltaxe and Guthrie (1987) and Shriberg et al (2001) that accent placement is disordered in autism.

The PEPS-C was also used to examine a single case study of a seven year old boy with HFA (Peppe et al, 2006). Like the children with HFA in the previous study, this boy also performed poorly on form tasks, including scoring at least 1.5 standard deviations (SD) below the mean on all form subtests except imitating phrases, where he scored as well as the TD children in the previous study. His understanding and use of affective prosody was more than three SD below those of the TD children. Peppe et al stated that despite the fact that the use of pragmatic prosody (contrastive stress) is the first prosodic function acquired developmentally and that there was a negligible difference between the scores of the youngest TD children and the adults in the previous study, the score on this subtest for the boy in the case study was also more than three SD below those of the TD children.

In a broader report of the PEPS-C, Peppe, Cleland, Gibbon, O'Hare and Castilla (2011) compared the results of the 31 children with HFA reported above (McCann & Peppe, 2004) with TD chronological age (CA) matched peers and with language age (LA) matched peers. The paper also included comparisons of results for 40 children with AS (mean age 9.4 years) with TD peers matched by CA or LA. Although understanding and expression of prosody was assessed, only expressive results were detailed. When compared with LA matched children, significant differences were found for the children with HFA in use of affective prosody, contrastive stress (pragmatic prosody) and imitation of words and phrases items (prosody forms). Differences in these tasks as well as appropriate use of phrasing and sentence types (grammatical prosody) were also statistically different when the results of the children with HFA were compared with their CA matched peers. Alternatively, when compared with LA matched children, the children with AS only performed significantly poorer when imitating phrases. Imitation of words and grammatical phrasing were additional significant difficulties when the children with AS were compared with their CA matched peers. Difficulties with imitation tasks were therefore consistent across the group with HFA as well as those with AS. Peppe et al concluded that the prosodic differences between these groups could not be attributed to their age, as the difference between the ages of the two groups was not statistically significant. Neither could the differences be due to non-verbal abilities as although the AS group had higher non-verbal abilities, there was a lack of correlation between the scores of prosody tasks and results of non-verbal testing. Although no difference was found between the receptive vocabulary of the children with AS and the CA matched TD children, the language skills of about one third of the children with AS were below the normal range, with the expressive difference between the two groups being significant. Peppe et al suggested that at least some of the prosodic difficulties experienced by these children may be explained by poorer language abilities, and recommended that AS and HFA groups should be distinguished when aspects of language and communication are being examined.

Several other researchers have more recently assessed understanding and expression of prosody without the use of the PEPS-C. An experiment aimed at perception and production of stress (syllable and word emphasis), intonation (changes in pitch over phrases and sentences) and phrasing (rate and pausing patterns within utterances) was conducted with 27 participants with ASD, aged 14 to 21 and 13 TD children with an average age of 16 years 7 months (Paul et al, 2005a). Twelve tasks involving understanding and use of prosody were included, which Paul et al named -

- grammatical stress (lexical stress), e.g. con duct / con duct.
- pragmatic/affective stress (contrastive stress), e.g. I want chocolate icecream / I want chocolate icecream.
- grammatical intonation (questions versus statements), e.g. He speaks French? / He speaks French.
- pragmatic/affective intonation, e.g. adult speech versus ‘motherese’.
- grammatical phrasing, e.g. Ellen, the dentist is here / Ellen, the dentist, is here.
- pragmatic/affective phrasing, e.g. say the word or point to the picture of how the person feels.

Significantly poorer results were obtained for the participants with ASD for understanding and use of contrastive stress (pragmatic/affective stress) and for use of lexical stress (grammatical stress). The authors concluded that both understanding and use of both grammatical and pragmatic/affective stress is a problem in ASD, although this was despite the fact that the result for understanding of grammatical stress did not reach statistical significance.

Three experiments were involved in a study of perception of affective prosody and perception and production of lexical stress (grammatical prosody) by Grossman et al (2010), who compared the results of 16 adolescents with HFA with 15 of their TD peers. Perception of affective prosody required participants to label spoken sentences (that had been filtered to maintain prosody but to eliminate verbal content) as sad, happy or neutral. Unfiltered sentences were also used to ensure understanding of the research task and were found to be easier for both groups than the filtered task. The neutral context proved to be most difficult for both groups and no significant differences in understanding of affective prosody between the groups was established. The perception and production of lexical stress stimuli were composed of comparisons of compound words and phrases, e.g. **hot**dog vs hot **dog.** No significant differences between the groups were found for perception or production of lexical stress, although the productions of the HFA adolescents were significantly longer than those of their TD peers. Further acoustic analysis of the production of lexical stress in this study will be discussed later.

2.3.4 SUMMARY OF PROSODY RESEARCH IN ASD

The above research indicates that individuals with ASD are not a homogenous group in their understanding and use of prosody, and that differences within individuals occur. The difficulty of ascribing prosodic difficulties across the autism spectrum is further confounded as many projects have combined and compared different groups within the spectrum, e.g. AS, HFA and autism. Only a handful of studies have defined AS specifically and the majority of projects have involved small numbers of participants.

The increased use of the prosody assessment tool the PEPS-C has shown that expression of prosodic forms, which involve imitation of prosody, has been an almost universal difficulty for individuals on the spectrum. The prosodic function areas which have been found to be most problematic consistently in ASD are understanding and use of *affective* prosody and *pragmatic* prosody (specifically contrastive stress), although indications of difficulties in the *grammatical* prosody arena are becoming more apparent.

To date, information regarding the use and understanding of grammatical prosody along the autism spectrum has varied and although results have not always revealed significant differences, several authors have implied that individuals on the spectrum have performed poorer than their peers overall. Across ASD groups, few difficulties have been detected in understanding question and statement forms. Expressively, although not statistically significant, some children with AS and HFA have not been able to use question and statement forms as well as control group participants. Exclusive groups of children with AS have not had difficulties understanding grammatical phrase boundaries, nevertheless some combined groups of children with HFA/AS have been less able to understand these concepts than control group children. The ability to use phrase boundaries has been shown to be somewhat intact in ASD, HFA and AS. However, one study did reveal a statistical difference when children with HFA and with AS were compared with CA matched rather than language age matched peers. Additionally, although some individuals with ASD are less able to understand and use word stress (lexical stress) than their peers, generally this area has not proved to be a major problem, particularly in AS. Problems using default (or primary) sentence stress have also only been apparent in a small number of children with autism.

Only some of the individuals with HFA and AS who have been assessed have had difficulties understanding affective prosody. However, children with HFA have been found to have more problems than their peers when expressing affective prosody.

The limited research with individuals with AS has thus far not found statistical evidence of impaired use of affective prosody, while reports regarding individuals with autism have not specifically addressed this domain.

Understanding of pragmatic prosody (specifically contrastive stress) has not been found to be problematic in individuals with HFA/AS, although one combined group of children with ASD did not comprehend contrastive stress as well as their peers. Apart from two studies involving adolescents with AS, all other studies have found statistically significant differences in the use of contrastive stress in individuals with autism, HFA, and AS when compared with control groups.

It is therefore apparent that there is a dearth of information regarding understanding and use of prosodic functions in ASD generally, and particularly in AS. The conflicting results of the above studies indicate a need for further research involving both receptive and expressive prosody skills with large numbers of participants who have the same diagnosis (i.e. autism, HFA or AS). Nevertheless, difficulties with prosody are apparent. Current theory regarding the cause of the communication and prosodic impediments in ASD places emphasis upon the cognitive and social/emotional difficulties associated with these disorders, particularly problems understanding Theory of Mind.

2.4 THEORY OF MIND

Theory of Mind (ToM) concerns the ability of individuals to understand and recognize their own and other people's internal mental states (Baron-Cohen, Leslie & Frith, 1985). ToM was originally thought to develop in the fourth year of life, when most children are able to reflect upon their own thoughts and are beginning to realize that other people also have thoughts, feelings and beliefs, which may not coincide with their own. Many theorists now believe that ToM has precursors in the early social interactive exchanges between children and their caregivers, with its first manifestation being joint attention acts. It is known that joint attention poses particular difficulties for children with ASD. Tasks to assess ToM vary in difficulty, with those concerned with first order beliefs (the ability to think about another person's thoughts about an objective event), being easier than second order beliefs which require "the ability to think about another person's thoughts about a third person's thoughts about an objective event" (Baron-Cohen, 1989, p.288). Some children with autism have been found to have difficulties in both of these areas which Baron-Cohen et al (1985) believe is not related to intellectual ability. While ToM tests assessing 'perception' and 'desire' have not posed as many difficulties for participants with ASD, the most profound deficits have been found in those related to 'pretence', 'imagination' and particularly 'beliefs'. Peppe et al (2006) suggest that difficulties understanding ToM may be the cause of prosody impairments, or alternatively, that prosody difficulties may result in impaired ToM. Nevertheless, prosodic difficulties may not be related solely to ToM difficulties.

The aim of the 'Reading the mind in the voice' experiment (Rutherford et al, 2002) was to determine if, compared with a control group, people with autism are impaired at detecting affect from prosody/voice, and to relate the results to ToM. Nineteen individuals with HFA or AS aged 16-59, 78 university students or staff and 20 TD adults aged 18-53 were included. Participants were required to listen to 40 phrases taken from audiotapes of dramatic performances and choose one of two adjectives to best describe the mental state of the speaker, e.g. ‘What on earth do you mean?’ (perplexed/accusatory). As the AS/HFA group did not perform as well as the control groups, the authors concluded that the results agree with previous work suggesting that people with HFA and AS have a specific deficit in the ability to make social inferences. However, the mean correct items for the groups were 81% AS, 92% university controls and 91% non university controls, therefore indicating that all of the groups made many correct choices. These results do not necessarily illustrate that the AS/HFA group did not understand ToM. The target adjective that posed the most difficulty for the AS group was ‘annoyed’, and it is interesting to note that the phrase spoken to elicit this adjective (Yes, of course, Vector dear … I’ll just …) contained contradictory messages as although using an annoyed voice the speaker uses the endearing term ‘dear’. This is consistent with the comments of Lindner and Rosen (2006) that individuals with HFA/AS may be relying on verbal cues to interpret emotion.

A revised version of the previous test, ‘Reading the mind in the voice – revised’ (RMV-R) was used to test 40 males and 10 females with HFA/AS and a matched control group of 17 males and 5 females, all in the 17-50 years age range (Golan et al, 2007). The revised test consisted of 25 phrases with a choice of four adjectives for each phrase. While above chance scores were achieved for all control group members and all but four of the HFA/AS individuals, the latter group did score significantly lower than the control individuals.

To determine the relationship between prosody use and communication and socialization ratings, Paul et al (2005b) compared the prosody performance of the 30 HFA/AS males in Shriberg et al's (2001) study with their results on the Vineland Adaptive Behaviour Scales – Survey Form (Sparrow et al, 1984 cited in Paul et al, 2005b) and the Autism Diagnostic Observation Schedule-Generic (ADOS-G) (Lord et al, 2000, cited in Paul et al, 2005b). Results indicated that although not related to verbal IQ, the difficulties of the HFA/AS participants in using stress and resonance appropriately were related to listeners' perceptions of their social and communicative competence.

While difficulties with theory of mind tasks have been shown in ASD, not all individuals with ASD present with these problems, suggesting the possibility of subgroups in this population. Ozonoff, Pennington and Rogers (1990) stated that for a deficit to be considered a primary deficit all members of a clinical group should be affected. Furthermore, it has not been proved that prosodic difficulties result solely from a lack of ToM, leaving the possibility that other causes may contribute to these problems. Over the years a number of authors have suggested that speech motor difficulties are a concomitant cause of the speech difficulties in this population. More recently, speech motor difficulties have also been implicated as a cause of the prosodic difficulties (Shriberg et al, 2001) and increased research in this area is warranted.

2.5 MOTOR SKILLS IN ASD

Expressive prosody requires the coordination of motor acts involving movement of pitch, regulation of timing of utterances and control of speech volume and is thus inherently vulnerable to disturbances in speech motor control. There is now general acceptance that many people with autism and AS have motor difficulties, (Dawson, 1998; Dzuik et al, 2007; Gillberg & Billsteadt, 2000; Smith & Bryson, 1998) with 'soft' neurological signs being mentioned in international diagnostic tools, such as the DSM IV-TR (APA, 2000) and the ICD 10 (World Health Organization, 1993). Additionally, many people on the spectrum have 'stereotypical motor mannerisms' (APA) including hand and arm flapping, twirling, rocking and toe walking, and unusual gait is often reported. Over the past decade or so, an increasing body of evidence in support of gross and fine motor difficulties in ASD has emerged (Anzalone & Williamson, 2000; Dawson, 1998; Rinehart, Bradshaw, Brereton & Tonge, 2001).

When using the Test of Motor Impairment (Stott, Moyes & Henderson, 1984, cited in Manjiviona & Prior, 1995), which assesses manual dexterity, ball skills and balance, to compare the motor skills of 9 children with HFA and 12 with AS, Manjiviona and Prior found that motor skills could not be used to distinguish AS from autism. However, both groups did display clinically significant motor impairment with 66.7% of the children with HFA and 50% of the AS group performing motor tasks at a much lower level than their age peers.

A later version of the above test, the Movement Assessment Battery for Children (Movement ABC) (Henderson & Sugden, 1992, cited in Green et al, 2002), which also assesses manual dexterity, ball skills, and static and dynamic balance, was used by Green et al to compare the skills of 11 children with AS, and 9 children with developmental coordination disorder (DCD). Additional testing included the ability to mime the use of familiar objects and to imitate non representational actions, e.g. hand and arm movements. All participants met the criteria for motor impairment, with five of the six most severe having AS. The children with AS showed a tendency to poorer performance than the children with DCD on the battery of tests, with their balls skills being significantly poorer. They also had more problems with mime and imitation than the children with DCD and problems with motor planning were proposed. The Movement ABC was also used to assess the motor skills of 26 Children with AS and 16 children diagnosed with learning disabilities (LD) (Miyahara et al, 1997) with 85% of the children with AS and 88% of the children with LD displaying motor difficulties.

Problems executing goal-directed motor acts were also found in 36 children with autism and 24 children with moderate learning disability (MLD) compared with 28 TD children (Hughes, 1996). Motor planning was involved in the tasks which required reaching for a rod with one white and one black end and inserting the nominated end of the rod into a red or blue disc. Although both clinical groups were less able than the control group significantly, the children with autism also displayed significantly poorer ability than the children with MLD.

Weimer, Schatz, Lincoln, Ballantyne and Trauner (2001) describe the results of a battery of tests of motor abilities administered to 10 male children and young adults with AS and a control group of 10 males matched for gender, Verbal IQ, age and socioeconomic status. Evidence of deficits on the tests of apraxia, particularly posturing of the whole body, repetitive finger-thumb apposition with the dominant hand and balancing on the non-dominant leg with the eyes closed was found for the participants with AS, which Weimer et al proposed indicated a deficit in proprioception, rather than motor difficulties. The AS group did not display impairments on the motor function tests, e.g. finger tapping, and placing pegs in a grooved pegboard. The time taken to place the pegs was also not significantly different, contrasting with the results of Smith and Bryson (1998), whose study involved participants with autism rather than AS.

Twenty young adults with AS and 10 healthy control participants (CP) were included in an exploration of neurological abnormalities by Tani et al (2006). Assessment included reflexive, cognitive, motor and sensory functions with the participants with AS performing significantly worse than the CP. Statistically significant scores were also revealed on examination of neurological soft signs. Similarly to the participants with AS in Weimer et al's (2001) study, the adults with AS in Tani et al's study had specific difficulties with whole body clumsiness and abnormal finger-thumb opposition. Significant difficulties were also noted for mirror movements and complex motor acts. Tani et al concluded that "abnormalities in motor performance together with the other features of AS persist into adulthood" (p.254).

The studies cited above indicate that impaired gross and fine motor skills are present in autism, HFA and AS. Wetherby et al (2000) also suggested that the imitation difficulties found in children with ASD also support the role of motor impairment.

2.5.1 IMITATION SKILLS

The ability to imitate is an important aspect in the development of young children as much is learned, particularly regarding communication, by copying the vocalizations and body movements of others. Ungerer (1989) reported significantly reduced vocal and gestural imitation skills in children with autism, and stated that imitation ability plays an important role in the development of representational thought, particularly symbolic play. Baranek (2002) agreed with this premise, suggesting that early imitation skills may predict the development of expressive language and play skills in children with autism.

Poor ability to imitate motor tasks has been confirmed repeatedly in many studies of individuals with ASD (Baranek, 2002; Curcio, 1978; Rogers & Bennetto, 2000; Rogers et al, 2003; Sigman & Ungerer, 1984; Smith & Bryson, 1998). Baron-Cohen (1988) wrote that while imitation problems are not specific to autism, abstract gestures may pose particular problems for children with autism.

In two experiments designed to examine gestural abilities, Attwood, Frith and Hermelin (1988) included in their first experiment 22 adolescents with autism, 22 adolescents with Down's syndrome and 47 preschool children aged between three and six years of age. Results of the first part of this experiment, which was concerned with whether the subjects could respond to eight simple instrumental gestures, revealed that all participants understood the meaning of most of the gestures. The second part of experiment one required initiation of gestures upon verbal requests. Children under six years and participants with moderate to severe autism were able to produce only half of the gestures, while the remaining groups all performed well. Attwood et al concluded that in autism the ability to use simple instrumental gestures was not specifically impaired, but that the reduced ability of some participants to produce instrumental gestures may have been due to comprehension difficulties. The second experiment involved observations of the use of spontaneous gestures. Eighteen children with autism and 13 children with Down's syndrome were observed at play and at meal times at schools that they had attended for more than twelve months. Fifteen four year old TD children were used as controls. These children, who were observed at preschool, were expected to display fewer social interactions due to their age. The mean number of gestures used by the three groups was not significantly different, however, while the children with Down's syndrome produced the most expressive gestures, followed by the preschool children, no evidence of use of expressive gestures was observed in the children with autism.

The abilities of twenty children and adolescents with autism to imitate non-symbolic manual postures and sequences were compared with two controls groups, one consisting of 20 children with language impairment (LI) and the other including 20 TD children (Smith & Bryson, 1998). Participants with LI were matched to the group with autism by gender and "as closely as possible" for CA and standard scores on the Peabody Picture Vocabulary Test –Revised. Control tasks assessed manual dexterity (which involved the use of a grooved pegboard task), gesture memory tasks of postures, and sequences of actions. Postures required matching black and white picture stimuli to hand and finger actions (eight single handed signs, four bimanual symmetrical signs and four bimanual asymmetrical signs), while action sequences necessitated pointing to or arranging photographs of two or three gestures selected from fist, palm or chop in the order of presentation. Imitation testing required participants to imitate the above postures with a model absent (immediately after the experimenter), a model present (model held in view of the participants) and with no visual feedback (participants' hands were obscured by a screen). Each participant also had to imitate six two-action non-symbolic sequences and six three-action non-symbolic sequences immediately after demonstration. Results of the control tasks revealed that the group with autism was significantly slower than both control groups when placing pegs into the grooved pegboard. No significant differences were found between any of the groups for recognizing postures, (all groups chose similar not dissimilar foils), or arranging correct sequences of postures (all groups found it easier to sequence two rather than three postures). No group differences were found for ability to imitate simple sequences of postures, but the group with autism did perform significantly poorer on imitation of single postures across all conditions, leading the authors to conclude that deficits in motor coordination contributed to their poorer performance. Slowing of movements often occur in mild to moderate motor difficulties in an attempt to increase accuracy of performance.

From research conducted over 25 years ago, which showed that that the imitation ability of children with autism was impaired when compared with TD younger children and with intellectually delayed children matched by mental age, Jones and Prior (1985) concluded that motor dyspraxia is evident in and affects the non-verbal communication of many individuals with autism. Many of the children with HFA who have been assessed with the PEPS-C (Peppe & McCann, 2003) have shown significant difficulties using prosodic forms, which include being able to imitate words and phrases with specific prosody. Peppe et al (2007) suggest that problems of this nature may arise from a motor planning difficulty (dyspraxia). Research regarding dypraxia in ASD has become more prominent in the last decade.

2.5.2 DYSPRAXIA

While the presence of dyspraxia in ASD was reported almost 40 years ago, (DeMeyer et al, 1972), there has generally been a dearth of information available in this area. Nevertheless, Wetherby et al (2000) state that although motor skills research in ASD is sparse, dyspraxia in these clients is frequently observed by clinicians. They suggest that in addition to the social, communication and cognitive impairments, apraxia/dyspraxia may be a compounding factor in the ability of children with ASD to speak or use sign language.

Kent (2000) states that speech motor control includes “the planning and preparation of movements (sometimes called motor programming) and the execution of movement plans to result in muscle contractions and structural displacements” (p.391). Anzalone and Williamson (2000) believe that children with autism may have gross and fine motor difficulties with the three steps of praxis, including formulation of a goal (ideation), how the goal is to be accomplished (motor planning) and carrying out the planned action (execution). Additionally they state that the inability of many children with autism to play or explore the environment appropriately, is related to difficulties with ideational praxis, which entails the ability to think about how toys, objects and one’s body can be incorporated into play and learning situations.

A ‘praxic’ battery assessing motor abilities and an imitation battery involving manual acts with the hands, oral-facial movements and actions on objects were used to compare the imitation abilities of 24 children with autism (mean age 34 months), 18 children with fragile X syndrome (FXS), 20 children with developmental disorder and 15 TD children (Rogers et al, 2003). TD children were younger and had higher verbal skills than the clinical groups. The performance of the children with developmental delays and the TD children were superior to the performance of the ASD group, whose imitations of actions on objects, oral-facial imitations and overall imitation scores differed significantly. The children with autism were also less able to imitate manual actions than the other groups however the difference did not reach statistical significance. Those children with FXS who also presented with autism displayed the same imitation difficulties as the children with autism, whereas the children with FXS who did not have autism performed as well as the other children with developmental disorder, which the authors stated was further evidence of specific imitation difficulties in ASD. While Rogers et al conceded that the existence of a specific oral or speech dyspraxia may be a possibility in ASD, they concluded that a generalized dyspraxia was not the cause of the imitation problems as “imitation performance was correlated significantly with fine motor function, but not praxis (motor planning)” and the variability in imitation could be accounted for by overall developmental functioning (p.776).

Conversely, Dziuk et al (2007) suggested that dyspraxia may be a core feature of autism or the marker of the neurological abnormalities underlying the disorder. They stated that as well as the difficulties with imitation witnessed in ASD, people with the disorder also have deficits in their ability to perform motor movements on command and during tool-use. Using a basic motor skills test standardized for children, as well as a praxis examination which included gestures to command, imitation of gestures and gesturing tool-use, the abilities of 47 children with HFA or AS and 47 TD children aged 8 to 14 years were compared. Dziuk et al found that basic motor skills were significant predictors of performance on the praxis examination. The children with ASD showed significantly poorer basic motor skills and praxis and were slower to complete repetitive movements than the TD children. As, after accounting for the motor skills deficits, the praxis skills of the children with ASD were still poorer than the TD children, Dziuk et al concluded that problems with basic motor skills cannot fully account for the dyspraxia in ASD. They postulated that outside of the regions which would account for the problems with basic motor skills, connections between neural systems, possibly involving the frontal and parietal regions and the cerebellum, may contribute to dyspraxia in children with ASD.

2.5.3 ORAL MOTOR SKILLS

As can be seen from the above reports, evidence of gross and fine motor difficulties in ASD is accumulating with many researchers suggesting dyspraxia as a cause. Specific oral motor problems have also been found in ASD, with Anzalone and Williamson (2000) noting that children with autism have concomitant oral/verbal dyspraxia, which interferes with feeding and speech development.

From clinical experience that children with autism have great difficulties imitating lip, tongue and hand movements, Page and Boucher (1998) hypothesized that oromotor and manual dyspraxia may contribute to the impaired speech and signing abilities of children with autism. They assessed the oromotor functioning, hand skills and gross motor skills of 33 children attending a school for children with autism and found that 70% of the children had marked impairment of tongue movements, 55% had manual impairments while 16-17% displayed gross motor impairments. Groping behaviours (trying to move the mouth) were also noted in 33% of the children. Page and Boucher concluded that their hypothesis was confirmed. They suggested that as they also found that motor impairments tended to be reduced in the older children, oral and manual dyspraxia may reflect a maturational delay in autism, which may possibly resolve over time.

Apart from assessing the acoustics of the speech of children with ASD (as reported below), Velleman et al (2010) appraised their motor skills, finding that of the 10 children with autism in their study seven displayed problematic oral motor skills and five had sequencing difficulties and below age expected global motor skills. Eight children also had voice characteristics which were of concern. Velleman et al also conducted a parental survey of 40 children with ASD, which supported the presence of an underlying motor-related speech problem in ASD, with 60% of the children reportedly displaying speech that was dyspraxic, dysarthric, or both. Using results of the motor assessment as well as acoustic analysis (to be discussed later), they concluded that apraxic and dysarthric symptoms can co-occur in ASD.

2.5.4 SPEECH MOTOR SKILLS

Although speech difficulties were reported over thirty years ago (Bartak, Rutter & Cox, 1975), until recently, it was generally accepted that people with autism spectrum disorder did not present with serious articulation difficulties (Aarons &

Gittens, 1992). Tager-Flusberg (1989) stated that although phonological development was delayed and developed at a slower rate in verbal children with autism, serious articulation difficulties were not present as the pattern of sounds was similar to that of typically developing children.

However, research has shown since that many people with autism spectrum disorder who are able to speak do have speech articulation difficulties. Adams (1998) argued that anecdotal information has indicated that some children with HFA demonstrate developmental articulation errors and phonological processes well into adolescence. Adams found significant differences between four children with ASD and four TD children in the ability to perform oral movements on demand or by imitation, and to produce complex phonemic syllables. Although restrained by the limited number of children in the study, and cautioning about generalization of the findings, she suggested that the problems noted in the children with autism were most often associated with developmental apraxia of speech and that treatment should focus on adaptation of motor programming.

Atypical speech processes in four siblings with ASD were also reported by Wolk and Giesen (2000). Typical difficulties observed included consonant distortions and substitutions, vowel distortions, velarisation, syllable and final consonant deletions, and cluster reductions. In a study involving a larger number of participants, 15 with high functioning autism (HFA) and 15 with AS, Shriberg et al (2001) found that 33.3% of the participants displayed articulation distortions particularly relating to liquids (r and l) and lateralized or dentalized sibilants (s, z, sh, ch, and j).

Forty-one percent of 30 HFA children and 39 AS children (aged 5 to 13 years) who were included in a study by Cleland, Gibbon, Peppe, O'Hare and Rutherford (2010) were found to produce at least some speech errors, while six of the HFA children and two of the AS children (12%) had a speech delay/disorder. The most common errors were gliding (w and y), cluster reduction and final consonant deletion, which Cleland et al concluded represented delayed rather than deviant speech. They suggested that a possible cause may be an underlying neuromotor difficulty, but did not elaborate further upon this.

Recently, Shriberg et al (2011) used the Speech Disorders Classification System (SDCS), a system devised by Shriberg (Shriberg et al, 2010 cited in Shriberg et al, 2011) to classify the speech disorders of children allocated to an ASD group and to determine whether their speech was indicative of Childhood Apraxia of Speech (CAS). Shriberg et al describe the categories within the SDCS as -

- SD - speech delay in 3-9 year old children who have mildly to severely reduced intelligibility due to age inappropriate speech sounds deletions, substitutions and distortions
- SE - speech errors in 6-9 year olds whose speech impairment is limited to distortions of one or two English sounds or sound classes: the sibilants 's' and 'z', the rhotic consonant 'r' and/or the stressed and unstressed rhotic vowels as in 'bird' and 'sister' respectively (as in American English)
- PSD - speech disorders that persist past 9 years of age, and for some speakers, for a lifetime
- MSD-AOS - Motor Speech Disorder-Apraxia of speech, which is the same clinical entity as CAS

- MSD-DYS - Motor Speech Disorder-Dysarthria, involving neuromuscular deficits
- MSD-NOS - Motor Speech Disorder-Not Otherwise Specified, which is proposed for speech signs that are not specific for apraxia or dysarthria and for speakers who have signs of motor speech involvement but do not meet MSD-AOS or MSD-DYS criteria.

With the exception of SE which only involves distortions, all other categories may include deletions, substitutions and distortions. Additionally, all the MSD categories may have difficulties with prosody and possibly with reading (Shriberg et al, p.408).

The ASD group in the Shriberg et al study (2011) consisted of 46 children aged 4 to 7 years, 29 of whom met criteria for ASD, with the remaining children presenting as borderline ASD. Shriberg et al state that the 15.2 % of the group found to have a SD is a similar percentage to previous research of SD in three year old children, and indicates a modestly increased risk of children with ASD also having a SD. However, they interpreted the evidence of SE (particularly dentalized sibilants), in 31.8% of the six and seven year old children with ASD, as support for a substantially higher risk of concomitant speech errors in ASD. It was also claimed that the participants with ASD did not display speech which was consistent with MSD-AOS or with MSD-NOS, as they only made errors of more than 50% on three of the ten indices of motor speech disorder. The indices which were most problematic for the ASD group included lengthened vowels, increased repetitions and revisions, and increased phoneme distortions. Ten TD children aged four to seven years, 13 four to six year olds with delayed speech, and 15 children and adults diagnosed with CAS were also involved in the study. The speech errors of the ASD group were not compared with the control groups. When acoustic characteristics were compared with the control groups, the ASD group was found to be significantly louder and have significantly higher or variably higher pitch. Pitch results were reportedly confirmed by acoustic analysis but were not reported in detail in the paper. The ASD group displayed stress problems similar to the TD and SD groups but they did not display the slower speech rate that was evident in the CAS group. Although Shriberg et al stated that the participants with ASD made more than 50% of errors on lengthened vowels and had increased phoneme distortions (albeit, significantly fewer errors than those made by the participants with CAS), they concluded that they did not have the lengthened vowels, uncommon phoneme distortions and significantly slow speech rate that are core signs of motor speech disorders in adults. However, they were comparing young children with ASD with children and adults with CAS and did not state how many adults were included in this group. Shriberg et al also concluded that rather than the excessive/equal stress which is characteristic of acquired apraxia of speech, the misplaced stress common in ASD suggests signs of motor impairment rather than motor planning per se. With Kwiatkowski, Shriberg (cited in Shriberg et al, 2011) also devised the ‘speech attunement framework’. This requires ‘tuning in’ to one’s communication community and ‘tuning up’ to the “phonological and phonetic behaviours subserving intelligible and socially appropriate speech, prosody and voice production” (p.420). Shriberg et al suggest that it is tuning up which is the problem in ASD.

That there are speech motor problems in ASD appears to be confirmed in most of the above studies, but whether the difficulties are related to dyspraxia and/or other motor speech difficulties is yet to be determined. Kent (2000) suggests that speech motor control disorders include dysarthria and dyspraxia (which are often termed 'the motor speech disorders') and disorders of fluency, although he concedes that the inclusion of fluency disorders may be considered controversial. Motor speech disorders are often associated with pitch, loudness and timing difficulties and involve prosodic difficulties (Love & Webb, 1992). The prosodic difficulties and acoustic characteristics of speech observed in individuals with motor speech disorders have also often been detected in the speech of many individuals on the autism spectrum.

2.6 ACOUSTIC CHARACTERISTICS OF PROSODY IN ASD

As with studies of prosody in general, acoustic analysis of the speech of individuals with ASD is also very limited. In their 2003 review of prosody in ASD, McCann and Peppe suggested that more acoustic analysis was needed to establish the prosodic features that characterize both atypical and typical prosody. Since that time approximately six additional studies of ASD have involved acoustic analysis with all but one study to date comprising less than 12 participants with ASD. The most common difficulties found include increased length and variability of duration, narrower pitch ranges (although these have not always been statistically significant), and pitch accents placed on function rather than content words.

Two of the earliest studies involving acoustic analysis involved visual examination of spectrograms. Fletcher (1976) examined intonation patterns in the spectrograms of six children with autism and six TD children and determined that the children with autism were not able to imitate intonation contours as well as the TD children. Bagshaw (1978) examined spectrographic information of the frequencies used and duration of two imitation tasks. A trend towards greater variability in the duration of the utterances of three individuals with autism aged 5 to 18 years was found. However, only one control participant was included, a TD child aged 4 years.

Like her ground breaking work in prosody in general, Baltaxe and her colleagues were some of the first researchers to implement any type of acoustic analysis of data from individuals with ASD. In 1981, Baltaxe studied pitch (in Hz), intensity (in decibels) and duration (in milliseconds) in the speech of eight children with autism and eight TD children on imitation tasks, which included declaratives, yes/no questions, 'Wh' questions and commands. Mean length of utterance (MLU) was used as a measure of the psycholinguistic age of participants and some instrumental acoustic measures were used to analyze the data. Results indicated that to express prosodic information the TD children primarily used frequency with accompanying synchrony in intensity, whereas there was a relative lack of synchrony of frequency in the children with autism who appeared to over-select intensity. The frequency ranges of the TD children were also greater than those of the children with autism, with Baltaxe commenting that at times the frequency contours of the children with autism appeared 'flat and frozen into place', giving the impression of monotony. The typically developing children showed significant differences between the length of individual words in isolation and the length of the same words within utterances, whereas these differences were smaller or absent for the group of children with autism. The overall duration of the utterances of the children with autism were longer and showed greater variability than the control group. Baltaxe suggested that the increased variability could be an artifact of the increased duration. Highly variable errors have also been reported in children with motor speech disorders (Kent, 2004).

At a conference in 1984, Baltaxe et al presented results of a previously peer-reviewed study which explored differences in the intonation contours of three groups of children. The groups consisted of six TD children, six children described as aphasic and five children with autism, who were matched by MLU, gender and 'as closely as possible' socio-economic class. The TD children were considerably younger than the children with autism or aphasia. Using acoustic analysis, subject/verb/object (SVO) statements, which were produced spontaneously under controlled conditions, were examined for the range of fundamental frequency used, terminal fall (which is expected in English declaratives), the intonation contour of the utterance, (in SVO obtrusions of pitch are expected on stressed vowels), declination effect (there is a tendency for pitch to drift downwards in statements) and co-variation of frequency and intensity. Normal children had the greatest frequency range, followed by the children with autism, then the aphasic children. While there were significant differences between the TD children and the aphasic children, there were no significant differences in the range of frequencies between the TD children and the children with autism. However, individually the children with autism reportedly did present with very narrow or very wide pitch ranges. Terminal fall was produced consistently by five of the TD children, three of the children with autism and only two of the aphasic children. Pitch obtrusions were less frequent in verb positions for all groups, and the declination effect was used most by the TD children and least by the children with autism. Although all the children produced co-variation of frequency and intensity, with the TD group having the highest percentage of usage, the children with autism and those with aphasia showed considerable variability with some children lacking this ability altogether. Baltaxe et al concluded that despite the considerable variability between and within subjects, frequency and intensity appear to be important markers of prosody in the speech of young children.

Acoustic analysis of prosody in ASD was non-existent for almost a decade, then, over the next 13 years only two studies were reported. Doctoral research by Adams (1993) revived these investigations, with the prosody used by eight children with HFA and eight TD children on imitative and spontaneous speaking tasks being analyzed acoustically and perceptually. Experienced judges determined that the HFA children used higher pitch, were louder and spoke faster than the TD children and also used abnormal manipulation of intonation and stress. The use of overall higher pitch was confirmed acoustically, although no differences were noted between the groups when measurements of fundamental frequency were taken at discrete intervals in repeated sentences. Results also showed that the HFA children produced more syllables per second and displayed a tendency towards greater intensity, but these results were not statistically significant and were within the normal range. Adams suggested that listeners may be attuned to subtle acoustic differences which may not be captured by acoustic measurements.

Fosnot and Jun (1999) compared the intonation and timing characteristics of four children with autism, four TD children and four children who stutter. Testing required the children to read eight sentences three times, e.g. It’s a rhino/It’s a rhino?, It’s not a rhino/It’s not a rhino?, then, to imitate an adult saying the sentences. Confirming previous findings (Bagshaw, 1978; Baltaxe, 1981) the children with autism displayed significantly longer and more variable durations of their sentences and used higher pitch ranges than the other two groups in both the reading and imitation tasks. They also used more pitch accents and at times placed pitch accent inappropriately, e.g. on function words, corroborating the previous work of Baltaxe and colleagues. However, they used default sentence stress (stress on the last stressed word in a sentence) predominantly. Non-grammatical pauses were used more frequently by the children with autism (although this may reflect the timing difficulties) and more than half of their question forms could not be distinguished from statements.

Another small study examining the abilities of four teenage males with AS compared with four TD teenagers formed part of a Master's thesis (Unger, 2006). Pitch range differences whilst reading a dramatic passage, and pitch declination when reading seven sentences were compared. Although not statistically significant, the teenagers with AS were found to use a smaller pitch range than the control group. Preserved grammatical prosody was concluded as the expected pitch declination was used by all but one of the AS group, and he only made one mistake out of seven.

Research over the last four years has involved slightly increased numbers of participants and has often examined a broader range of acoustic characteristics. Furthermore tools to conduct acoustic analysis may now be downloaded for free from the internet, e.g. PRAAT (Boersma, 2001) hence facilitating ease of access and thus increased use of acoustic analysis.

The pitch, amplitude and duration of the utterances of nine individuals with autism, nine with AS and ten TD people aged 6 to 21 years were analyzed by Hubbard and Trauner (2007). The initial phase of the project was to elicit utterances by repetition of stimulus phrases. The hypothesis that the participants with autism and AS would display a narrower pitch range was not confirmed, with the individuals with autism actually showing a larger pitch range than the other two groups. While the TD group and the group with autism produced ‘anger’ louder than ‘happy’ and ‘sad’, the AS produced anger and happy louder than sad, leading Hubbard and Trauner to suggest that they don’t reliably use intensity as a component in encoding anger. The AS and TD groups both used the longest vowel length in the word sad (as would be expected), but the group with autism did not do so as reliably as the others. Subjective ratings of the ability of participants to encode the emotional content of the utterances were interesting, with correct scores of 85% for the AS group, 77% for the TD group and 59% for the participants with autism being given. The second part of the study analyzed the pitch of utterances elicited by spontaneous completion of a story. This aspect was compromised by the fact that only five of the nine participants with autism were able to complete the tasks as many responded with single words only or perseverated on the content of the story. Compared with the first task, the correlation of pitch range with emotion was not as strong for the majority of participants in this second task, although subjective ratings were almost identical. A third task involved comparisons of subjective ratings of produced emotion, with three people rating utterances as happy, sad, angry or ambiguous. Subjective ratings did not find prosody in ASD to be flat or monotone.

In the largest acoustic analysis to date, Diehl, Watson, Bennetto, McDonough and Gunlogson (2009) examined the variations in fundamental frequency (F0) in the narratives of 21 children and adolescents with HFA aged 10 to 18 years compared with 21 TD control participants matched by gender, age, full scale IQ, verbal IQ and language skills. A similar second study examined the F0 variations of 17 children aged 6 to 14 years, 2 with AS and 15 with HFA, who were compared with 17 TD children matched by age, gender, receptive and expressive language scores and verbal reasoning abilities. Acoustic analysis of data in this study was conducted with PRAAT (Boersma, 2001). While the children and adolescents with HFA displayed a statistically significant wider F0 range than the TD participants, their average pitch, although higher, did not differ significantly from the control group. Perceptual judgments of speech by a trained clinician indicated that the individuals with HFA who had increased F0 variations tended to be judged as having a greater level of communication impairment. Similar results were obtained for the younger group of children with ASD in the second experiment, with their average pitch being identical to the average pitch of the TD children. No differences were detected in the perceptual judgments.

Schoen, Paul and Chawarska (2010) and Grossman et al (2010) also used PRAAT (Boersma, 2001) to acoustically analyze utterances. Twelve children with autism aged 18 to 36 months and 11 typically developing (TD) children matched by chronological age and gender ratio were included in the Schoen et al study, while Grossman et al included 11 adolescents with HFA and 9 TD control participants. The children with autism produced significantly more complex pitch contours and their pitch levels were higher than the TD children, who also tended to use a flat pitch contour. This difference was interpreted as either a motor control problem or as a self-stimulatory function. In contrast, no statistical differences were found for pitch or for intensity levels between the HFA adolescents and the TD adolescents. Timing difficulties were noted in the HFA group, with their overall utterance length being significantly longer than that of the TD adolescents. Perceptual judgments of these productions also indicated that they were perceived as slow and laboured, with exaggerated pauses often being used between syllables. Although the durations of most of the utterances of the children with autism were within the expected 0.1 to 0.5 second range, they also "produced a significantly greater number of long vocalizations, over 0.5 seconds in duration" (p.200), which Schoen et al conceded could be related to motor difficulties, although they did not believe that motor problems could be the only cause of the difficulties.

The increased evidence of motor difficulties in ASD provided the impetus for Velleman et al (2010) to compare the speech acoustics of ten 4 to 6 year old children with ASD with eight 5 to 8 year old children with Childhood Apraxia of Speech (CAS) and eight TD children who were also 5 to 8 years old. The authors cautioned comparisons of children of different ages, but found unexpectedly that despite their younger ages, fundamental frequencies were lower for the children with ASD than the TD or CAS children, and their mean vowel formant frequencies were higher. They also displayed shorter phonation times for prolongations of the vowel [a] and the fricative [f] than the children with CAS, whose phonation times were also lower than the TD children. Velleman et al also measured lexical stress ratios, which they state were measured grossly, by dividing the durations of the stressed vowels by the durations of unstressed vowels in the words 'Bobby', 'puppy' and 'mommy'. Unlike the TD children, the children with ASD and CAS had more varied and more extreme lexical stress ratios, and did not use appropriate phrase-final lengthening. However, lexical stress ratios were influenced by phrase-final lengthening. Like the participants in the study by Grossman et al (2010) cited above, timing problems were also noted in the children with ASD, although, as stated by Velleman et al, the slower rate for the ASD children could be related to their younger age. Velleman et al concluded that some children with ASD exhibited “several characteristics similar to some of the features of CAS” (p.158), and some showed “some features consistent with a diagnosis of dysarthria, especially with respect to perceptually judged vocal quality” (p.159).

Although acoustic research findings at times vary regarding the prosodic characteristics found in autism spectrum disorder, that there are difficulties is not disputed. Given these acoustic findings, the problems with understanding and using prosodic functions and the evidence of motor difficulties in ASD, one may ask what are the neurological bases of these difficulties?

2.7 NEUROLOGICAL BASES OF PROSODY

It has been postulated, primarily using evidence from studies of adults with brain lesions, that linguistic (grammatical) prosody is predominantly associated with the left hemisphere of the brain while social/emotional (affective) aspects of prosody are controlled by the right cortical hemisphere (Amebu Seddoh, 2002; Tager-Flusberg 1989). Adolphs, Damasio and Tranel (2002) found support for this postulation in research providing statistically significant differences between participants with left or with right hemisphere damage in tasks involving recognition of emotions. However, they also found evidence of the involvement of the left frontal operculum, and suggested that not only the cortex, but sub-cortical structures, including the basal ganglia and amygdala are also involved in the processing of emotions.

Support for the involvement of basal ganglia is also reported by Sidtis and Van Lancker Sidtis (2003), who, after reviewing the literature, proposed that prosody may be affected by simple or complex damage to multiple levels of brain subsystems which contribute to perceptual, motor and organizational factors. They assert that the notion of affective prosody being processed in the right hemisphere is oversimplified and not substantiated, and that individuals with right hemisphere damage rarely display prosody deficits.

Using positron emission tomography (PET), Imaizumi et al (1997) examined cerebral blood flow during a task requiring six healthy volunteers to identify speakers and emotions from spoken words. As regions in the cerebellum and the frontal lobe were activated during this task, they suggested a functional relationship between these two regions involved in emotion.

Sidtis and Van Lancker Sidtis (2003) also state that in a number of studies no differences regarding hemispheric involvement in linguistic tasks were observed. Nevertheless they assert that the left hemisphere provides acoustic-perceptual processes for timing phenomena, while the right hemisphere provides acoustic-perceptual processes for pitch phenomena. Acoustic studies of prosody have mainly focused on pitch and timing (rate), with receptive disturbances of rhythm (a timing phenomenon) only being reported in patients with left hemisphere lesions (Sidtis & Van Lancker Sidtis). However, they also acknowledge the important role of the cerebellum in timing, and that ataxic speech, which involves problems with timing and coordination of articulation, can be produced by damage to the cerebellum. Sidtis and Van Lancker Sidtis also comment upon the fact that motor speech disorders are accompanied by deficits in the production of affective prosody. Petersen (2002) reported that the cerebellum has been overlooked in studies of prosody and queried a left cerebellar contribution to a presumed right cerebral cortical role in language prosody.

McCann and Peppe (2003) state that the idea of linguistic and affective prosody being discrete entities is controversial, while McCormack (1996) suggests that prosody is not an autonomous and discrete linguistic system which functions independently from other levels of speech and language organization. Current theoretical models of prosody suggest that multiple brain areas are involved, with communication between the areas being a crucial component.

2.7.1 NEUROLOGICAL BASES OF PROSODY IN ASD

Many of the individuals with ASD who have been involved in neurological research in relation to prosody have performed similarly and have used the same neural areas as control participants. However, increased activity has been reported in some cortical areas, particularly the temporal lobes, while a lack of activation and more recently a lack of deactivation have also been found.

Erwin et al (1991) used an EEG to record the P3 responses of 11 male adults with autism and 11 TD adults, (including males and females). Tasks involved auditory discrimination of nominated ‘rare’ stimuli which required pressing of a button, and cognitive association tasks which necessitated matching stimuli to appropriate pictures. The latter tasks involved phonemic discrimination, e.g. ba/pa, linguistic prosody, e.g. ‘Bob’ spoken as a statement or as a question, and affective prosody, e.g. ‘Bob’ spoken with happy or angry prosody. An additional task involved matching the emotional content of sentences with the appropriate word (affective prosody). All participants performed within normal limits and displayed normal P3 responses to all of the stimuli suggesting that those with autism were able to process prosody as well as the control group. An alternative conclusion could be that P3 responses may not be sensitive markers of prosody.

Functional Magnetic Resonance Imaging (fMRI) was utilzed to determine the cortical networks used by nine children with HFA when processing affective and linguistic prosody (Wang, Dapretto, Hariri, Sigman & Bookheimer, 2001). The children had to determine whether pairs of sentences sounded the same or different. Three conditions were used and involved eight pairs of sentences each. A linguistic prosody condition consisted of four pairs of sentences with neutral intonation and four with questioning intonation (rising intonation at the end of the sentence). Affective prosody utilized four pairs of sentences indicating ‘sad’ and four indicating ‘angry’. A third semantic control condition which necessitated determining whether sentences sounded alike regardless of the literal meaning, involved eight pairs of sentences, half of which had the questioning intonation while the other half used the same affective prosody as in task two. All of the HFA children performed above chance in all tasks, and their profiles of brain lateralization were similar to that expected of typically developing children. However, in the affective condition right temporal regions were activated with no reliable activity being detected in the right frontal regions as the authors had expected. The authors concluded that children with HFA may process prosody using different cortical networks from typical children.

In contrast to the conclusion aforementioned, a study involving three of the same authors from the previous report (Ting Wang, Lee, Sigman, & Dapretto, 2006) found that in tasks involving comprehension of irony, 18 children with AS or autism showed significantly greater neural activity within the same neural networks recruited by 18 TD children. The children were asked to listen to three scenarios and decide whether the speech sounded sincere or ironic. The scenarios involved prosodic cues with knowledge of an event outcome, prosodic cues only, and event outcome knowledge only. While all of the participants interpreted the communicative intent of irony well above chance, the children with ASD performed with less accuracy than the TD children in the scenarios which provided knowledge of the context of the event. Overall, recruitment of right prefrontal and temporal regions was stronger in the ASD group than the TD group. Interestingly, no significant differences were obtained in the scenario providing only prosodic cues, although the ASD group did show heightened bilateral recruitment of temporal regions. As the neural responses of the children with ASD were more intense, but within the same networks activated in the TD children, Ting Wang et al concluded that increased task difficulty may require more intense activation of relevant brain regions, thereby suggesting that the children with ASD had to exert more effort to process these tasks.

Passively evoked brainstem responses to click stimuli and to speech syllables with descending and ascending pitch contours were utilized by Russo et al (2008) to examine sensory encoding of pitch in 21 verbal children with ASD and 21 TD children. Reportedly, the children in the ASD group included one with autism, seven with AS, one with PDDNOS (Pervasive Developmental Disorder Not Otherwise

Specified) and 12 with a combined AS/PDDNOS diagnosis. The latter group is a little confusing as, in Australia, a diagnosis of PDDNOS is usually only given if the criteria for AS are not met. No differences were found between the groups for brainstem responses to click stimuli, but a subgroup of five children was found to have deficient brainstem encoding of pitch. Russo et al hypothesized that abnormal development of subcortical brain regions including the brainstem as well as poor connections with the cerebral cortex may underlie these deficiencies. Impaired receptive prosody in ASD was nominated as a possible result of this deficiency. However, the receptive prosody of these children was not assessed.

Hesling et al (2010) queried whether the prosodic impairment in ASD is the result of “abnormal neural network functioning, with a hypo or hyper activation of right cortical areas and/or from an altered balance between activated and deactivated networks” (p.2). Eight male adults with HFA (mean Verbal Intelligence Quotient (VIQ) of 89) were compared with eight adult controls (mean VIQ of 128.33) during prosodic tasks which utilized fMRI (functional Magnetic Resonance Imaging) techniques. While bilateral temporal lobes were activated in both groups, only the adults with HFA displayed activity in the left supra marginal gyrus (SMG of the temporal lobe). It was hypothesized that the increased activity in the left SMG was a compensatory strategy used by the HFA adults who may “rely more on working memory processes and processes translating from auditory to articulatory representations than controls” (p.7). Additionally, unlike the control adults, who deactivated the left medial frontal cortex, the left precuneus and the right anterior cingulate cortex in comprehension tasks, the adults with HFA did not deactivate any cortical areas. Deactivation is considered to suppress cortical regions which are not task related to facilitate activation of cortical regions which are specific to tasks (Hesling et al). The authors concluded that abnormal activation and deactivation of neural regions is apparent in speech perception in autism.

It is therefore apparent that at least in some individuals with ASD increased and/or decreased activity in cortical and sub-cortical areas does occur. However, the diversity of brain structures involved is wide, and the underlying cause or causes of these problems is still being considered.

2.8 CONCLUSION

The above studies attest to the general acknowledgment that that the speech of many people with ASD is characterized by unusual prosody, and within this cohort some individuals display motor difficulties which may underpin their problems. Therefore, this research sought to answer the question 'Is there evidence of impaired speech production in the prosody of individuals with AS?'

As information regarding prosody in AS is still very limited, gaining increased knowledge of the expressive and receptive prosody of a large group of individuals with AS and comparing their prosody with control participants (CP) who have not been diagnosed with autism, AS or language difficulties was considered to be essential. Acoustic information pertaining to prosody in AS is particularly sparse, so additional knowledge of the acoustic correlates of their speech was also highly pertinent. Hence further aims of this research were to clarify the questions 'Is prosody impaired across both receptive and expressive prosody areas in individuals with AS?' and 'Do the acoustic characteristics of individuals with AS differ from other individuals in the population?'

It was hypothesized that -

1. The AS group would have significantly more difficulties with prosodic production tasks than with prosodic comprehension tasks.
2. The AS group would have more difficulties with affective and pragmatic prosody than grammatical prosody.
3. The participants with AS would not understand or use contrastive stress as well as the CP.
4. The participants with AS would use a narrower pitch range than the CP.
5. Durational differences between the AS group and the CP would be found.
6. The participants with AS would not be able to produce speech rhythm as well as the CP.

The following chapter will describe how this research was undertaken.

CHAPTER 3 METHODS

3.1 STUDY DESIGN

This study was designed to ascertain whether evidence of speech motor difficulties would be found in the prosody of the speech of individuals with Asperger syndrome (AS). An experimental group comparison design was used to examine the understanding of prosody, the use of prosody, understanding and use of typical English rhythm and the acoustic qualities of speech. Permission to conduct the research was obtained through the Social and Behavioural Research Ethics Committee of Flinders University, South Australia (Appendix A).

The understanding and expression of prosody was assessed with the input (understanding) and output (expression) subtests of the Profiling Elements of Prosodic Systems – Children (PEPS-C) (Peppe & McCann, 2003). Expressive prosody in spontaneous speech was also examined. The understanding of typical English rhythm was examined with an adaptation (McCormack, 1999) of the Bolinger Sentence Test (Bolinger, 1965). The expression of rhythm was assessed through reading of a set of sentences designed to elicit examples of the English Rhythm Rule. The Rhythm Rule requires manipulation of rhythmic structures to maintain the alternating strong and weak stresses which are prominent in English. These experimental tests are described below. As there is a dearth of information regarding the acoustic parameters of prosody in individuals with AS, acoustic analysis of expressive prosody (including the Rhythm Rule sentences and spontaneous speech) was also undertaken.

3.2 DEFINITION OF EXPERIMENTAL GROUP PARTICIPANTS (AS)

The experimental group, which consisted of participants with AS who were all native speakers of English, was recruited through the Autism Association of South Australia (Autism SA). Clients with AS may only be registered with Autism SA if two practitioners trained in autism diagnoses believe they meet DSM IV-TR (APA, 2000) criteria for AS. By definition, no participants will have a clinically significant general delay in language or in cognitive development.

Permission to access clients of the association was obtained from Autism SA's Ethics committee (Appendix A). Staff of Autism SA identified clients with AS who were in the 15 to 45 year age group. Without disclosing the clients' details to the author, staff advised the author of how many letters would be required. A letter of introduction signed by the author's principal supervisor (Appendix B) was written to introduce the researcher. The letter provided information about the purpose of the study and explained the voluntary and confidential nature of the study. The letter of introduction and a consent form (Appendix B) were placed in envelopes by the author. Autism SA staff then addressed and posted the letters to all of the identified clients. A total of 332 letters were sent to the respective clients. Clients interested in participating in the study were asked to contact the author directly by email, post, fax, mobile or telephone. In total sixty-seven clients (twenty percent) responded. All participants signed their own consent forms and the parents of those participants who were less than 18 years of age also signed their consent. A small payment was made to each participant to cover incidental costs of participation. The author arranged to assess the participants in their homes or in an office at Flinders Medical

Centre in southern Adelaide. Recruitment and assessment of the participants with AS lasted for a period of six months approximately.

3.3 DEFINITION OF CONTROL PARTICIPANTS (CP)

Control participants (CP) were recruited from a selection of people known to the author, from local high schools and from Flinders University. A modification to the project, which was granted by the university ethics committee (Appendix A), allowed contact with high schools to facilitate recruitment of CP. All CP were matched by age, gender and educational status to the participants with AS. A letter of introduction (Appendix B) and a consent form (Appendix B), similar to the letter and consent form sent to the participants with AS, were sent to the school principals who nominated a staff member to recruit students. The letter, which was signed by the author's principal supervisor, introduced the researcher, explained the project and requested people who had English as their first language and who had not been diagnosed with a language disorder to volunteer. The nominated school staff member and the author arranged dates and times of visits to the particular school to assess the students. CP who were above school age or where no longer attending school were recruited from people known to the author, or through Flinders University. These people were assessed in their homes or at the university. A small fee was paid to all CP to cover incidental costs of participating. The signed consent of the parents of participants who were less than 18 years of age was also obtained. None of the control participants had a diagnosis of ASD or language disorder and reportedly, none had been identified with learning difficulties or had ever been suspected of the aforementioned disorders. The recruitment and assessment of the 50 CP took approximately ten months.

3.4 DETAILS OF PARTICIPANTS

Of the 67 people with AS who responded in the recruitment phase, four lived in country regions of South Australia and unfortunately could not be accessed. An additional five respondents did not attend appointments and withdrew from the study, leaving a cohort of 58 participants with AS. All of these people were assessed with the receptive and expressive subtests of the PEPS-C, the Rhythm Rule test and the modified Bolinger test. The 50 CP were also assessed on the same tests.

To ensure participants were able to read and understand written information presented during Rhythm Rule testing, the reading comprehension abilities of all participants were assessed. Seven CP and seven participants with AS were excluded from the Rhythm Rule assessment as they did not gain a comprehension score of at least twelve years, which was deemed to be the level required for fluent reading of the test material. Forty-three CP remained eligible for the Rhythm Rule testing. Of the 51 participants with AS remaining, a further 8 individuals were excluded either because their audio data became corrupted or they could not be matched by age and educational status with a participant in the control group. Therefore, 43 participants with AS and 43 CP were included in the Rhythm Rule analyses. The spontaneous speech samples of these 86 individuals were also analyzed. As the audio data of one CP later became corrupted, this participant and the matched participant with AS were excluded from the acoustic analysis of the Rhythm Rule which then included 42 participants with AS and 42 CP.

TABLE 3.1 ***Number of Participants in Each Test***

	AS	**CP**
PEPS-C	58	50
Bolinger Test	58	50
Rhythm Rule Sentences	42	42
Spontaneous Speech	43	43

3.4.1 MATCHING OF CONTROLS

As far as possible CP were matched to participants with AS by gender, age and educational status, and were also matched broadly by socio-economic area.

3.4.1.1 Gender of participants

Of the 58 participants with AS, 7 were females and 51 were males, while the fifty CP included 6 females and 44 males. After the exclusion of some individuals (as described above), a total of 6 females and 37 males with AS, and 6 female and 37 male CP were used for the analysis of the use of the Rhythm Rule and the spontaneous speech samples.

3.4.1.2 Ages of participants

Under the assumption that mature prosody (as for other aspects of speech and language) is achieved by adolescence (Baltaxe et al, 1984; Tager-Flusberg, 1989), an age range of 15 to 45 years was chosen when recruiting participants. All of the individuals with AS who participated in the study ranged in age from 15 to 40 years while the age range of the CP was 15 to 42 years. No statistical difference was found between the age means of the two groups (participants with AS $\bar{x}$ = 20.74, SD 6.88, CP $\bar{x}$ = 20.6, SD 7.5). Both groups of 43 participants with AS and 43 CP who were included in the study of the use of the Rhythm Rule and spontaneous speech had an average age of 20.4 years. Appendix G provides details of the specific ages and educational status of these participants.

3.4.1.3 Educational status of participants

All research participants were categorized into the following categories.

1. still at or completed high school or TAFE (Technical and Further Education)
2. attending or attended university
3. did not complete high school.

Individually, the 86 individuals in the AS group and the control group who participated in the Rhythm Rule and spontaneous speech aspects of the study were matched as closely as possible for educational status.

3.4.1.4 Socio-economic status of participants

As far as possible CP were recruited from broadly similar districts to the participants with AS. The majority of the individuals with AS (78%) lived in the southern and eastern suburbs of Adelaide, South Australia (including the hills), therefore CP were also recruited from these areas predominantly (86%). The schools attended by CP were also in the similarly broad locations of the schools of the participants with AS and a mix of government and private schools were included in both groups.

3.5 INSTRUMENTS USED

3.5.1 THE NEALE ANALYSIS OF READING ABILITY - 2nd EDITION REVISED

To ensure all participants had adequate comprehension to meet the demands of the tasks a conservative approach was adopted with only participants with a reading comprehension age of at least 12 years being included in the analysis of the use of the Rhythm Rule and, as a consequence, the analysis of spontaneous speech. This was assessed for all participants using the Neale Analysis of Reading Ability – Second Edition, Revised (NARA - 2R) (Neale, 1999). The NARA-2R was chosen for this study as it was developed in Australia and provided Australian normative data. Two forms of this assessment, which assesses the reading of text, are available with Form 1 being used in this study (Appendix C). According to Neale (1999) this test has been shown to have excellent psychometric parameters for reliability and validity.

3.5.2 ASSESSMENT OF SPEECH RHYTHM

In English, strong and weak stresses usually alternate with the placement of stress patterns in words of more than one syllable being dependent upon the following word. It is therefore unusual for two strong stresses to be spoken consecutively. This unconscious adjustment of stress patterns in connected speech to avoid stress clashes has been named the Rhythm Rule. When reading aloud, it is usual for people to ‘look ahead’ and modify their speech production to adjust to this rhythm.

Two tests were used to assess understanding and use of English rhythm in this study.

3.5.2.1 THE ADAPTED BOLINGER SENTENCE TEST

The test used to assess awareness of the rhythm of English was a modified form of the Bolinger Sentence Test (Bolinger, 1965). The test consists of 18 pairs of sentences, which each have the same words and syntax, but different prosodic characteristics. An example of one set is –

She wrote me a curt and hurried reply.

She wrote me a hurried and curt reply.

The original form of the test ordered the sentences such that the second sentence in each pair had the stronger alternating rhythm structure. The test was modified by McCormack (unpublished, 1999) to randomize presentation so that awareness of an order of presentation did not prime participants in their preference choice. McCormack created two forms, Form A and Form B. Form B was used in this study (Appendix D). Participants are required to read the two similar sentences in each set, either to themselves or aloud. They must then denote which sentence sounds better to them by circling the appropriate section on the test sheet. If the optimal speech rhythm of alternating strong and weak syllables is not the perceived preference choice for speakers of English, then one would expect that the choices between the test's sentence pairs would be random, resulting in a 50/50 (two-way choice) pattern of responses.

While neither choice is right nor wrong, previous studies have indicated that native speakers of English prefer the alternating rhythm. Therefore, the majority of English speakers tend to choose the first sentence in the above example as the one they believe sounds better, as they prefer alternated strong and weak stresses, e.g.

“curt and hurried”

S W S W (alternating strong and weak stresses)

versus

“hurried and curt”

S W W S (strong and weak stresses not alternating).

Although the Bolinger Sentence Test has not been standardized, norms for over 200 adult speakers of English are available for these tests and indicate that alternating stresses are preferred at least 80% of the time. The results of 58 participants with AS and 50 CP were included and compared in the analysis of this test.

3.5.2.2 THE RHYTHM RULE EXPRESSIVE SENTENCES

The Rhythm Rule (RR) relates to the unconscious adjustment of stress patterns in connected speech to avoid stress clashes. In English strong and weak stresses are usually alternated with the placement of stress patterns in a word being dependent upon the following word. It is therefore unusual for two strong stresses to be spoken consecutively. When reading aloud it is usual for people to ‘look ahead’ and modify their speech production to apply the RR. Looking ahead allows planning for words not yet spoken, therefore an inability to apply this rule and therefore adjust speech stress in this situation, may imply motor-programming problems.

The questions and answers used to elicit the Rhythm Rule (Appendix E) were devised by McCormack and Ingram (1995), who studied use of the RR in the speech of individuals with ataxic dysarthria. They found that the test material was sensitive to disturbances in speech motor programming for rhythmic look-ahead in these individuals. Sentences were chosen specifically to reflect typical English linguistic stress changes. Therefore, like the Bolinger sentences, individuals reading the RR sentences also tend to prefer the alternating strong and weak stresses which contribute towards a regular rhythm.

Participants were shown the sentences (as in Appendix E) and asked to read them aloud in their normal reading voice. The questions control the rhythmic pattern in the answer. For example -

How many officers were at the party? There were thirteen officers at the party.

or

At the party, were there ten sergeants or thirteen officers? There were thirteen officers at the party.

As participants were required to read these sentences, a reading age of at least 12 years was determined, enabling 43 ASP and 43 CP to be included. The sentences contained four target words, including ‘thirteen, sardines, Japanese’, and ‘bamboo’. Each target word was presented in five different contexts, resulting in a total of 20 questions and answers.

Responses for the 86 participants were recorded on digital audiotapes and later transferred to a computer. After listening to the digitized recordings, the number of times the RR was not applied was calculated for both groups and error rates were compared. One question and answer (the first in the example above) for each subject was then copied to a separate computer audio file using the Adobe Audacity 3 program (Adobe Systems Inc, 2007). The acoustic parameters of intensity, average pitch, minimum pitch, maximum pitch, pitch range and duration used by each participant in the sample RR sentence were then analyzed using PRAAT 5115 (Boersma, 2001). However, as the recording for one of the control group members became corrupted, one age matched participant with AS was also excluded, thereby reducing the number of participants whose results were acoustically analyzed to 42 in each group.

3.5.3 THE PEPS-C

Understanding and expression of prosody was assessed using the Profiling Elements of Prosodic Systems – Children (PEPS-C) which was devised by Peppe and McCann (2003) to assess receptive (input) and expressive (output) prosody. The test was originally intended for use with children, but the authors state that it is also suitable for use with adults (Peppe & McCann, 2003). The test was developed in Scotland, however, for use in this study, the PEPS-C authors produced an Australian English version of the computerized test (version 1.9_3d), which utilized a southern Australian accent. Reliability and validity data for the PEPS-C is not available currently, although norms have been developed for Scottish children.

Prior to testing, a vocabulary check and a same/different concept check are administered to ensure that participants are familiar with the latter concept and with the words used in the PEPS-C. The PEPS-C assesses prosody over six input (receptive) and six output (expressive) subtests. Eight of the twelve subtests relate to functions of prosody, while four of the subtests involve prosodic forms, which will be described below.

Input subtests require participants to look at a picture or pictures on a computer screen, listen to a spoken stimulus, then respond using a computer mouse to mark a binary choice on the screen. Scores for input subtests are automatically recorded onto the PEPS-C computer program during testing. Correct responses score 1, while incorrect responses score 0. McCann et al (2005) suggest that as a binary choice is involved, to exhibit reasonable strength, scores of at least 75 percent should be deemed to have reached competence. Output subtests require the participant to either look at picture stimuli on the computer screen then say a word or phrase, look at a picture stimulus listen to a spoken stimulus then say a word or phrase, or imitate words or phrases. Scoring of the output subtests is recorded by the assessor during testing using a specifically programmed USB numeric keypad. Scores for output function subtests are scored 1 for correct responses, while incorrect and ambiguous responses score 0. Results of output form subtests involving imitation receive a score of 1 for a good response (a perfect echo of the stimulus), 0.5 for a fair response (not as exact as the stimulus), and 0 for a poor response (incorrect imitation).

Table 3.2 describes the four input (receptive) and four output (expressive) subtests which are related to communicative functions and include pragmatic, affective, and grammatical (or linguistic) functions. (Peppe et al, 2007).

TABLE 3.2 ***Input and Output Subtests in Relation to 4 Communicative Functions***

Subtest	**Code**	**Function**
Affective prosody		
Affect Input	AI	identifying like versus dislike
Affect Output	AO	expressing like versus dislike
Pragmatic prosody		
Focus Input	FI	identifying contrastive stress
Focus Output	FO	producing contrastive stress
Grammatical prosody		
Chunking Input	CI	understanding phrasing/chunking
Chunking Output	CO	producing phrasing/chunking
Interactional/Grammatical prosody		
Turn-end Input	TI	comprehension of questions and statements
Turn-end Output	TO	expression of questions and statements

TABLE 3.3 ***Input and Output Subtests in Relation to 2 Form Tasks***

Subtest	Code	Function
Intonation Input	II	perceiving whether single sounds are the same or different
Prosody Input	PI	perceiving whether phrases of sounds are the same or different
Intonation Output	IO	imitating words with different types of intonation
Prosody Output	PO	imitating phrases with different types of intonation

Table 3.3 describes the two input and two output form subtests (Peppe et al, 2007). The input form (receptive) subtests involve auditory discrimination of sounds which are based on transformed wave forms of words (II) and phrases (PI) from other subtests. The authors state that II and PI tasks are included to determine whether participants are able to process auditory information at a level which enables them to perceive the acoustic differences used in the input function tasks (Peppe et al, 2004). The expressive output form subtests require imitation of words (IO) and phrases (PO) with prosody which is similar to that used in the output function tasks.

Analysis of the input and output results of the PEPS-C subtests and the types of errors used by the 58 participants with AS were compared with the 50 CP. Intra-group comparisons were also made between the overall receptive and expressive scores of the experimental group and of the control group.

3.5.4 SPONTANEOUS SPEECH

The spontaneous speech samples of the 43 participants with AS and the 43 CP who were included initially in the RR testing were also digitally recorded and later transferred to a computer. A speech sample of approximately sixty seconds was then transferred to a separate audio file using Adobe Audacity 3 (Adobe Systems Inc, 2007). The samples taken started five seconds from the beginning of the recordings until approximately sixty seconds of spontaneous speech were obtained. During this process extraneous information, e.g. a closing door and the voices of other people were removed, hence leaving only the voice of each participant. As several of the people with AS found it very difficult to talk spontaneously, obtaining a sixty second speech sample from them proved to be quite time-consuming as small snippets of speech had to be included. The acoustic parameters of intensity, average pitch, minimum pitch, maximum pitch, and pitch range were analyzed for all 86 participants using PRAAT 5115 (Boersma, 2001). 44,100Hz was used as the sampling frequency. As these recordings were of spontaneous speech of varying length and topic, between groups comparisons of the duration of utterances were not appropriate.

The spontaneous speech sample files of the 43 individuals with AS and 7 of the CP (n = 50) were also transferred to compact discs. The discs were distributed to three speech pathologists who conducted perceptual analyses of the samples. Two of the speech pathologists have more than twenty years' experience each, while the remaining person has more than ten years' experience as a speech pathologist. All have worked with children with disabilities and are experienced in perceptual speech analysis. They were asked to listen to the spontaneous speech samples and to use perceptual analysis to rate whether research participants presented as monotone, and/or had fluency, rate or loudness difficulties. (Appendix F provides a sample of the score sheet used). As the predominant aim of this exercise was to determine these characteristics for the AS group, all participants with AS (n = 43) were included. The seven CP were randomly selected and included so that the assessors would be blind to the participants' groups.

3.6 COLLECTION OF DATA

Participants were given a choice of where the assessment was to take place, either in their homes or at Flinders University. All participants sat at a table or desk in a comfortable chair with the assessor seated to their right hand side. Testing which did not require the use of a computer was conducted first so that the computer did not restrict the available room. Digital tape recordings of the NARA-2R (Neale, 1999) stimulus passages, a five to ten minute spontaneous, connected speech sample and the readings of the RR sentences were collected for all subjects. Recordings were obtained using a Sony TCD-D100 digital tape recorder with a sampling frequency of 44,100Hz. A Sony ECM-MS907 Electret Condenser Microphone was positioned to the left of the client and approximately 45 cm from his or her mouth. Maxell Ceramic Armor Metal Particles digital audio tapes were used to record the data. Data from the tapes was transferred to a computer using a Sony PCM-R300 High Density Linear D/A A/D converter.

Data for the 12 PEPS-C subtests were collected on a Hewlett Packard Model T60M283 laptop computer, with an attached Plantronics microphone. The computer was placed in front of the client with the assessor sitting to the right of the screen.

Adequate room was allowed for the client to access the computer mouse. A Belkin numeric USB keypad was located to the assessor's right hand side and the microphone was placed on the desk or table to the left of the computer screen and approximately 45 cm from the participant's mouth. Input data were recorded directly to the PEPS-C computer program automatically, while output data were also recorded to the PEPS-C program via the use of the numeric keypad, which had been programmed by the authors of the PEPS-C.

3.6.1 STATISTICAL ANALYSIS OF DATA

Statistical analyses of data were conducted with SPSS 15 and PASW Statistics 18. Effect size was calculated using Cohen's d (Cohen, 1988). Cohen's d was used to calculate all effect sizes, with values of .2 indicating small, .5 indicating typical or medium, .8 representing large or larger than typical and 1 or more representing much larger than typical strengths of relationships (Leech, Barrett & Morgan, 2008).

3.6.2 STORAGE AND ANONYMITY OF DATA

To ensure anonymity, coded identification numbers were applied to all paper records, tape recordings and data entered onto the computer. All paper based records, assessment tapes, computer recordings and informal notes by the author are stored in a locked filing cabinet or on a computer in the post-graduate student office in the Department of Speech Pathology and Audiology of Flinders University. Data and post collection analyses are also stored in a secure facility within the department.

CHAPTER 4 PEPS-C RESULTS

This chapter reports results of the Profiling Elements of Prosodic Systems – Children (PEPS-C) (Peppe & McCann, 2003), which comprises six input (receptive) and six output (expressive) subtests. The test was used to determine the expressive and receptive prosodic abilities of participants with Asperger syndrome (AS) (n = 58) and to compare their results with the abilities of the control participants (CP) (n = 50). Some subtests of the PEPS-C also allow examination of speech motor production.

4.1 THE PEPS-C

Scoring of the six input subtests is recorded automatically during testing therefore it is not subject to rater variation. However, as the six output subtests are rated perceptually during testing, original scores were re-rated to provide data to assess intra-rater validity and were correlated with scores from a second tester to determine inter-rater reliability.

4.1.1 INTRA-RATER VALIDITY

Approximately one year after the original testing, the six output subtests for all research participants were judged again by listening to the recordings, re-rating them and comparing the results with the original scores. Results were analyzed using Pearson's correlations. After the original testing had been conducted, it was found that the scoring for Chunking Output (CO) had been performed incorrectly therefore the re-rated score reflects the correct scoring. This score was also judged again. Apart from CO, the remaining intra-rater correlations were significant at $p<.001$, with a minimum correlation of .67 for Focus Output (FO) and a maximum of .94 for Turn-end Output (TO). Cronbach's alpha was used to calculate the intra-rater correlation co-efficient resulting in a mean of .81.

4.1.2 INTER-RATER RELIABILITY

To assess inter-rater reliability, original scores were correlated with the scores of an experienced speech pathologist (tester two), who listened to twenty percent of the recordings (including 11 participants with AS and 11 CP, who were selected randomly). Tester two is a speech pathologist with over 25 years' experience as a speech pathologist and university lecturer specializing in linguistics. Using Pearson's correlations all subtests were significant at $p = .001$ with the exception of Affect Output (AO) (r- .38, $p = .08$). Initially, tester two had difficulties perceiving AO, however, he tuned in to the stimuli when agreed scores were being considered. The minimum correlation was .67 for Focus Output with a maximum correlation of .93 for Turn-End Output. Cronbach's alpha was used to calculate inter-rater reliability resulting in a mean of .81.

4.1.3 AGREED SCORES

The PEPS-C provides an opportunity for testers to compare the scores they have given and to agree on a final score. Original and re-rated scores and tester two's scores correlated well with the agreed scores and are detailed in Table 4.1.

TABLE 4.1 ***Correlations with Agreed Scores***

Scores	Minimum correlation	Maximum correlation
Original	.85* AO	.96* TO
Re-rated	.78* FO	.99* IO
Tester Two	.69* AO	.99* IO

* p<.001

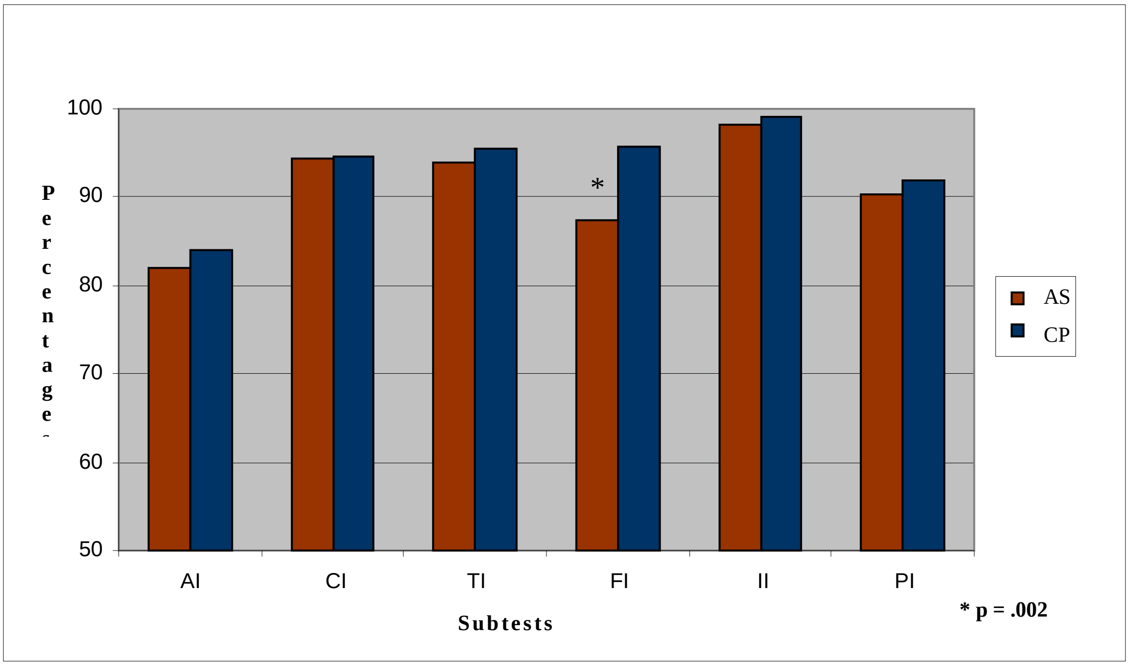
Cronbach's Alpha was used to assess internal consistency resulting in a correlation of .77. As agreed scores were highly correlated overall, they were used to assess the performance of the participants.

The authors of the PEPS-C originally devised this test to be used with children, but state that it is suitable for use with adults, who would be expected to achieve at or near perfect scores (Peppe & McCann, 2003). Both the participants with AS and the CP achieved high scores on a number of subtests resulting in a ceiling effect, therefore the data did not have a normal distribution. Independent *t*-tests were utilized to analyze the receptive and expressive data, but due to the skewed scores caused by the ceiling effect, logarithmic transformations were also applied to the data (despite the fact that the study involved a large number of participants) and confirmed the previous findings. Additionally, as participants were subjected to repeated measures Bonferroni significance was calculated and set at .004.

4.2 UNDERSTANDING OF PROSODY

PEPS-C input (receptive) subtests include Affect Input (AI), which assesses affective prosody, Chunking Input (CI) and Turn-End Input (TI), which assess grammatical prosody, Focus Input (FI) which assesses pragmatic prosody (specifically contrastive stress) and two form input subtests, Intonation Input (II) and Prosody Input (PI). Each subtest contains 16 items and as a binary choice is involved to achieve reasonable strength McCann and Peppe (2003) suggest that scores of at least 75 percent should be deemed to have reached competence. Both the CP and the participants with AS achieved scores of more than 80% for all input subtests. However, an independent *t*-test revealed a significant statistical difference between the two groups for the receptive pragmatic subtest (Focus Input) with the AS group ($\bar{x}$ = 13.97, SD 2.8) not performing as well as the CP ($\bar{x}$ = 15.32, SD 1.39, $p = .002$). Cohen's d (Cohen, 1988) was used to calculate effect size, with the magnitude of the difference in the means for Focus Input being typical ($d = .61$). No statistically significant results were found for any other receptive subtests. Figure 4.1 provides mean percentage scores for all input subtests.

FIGURE 4.1 *PEPS-C Input – Mean Percentage Scores*

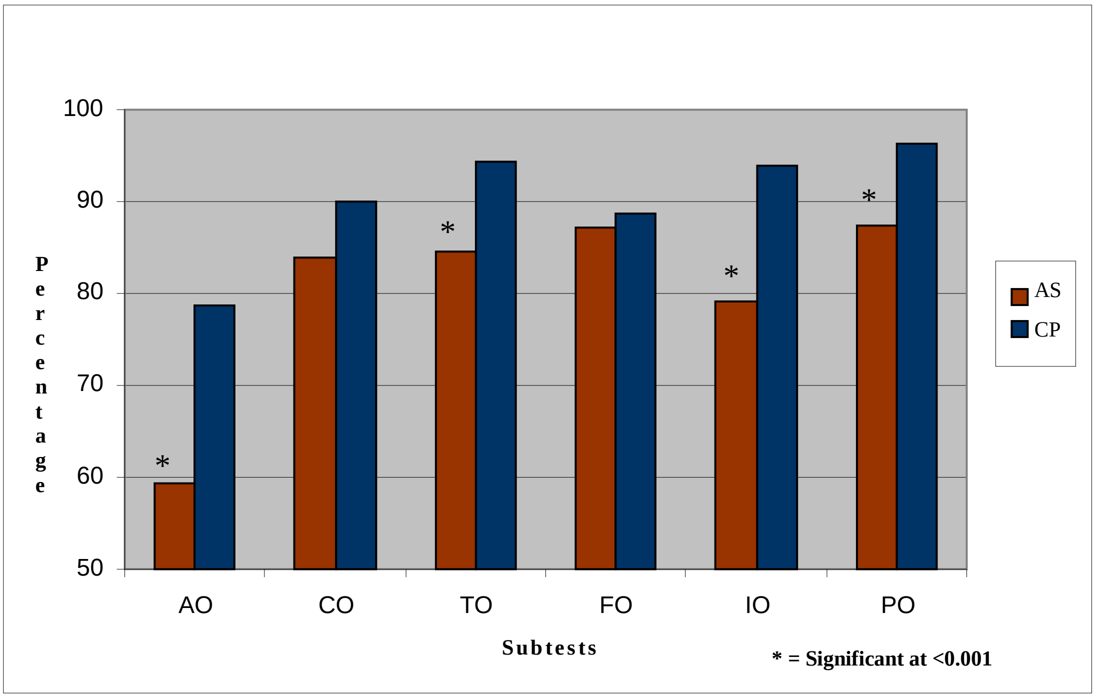


4.3 EXPRESSION OF PROSODY

Like the input subtests, PEPS-C output (expressive) subtests include an affective prosody subtest Affect Output (AO), two grammatical prosody subtests Chunking Output (CO) and Turn-End Output (TO), a pragmatic prosody subtest Focus Output (FO), as well as two form output subtests Intonation Output (IO) and Prosody Output (PO). Each subtest contains 16 items.

As can be seen on Figure 4.2 which provides mean percentage scores for all PEPS-C output subtests, both groups did not perform as well on the output subtests as they did on the input tasks (compared with Figure 4.1). Additionally, the AS group did not perform as well as the CP on all output subtests with significant differences for four of six of these.

FIGURE 4.2 ***PEPS-C Output – Mean Percentage Scores***



The deemed competence level of at least 75% was obtained for all output subtests with the exception of Affect Output for the participants with AS who achieved less than 60% for this subtest. Independent *t*-tests revealed statistically significant results for two of the four output function subtests, including, affective prosody (Affect Output) and interactional/grammatical prosody (Turn-End Output) and both of the output form subtests, (Intonation Output and Prosody Output). Cohen's d showed much larger than typical effect size for all these subtests, as all values were greater than 1 (Leech et al, 2008). Table 4.2 provides details of expressive prosody results.

TABLE 4.2 ***PEPS-C Output Results for the AS group and CP***

	AS (n=58)	CP (n=50)	Cohen's d
Subtest	**Mean % Score (SD)**	**Mean % Score (SD)**	
AO*	59.3 (5.17)	78.8 (3.36)	-4.47
TO*	84.6 (2.97)	94.4 (1.56)	-4.13
CO	83.9 (2.94)	89.9 (2.21)	-2.31
FO	87.1 (1.76)	88.8 (1.85)	-0.94
IO*	79.1 (2.98)	94.0 (0.97)	-6.72
PO*	87.3 (2.17)	96.2 (0.74)	-5.49

* p<.001

4.4 RESULTS OF PROSODIC FORM SUBTESTS

The four PEPS-C form subtests, Intonation Input, Intonation Output, Prosody Input and Prosody Output, require 'bottom-up processing' (Peppe, McCann, & Gibbon, 2004). Independent *t*-tests revealed no statistically significant differences between the research groups for the receptive subtests: Intonation Input (AS group $\bar{x}$ = 15.72, SD .64 and CP $\bar{x}$ = 15.86, SD .35), or Prosody Input (AS group $\bar{x}$ = 14.47, SD .78 and CP $\bar{x}$ = 14.72, SD .61).

In contrast, on the expressive subtests statistically significant differences were detected when comparing the ability of the individuals with AS to imitate words (Intonation Output) and phrases (Prosody Output) as can be seen in Table 4.2.

These results, where expressive prosody is significantly poorer than receptive prosody, are consistent with speech production impairment at the level of prosodic organization.

4.5 OVERALL RESULTS

Overall, the individuals with AS did not perform as well as the CP. However, this was the result of the highly significant differences in overall expressive (output) scores for the participants with AS, as shown in Table 4.3. The differences between the two groups' overall receptive (input) scores were not significant.

TABLE 4.3 ***Mean Ranking Scores using the PEPS-C***

	AS	**CP**
Mean Rank Sum*	40.95	63.51
Mean Rank Input	49.16	55.67
Mean Rank Output*	39.64	68.27

* p < .001

Furthermore, the better receptive than expressive abilities of the participants with AS were confirmed by comparing the sum of comprehension scores with the sum of expression scores. Using a paired samples *t*-test, a significant difference between the sum of the comprehension and expression scores was revealed for the AS group (t = 8.11, df 57, p<.001), while the difference between these scores was not significant for the CP (t = 1.76, df 49, p = .09).

4.6 RESULTS OF PROSODIC FUNCTION SUBTESTS

4.6.1 AFFECTIVE PROSODY

Affect Input (AI) and Affect Output (AO) are the PEPS-C subtests which assess affective (emotional) prosody. These subtests require identification and expression of the emotions of like and dislike. Neither the group with AS ($\bar{x}$ = 13.12, SD 1.97) nor the CP ($\bar{x}$ = 13.46, SD 1.36) had difficulties understanding affective prosody.

Conversely, as might be expected in ASD (Peppe et al, 2007), expression of affect was the subtest which the participants with AS found most problematic, with a statistically significant difference being found between their scores and the CP (details are provided in Table 4.2). It should also be noted that this was the one subtest where the AS group did not achieve the 75% competency level.

4.6.2 PRAGMATIC PROSODY

The PEPS-C subtests related to pragmatic prosody are Focus Input (FI) and Focus Output (FO), which assess the understanding and use of contrastive stress to indicate the focus of information in a sentence. Scoring of Focus Input relates to whether participants perceive that stress is placed on the first or second element (both of which are colours) to indicate the focus of information. Scoring of the output subtest (Focus Output) relates to whether participants place stress on the first element (a colour), the second element (an animal), or whether stress placement is ambiguous.

Of all the PEPS-C input subtests, Focus Input was the only one that resulted in a statistically significant difference between the AS group ($\bar{x}$ = 13.97, SD 2.8) and the CP ($\bar{x}$ = 15.32, SD 1.38), with the participants with AS performing more poorly (p =

.002, d = -.61). No statistically significant differences were found between the two groups for expressive pragmatic prosody (Focus Output) on the PEPS-C (as per information provided in Table 4.2).

4.6.3 GRAMMATICAL PROSODY

Four subtests assess grammatical prosody in the PEPS-C, including Chunking Input (CI), Chunking Output (CO), Turn-End Input (TI) and Turn-End Output (TO). Scoring of the Chunking Output subtest depends upon whether the boundary (pause) was marked after the first word, e.g. 'black, and red and pink socks', or the first phrase, e.g. 'black and red, and pink socks', or was ambiguous. Turn-end Output utterances are scored as a question form, a statement or as ambiguous.

There were no difficulties for either group and no statistical differences between the groups in understanding grammatical prosody including identifying appropriate phrasing (Chunking Input), AS group $\bar{x}$ = 15.14, SD 1.38, CP $\bar{x}$ = 15.13, SD 2.05, or identifying questions versus statements (Turn-end Input), AS group $\bar{x}$ = 15.3, SD 1.58, CP $\bar{x}$ = 15.26, SD .78.

Expressively, no statistically significant results were found between the groups for their ability to express correct phrasing (Chunking Output results are detailed in Table 4.2). However, statistically significant results were found for the ability to express questions versus statements (Turn-End Output), with the AS group ($\bar{x}$ = 13.53, SD 2.97) not being able to express these concepts as well as the CP ($\bar{x}$ = 15.1, SD 1.56, p = .001, d = -4.13).

CHAPTER 5 OTHER RESULTS

While the PEPS-C was used to explore whether evidence of speech motor disturbances could be detected in participants with Asperger syndrome (AS) and to assess their understanding and expression of prosody, including prosodic functions, additional testing of research participants was conducted to add to the body of information regarding prosody in AS. The ability to understand English rhythm and to apply appropriate rhythm using the ‘Rhythm Rule’ (refer to Chapter 3 for information) was assessed, with acoustic and perceptual analyses being applied to the expressive Rhythm Rule data and also to spontaneous speech samples. Acoustic analysis was used to measure intensity (loudness), minimum, maximum and average pitch and pitch range. Acoustic examination of duration of speech was also conducted for the rhythm rule sentences as they provide consistent speech samples of the same material across all speakers. All testing was recorded digitally and recordings were later transferred to a computer for acoustic analysis using PRAAT 5115 (Boersma, 2001). The results of these tests are reported below.

5.1 AWARENESS AND USE OF ENGLISH RHYTHM

5.1.1 THE ADAPTED BOLINGER SENTENCE TEST

A version of a speech rhythm comprehension test developed by Bolinger (1965) and modified by McCormack (unpublished, 1999) was used to gain additional information about the receptive prosodic abilities of research participants. The test requires speakers of English to make a preference judgment between 18 pairs of sentences where only differences in speech rhythm are involved. When choosing which sentence of the 18 randomized sets of comparative sentences in the test “sounded better”, the majority of participants in the AS group (n = 43) and the CP (n = 43) chose sentences with the alternating stress pattern, The average score for the participants with AS was slightly lower than that of the CP and for previously assessed adult natural speakers of English, but well above chance level (i.e. 50%). An independent *t*-test found no statistically significant difference between the two groups. Table 5.1 provides a comparison of the mean scores.

TABLE 5.1 ***Bolinger Mean Percentage Scores***

Group	**n**	**Mean % Score**
AS	58	70.6
CP	50	74.1
Adult English speakers	134	74.3

5.1.2 THE ENGLISH RHYTHM RULE

The Rhythm Rule was used to investigate the production of alternating speech rhythm in English. Participants were required to read aloud twenty questions and answers designed to elicit the Rhythm Rule (see Chapter 3 for further details). All participants had a reading comprehension age of at least 12 years. Tasks in the test require adjustments for shifts in the rhythmic alternation of stress. The results of this experiment were analyzed perceptually and acoustically.

5.1.2.1 Perceptual Analysis of Rhythm Rule data

Digitized recordings of the 20 Rhythm Rule responses for each of the participants with AS (n = 43) and the CP (n = 43) were analyzed perceptually to determine if participants produced the appropriate rhythmic structure for each context. The group with AS did not produce the adjustments for the Rhythm Rule in 35% of the possible examples, compared with 24% for the CP. When analyzed using an independent t-test, these results were statistically significant (AS group $\bar{x}$ = 6.98, SD 4.16, CP X= 4.74, SD 3.35, p = .007, d = .59). Examination of the data indicated that almost three times as many individuals with AS (25.6%) made errors on more than half of the Rhythm Rule sentences than the CP (9.3%). A Chi Square analysis was conducted and confirmed a statistically significant difference (χ^2(1,n=86 =3.9568, p = .047) between the two groups.

Although the AS group made significantly more errors than the CP, like the CP, the most common mistake made by the participants with AS was placing emphasis on the sentence final word (default stress). An independent *t*-test revealed that the type of errors made by the AS group ($\bar{x}$ = 5.49, SD 4.88) did not differ significantly from those of the CP ($\bar{x}$ = 3.95, SD 3.42, p = .09). Error types are shown in Table 5.2. Although previous studies have indicated that some individuals with ASD often place stress on more than one word in a sentence, this was not found in the current study as a similar, small percentage of both groups made this error type. Stress placed on an inappropriate word (excluding default/final stress) is considered in ‘other’ errors.

TABLE 5.2 ***Percentages of Error Types in Rhythm Rule***

Stress placement	AS	CP
Final word	76.66	80.39
More than one word	3.00	2.94
Other	20.34	16.67
	100.00%	100.00%

A particular subset of the sentences within the Rhythm Rule test requires the manipulation of sentence focus (contrastive stress) specifically. For example in the stimulus question

‘Did Sally buy the wooden chair or the bamboo chair at the shop?

the semantic focus of the sentence is not ‘chair’, but the type of chair, therefore, as a bamboo chair was bought, in the response stress should be placed on ‘bamboo’ to differentiate the type of chair purchased. As contrastive stress involving the manipulation of focus has previously been found to be problematic in ASD, additional analysis was conducted with the ‘Focus’ condition results omitted to ensure that they were not the sole influence on the poorer AS group results for the overall Rhythm Rule test. An independent *t*-test indicated that even without the ‘Focus’ data, the results of the ability to apply the Rhythm Rule for the participants with AS ($\bar{x}$ = 5.28, SD 3.4) were significantly poorer statistically than those of the CP ($\bar{x}$ = 3.81, SD 2.73, p = .031, d = .48).

TABLE 5.3 ***Percentage Distribution of Contrastive Stress Error Types in Rhythm Rule 'Focus'***

Stress placement	**AS**	**CP**
Final Word	75	80
Next word	25	20
	100%	100%

5.1.2.2 Perceptual analysis of the 'Focus'/Contrastive stress condition in the Rhythm Rule sentences

Seventy-nine percent of the participants with AS (n = 43) compared with 51 percent of the CP (n = 43) made some errors in Rhythm Rule 'Focus' condition sentences, although the AS group made almost twice as many errors as the CP. An independent *t*-test of the errors made revealed that the AS group ($\bar{x}$ = 1.7, SD 1.26) were significantly less able to apply the appropriate contrastive stress in an obligatory environment than the CP ($\bar{x}$ = .95, SD 1.07, p = .004, d = .64). All of the errors made by both groups consisted of either placing stress on the following word, or on the last word of the utterance (default stress). For example in response to the question

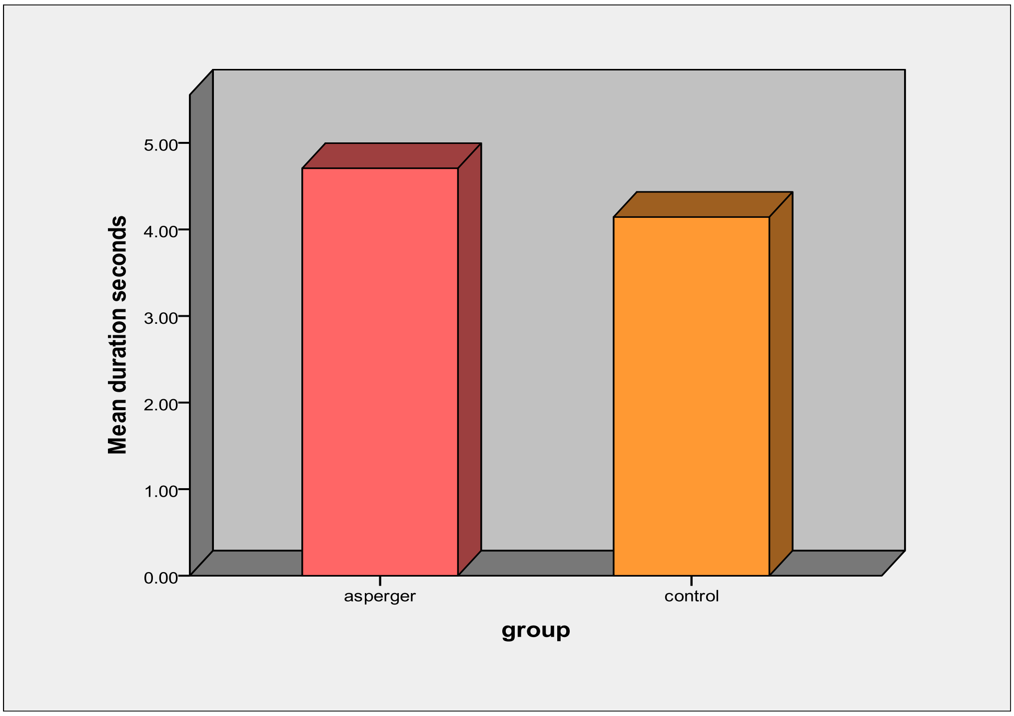
'Did Sally buy the wooden chair or the bamboo chair at the shop?

instead of stressing bamboo, 'chair' was stressed although chair was a given factor, while in default sentence stress, which was the predominant error type, participants placed stress on 'shop' rather than bamboo. As in the sentences involving the application of the Rhythm Rule, Table 5.3 shows that both groups displayed similar percentages of both error types. Nevertheless, although the type of errors made by the participants with AS were similar to the error types of the CP, the AS group made significantly more of these errors than the CP.

5.1.2.3 Acoustic analysis of Rhythm Rule data

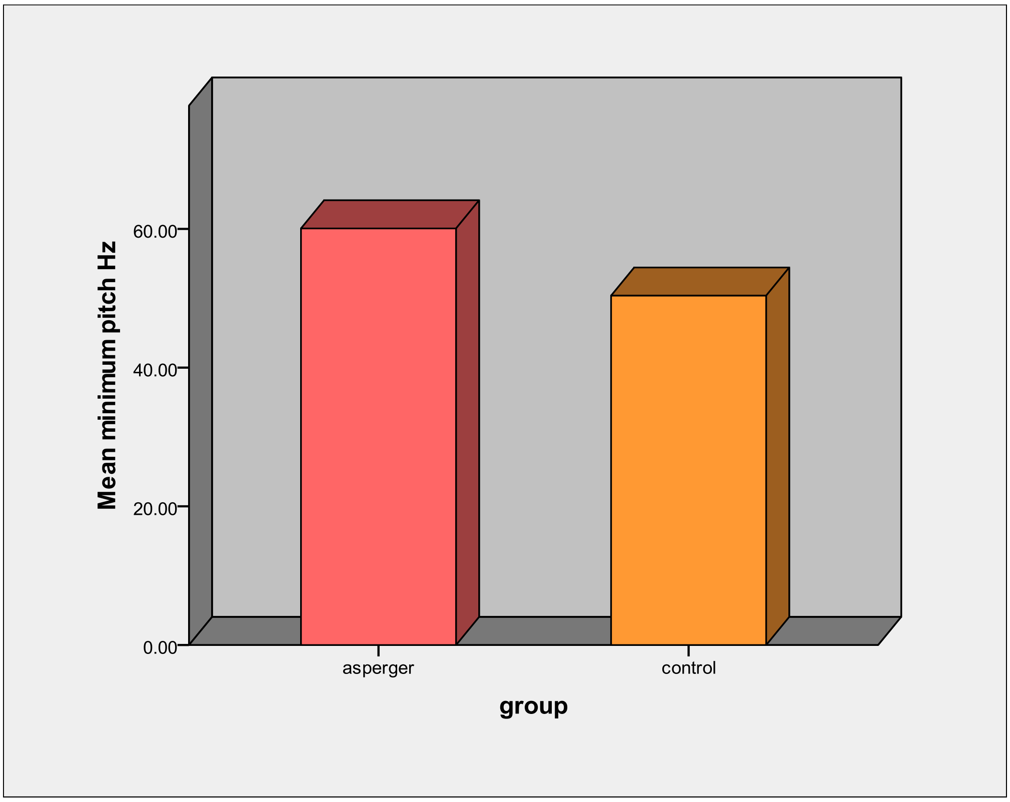
The first question and answer question from the Rhythm Rule experiment for each participant was analyzed acoustically from the digitized recordings. PRAAT (Boersma, 2001) was used for the acoustic analysis of amplitude, duration and pitch characteristics which are the main acoustic correlates of the prosodic features of speech. Comparisons using independent samples *t*-tests were made between the acoustic characteristics of the AS group (n = 42) and the CP (n = 42). Only two parameters reached statistical significance, including duration and minimum pitch. Figure 5.1 illustrates the timing (duration) differences between the participants with AS and the CP, while Figure 5.2 displays mean minimum pitch results.

FIGURE 5.1 ***Mean Duration (in seconds) of Time Taken to Read the Rhythm Rule Sample Question and Answer***



Statistical analysis of the overall time (in seconds) that it took each participant to read the sample Rhythm Rule question and answer (the duration of the task) indicated a significant difference between the two research groups with the participants with AS ($\bar{x}$ = 4.7, SD 1.3) requiring longer time to read the sample than the CP ($\bar{x}$ = 4.14, SD .78, p = .019, d = .61).

FIGURE 5.2 ***Mean Minimum Pitch in Hz for Rhythm Rule Sample Question and Answer***



As displayed in Figure 5.2, the minimum pitch difference which was almost 10Hz higher for the AS group ($\bar{x}$ = 60.07, SD 26.3) was statistically significant when compared with the CP ($\bar{x}$ = 50.37, SD 11.4, p = .001, d = .48).

Results for other parameters are recorded in Table 5.4.

TABLE 5.4 ***Other Acoustic Analysis results for Rhythm Rule tasks***

	AS	CP
	Mean (SD)	**Mean (SD)**
Loudness (dB)	64.84 (4.27)	64.68 (6.68)
Average pitch (Hz)	123.45 (35.48)	117.51 (29.14)
Maximum pitch (Hz)	200.82 (62.45)	194.68 (61.65)
Pitch range (Hz)	140.76 (62.35)	145.25 (62.06)

* p = <.05

The individuals with AS produced utterances that were almost 6Hz higher for average and maximum pitch and almost 5 Hz lower for pitch range however, like the results of some previous studies, these results were not statistically significant when compared with the CP. No statistically significant difference was found between the groups for loudness.

5.2 SPONTANEOUS SPEECH

Approximately sixty seconds of spontaneous speech were sampled from the digitized recordings for the AS group (n = 43) and the CP (n = 43) using Adobe Audacity 3. The samples were of participants' speech only and were therefore devoid of the speech of other people or of additional sounds (refer to Chapter 3 for further information). The pitch characteristics and amplitude of the above samples were analyzed acoustically using PRAAT (Boersma, 2001) and were also analyzed perceptually.

TABLE 5.5 *Spontaneous Speech Acoustic Analysis Results*

	AS	CP
	Mean (SD)	Mean (SD)
Loudness (dB)	61.01 (4.61)	60.32 (5.74)
Average pitch (Hz)	112.73 (32.8)	111.19 (31.12)
Minimum pitch (Hz)	43.18 (2.62)	42.64 (2.82)
Maximum pitch (Hz)	220.71 (63.25)	233.24 (63.51)
Pitch range (Hz)	177.53 (62.45)	190.6 (62.63)

* p = <.05

5.2.1 Acoustic analysis of spontaneous speech

Two of the main acoustic correlates for prosodic features (amplitude and pitch characteristics) were used to acoustically analyze spontaneous speech and to compare the results of each research group. Duration was not included as it cannot be compared in individuals using spontaneous speech. Acoustic analysis of spontaneous speech also allowed comparisons with perceptual analysis of spontaneous speech. Independent *t*-tests were used to make statistical comparisons of the acoustic characteristics of spontaneous speech between the participants with AS and the CP. Results, which are provided in Table 5.5, were not statistically significant.

As in the Rhythm Rule reading task, the mean dB used by both groups was almost identical, therefore no significant difference was obtained between groups for loudness (amplitude). Although not statistically significant, the narrower mean pitch range of the AS group determined in the Rhythm Rule reading task (4.5Hz) was confirmed in spontaneous speech, with a greater margin (13.1Hz).

The statistically significant difference between the two groups for minimum pitch in the Rhythm Rule task was not confirmed in spontaneous speech, with Table 5.5 showing that both groups performed similarly. Also unlike the Rhythm Rule task, where the mean maximum pitch was 6.1Hz higher for the participants with AS, in spontaneous speech the maximum pitch was 12.5Hz lower than the CP. Despite this apparently quite large difference, again the results did not reach statistical significance.

5.2.2 Perceptual analysis of spontaneous speech

Three experienced speech pathologists examined the spontaneous speech samples of participants with AS (n = 43) and CP (n = 7) to rate whether they presented as monotone, and/or had dysfluency, rate or loudness difficulties. All judges were blind to the group status of the participants.

TABLE 5.6 ***Perceived speech difficulties of 43 AS and 7 CP (n=50)***

	AS	**CP**
Monotone	34.9%	14.3%
Dysfluency	18.6%	0%
Rate	32.6%	14.3%
Loudness	14.0%	0%

As noted in Table 5.6, all three speech pathologists identified considerably more difficulties in the individuals with AS than in the CP across all areas rated. As there was a large difference between the number of participants in the two groups, non parametric analysis was used to compare the data. When comparing the sum of monotone judgments allocated by the three speech pathologists, a Mann Whitney U test revealed a significant difference between the AS group ($\bar{x}$ rank = 27.5) and the CP ($\bar{x}$ rank =13.1, $p = .015$). A Mann Whitney U test also revealed a significant difference between the AS group ($\bar{x}$ rank = 27.5) and the CP ($\bar{x}$ rank =13.4, $p = .013$) for the sum of fluency judgments scored by the three speech pathologists. As the rate and loudness of spontaneous speech included positive and negative scores it was not relevant to use a sum of these scores.

The seven CP were included in the perceptual analysis to facilitate concealment of the identity of the individuals with AS. To ascertain whether these seven CP were a representative sample, an investigation of the occurrence of monotone in spontaneous speech for all CP (n = 43) was conducted. Two experienced speech pathologists rated the CP. Results indicated that compared with the 14.3% of the seven CP randomly selected for the perceptual analysis, (as per Table 5.6), a similar percentage (16.2%) of all CP were perceived as monotone.

Pearson correlations were performed to identify which variables were associated with the perception of monotone and with dysfluency. The only correlation found with the sum of the dysfluency scores was Intonation Output (correlation -.399, p = .005). Significant correlations were also found with the sum of the monotone judgments and a number of variables, including pitch range, maximum pitch, decibels, RR errors and Turn-end Output, details of which are detailed in Table 5.7.

TABLE 5.7 ***Correlations with Perceived Monotone for All Perceptual Analysis Participants (n=50)***

	Correlation	**p =**
Pitch range	-.417	.003
Pitch maximum	-.416	.003
Decibels	-.391	.005
Turn-end Output (TO)	-.297	.036
RR errors	.288	.042

Standard multiple regression was also used to determine which spontaneous speech variables were related to the perception of monotone. Spontaneous speech variables were utilized as the perceptual analysis was originally performed on a sample of the spontaneous speech recordings. Forward analysis demonstrated a moderate variance, with pitch range accounting for 17% of the perception of monotone. Thus confirming that the range of pitch used appears to be the most important variable in the perception of monotone. A total of 32% of the perceived monotony could be accounted for when the number of errors in applying the Rhythm Rule and the mean decibels used were added.

Like the correlations in Table 5.7, which showed that the most significant correlations with perceived monotone were pitch range, maximum pitch and decibels, when only those participants who were identified as monotone were considered the correlations between pitch range, maximum pitch and decibels with monotone revealed even stronger correlations. Details of these moderate to strong correlations are provided in Table 5.8.

TABLE 5.8 ***Correlations with Participants Perceived as Monotone (n=16)***

	Correlation	**p =**
Pitch range	-.598	.014
Decibels	-.587	.017
Pitch maximum	-.583	.018

Independent *t*-tests were also performed to compare results of the 15 participants with AS identified as monotone with the remaining participants with AS (n = 28) to establish if any particular variables could be identified with monotone. The one statistically significant difference between the two groups with AS was errors made applying the Rhythm Rule, with the results for the AS ‘monotone’ group ($\bar{x}$ = 8.13, SD 5.99) being poorer than the 'remainder' of the AS group ($\bar{x}$ = 5.79, SD 2.99, p = .001, d = .49).

5.3 ARTICULATION FINDINGS

Although articulation is not a component of prosody, it can be reflective of speech motor impairment (Love & Webb, 1992) therefore details of articulation may contribute to the investigation of motor speech impairment in AS. While it was not a specific goal of this study to determine whether participants had articulation difficulties these became apparent during testing. As all of the participants in this study were 15 years or older, the articulation errors produced were not due to developmental phonological difficulties, but were rather residual articulation errors. Table 5.9 describes the percentage of participants with residual articulation errors and the type of errors used and it is apparent from this table that these difficulties were more prevalent in the participants with AS than in the CP. The rate of errors for the CP is approximately that expected in the general population (Shriberg et al, 2011). The articulation errors of the AS group predominantly involved substitutions of 'f, v or d' for 'th'.

TABLE 5.9 ***Percentage of Participants with Residual Articulation Errors and Summary of Error Types***

		Frequency and type of articulation errors produced			
		s		**r,l**	**th**
Group	**% of Group**	**Dentalized % [a]**	**Lateralized % [a]**	**% [b]**	**% [b]**
AS n = 58	22.4	20	13.3	6.7	60
CP n = 50	4	50			50

[a] One participant with AS met criteria for dentalized and lateralized sibilants errors

[b] One participant with AS met criteria for 'th' and 'r, l' errors

Implications of all results, including the above results and those of the PEPS-C, will be discussed in the following chapter.

CHAPTER 6 DISCUSSION

The main aim of this research was to determine whether evidence of impaired speech production could, in part, account for the expressive prosodic difficulties of individuals with Asperger syndrome (AS). As information regarding prosody in AS is very limited, the study also sought to increase the available knowledge in this area.

The findings showed that speech production difficulties do contribute to the impaired prosody of the participants with AS. Evidence of these difficulties, which will be discussed below, include inability to copy words and phrases with varying prosody (prosodic form), a substantial gap between receptive and expressive prosodic skills, with expressive prosody being poorer than receptive prosody, grammatical as well as pragmatic and affective prosody problems, difficulties applying the English Rhythm Rule, use of longer durations of specific utterances, differences in the use of pitch, increased residual articulation substitutions and increased dysfluency.

6.1 PROSODIC FORMS

The PEPS-C includes subtests to assess understanding and use of prosodic forms. Understanding of prosodic forms entails perception of whether transformed wave forms of words (short item discrimination) or phrases (long item discrimination) are the same or different. Expression of prosodic form requires imitation of words or phrases with various types of prosody.

Like many research projects which have found problems with the ability to imitate gross motor activities, oral motor tasks and speech in individuals with Autism

Spectrum Disorder (ASD), the most compelling evidence of impaired speech motor performance in the AS group was their inability to copy words and phrases with various prosodic intonations. The strength of these relationships, calculated with Cohen d, was particularly high. An inability to imitate on demand, which has been found consistently in ASD is indicative of motor planning difficulties (Adams, 1998; Dziuk et al, 2007; Peppe et al, 2007) as unlike spontaneous actions, which involve learned, automated motor actions, more complex motor planning is required to be able to copy actions on demand.

As suggested by the PEPS-C authors (Peppe & McCann, 2003) difficulties with expressive prosodic form may be due to poor perception of the stimuli (which would be evident in poor understanding of prosodic forms), not having the prosodic forms in one's repertoire, or poor motor planning. The participants with AS in the current study did not display difficulties perceiving input forms and showed that they had the forms in their repertoire as they were able to use them spontaneously in other subtests. As underlying representation was not a problem, implications are that poor motor planning may have contributed to their difficulties. The ability to imitate words was also correlated with perceived dysfluency by the three experienced speech pathologists who performed the perceptual analysis of spontaneous speech, and it is believed by many authors that dysfluency is a motor speech disorder (Kent, 2004).

The control participants (CP) achieved near ceiling and competency level scores for short form tasks (imitation of words) and long form tasks (imitation of phrases), while 29.3% and 15.5% of the individuals with AS did not achieve competency level scores for imitation of words and imitation of phrases respectively. In their 2007 study, Peppe et al included a control group of Scottish adults and when compared with these adults although a significantly different result for short item imitation would have been obtained for the participants with AS in the current study, long item imitation would not have achieved a significant difference. Conversely, Peppe et al (2011) found that when compared with language age matched children, children with AS displayed difficulties with long-item imitation only. However, short and long-item imitation difficulties emerged when these children were compared with chronological age matched peers, comparable with the results of the adolescents and adults with AS in the current project, who were matched by chronological age to the CP. Children with HFA displayed difficulties with both long and short item imitation tasks when compared with language age and chronological age matched children.

The majority of participants in the current study achieved near ceiling scores for understanding of short and long item prosodic forms and all participants achieved competency level scores. Both the CP and the participants with AS scored higher than Peppe et al's (2007) Scottish control adults for discrimination of short and long item prosodic tasks. Previous studies using the PEPS-C have shown that children with AS, HFA and autism are significantly less able to identify long item prosodic forms (Jarvinen-Pasley et al, 2008; Peppe et al, 2006; Peppe et al, 2007) while children with HFA have been found to have difficulties perceiving short item discrimination tasks as well (Peppe et al, 2006; Peppe et al, 2007). These above studies found that children on the autism spectrum tended to judge same auditory pairs as different whereas TD children displayed responses which were unbiased.

Both groups in the current study tended to judge long item stimuli as different and short item stimuli as the same.

The differences in results discussed above may be related to the experimental participants, e.g. AS versus autism, and to the ages of participants as it is assumed that prosody is not achieved fully until puberty (Baltaxe et al, 1984; Tager-Flusberg, 1989). In the current study the individuals with AS, who were at least 15 years old and did not have any known language difficulties, showed consistent difficulties imitating various forms of prosody, despite being able to understand them, thus suggesting the involvement of speech motor difficulties.

6.2 OVERALL RECEPTIVE AND EXPRESSIVE PROSODY

Whilst the overall prosodic score for the participants with AS was lower than the CP, this was a reflection of the substantial gap between their receptive and expressive prosodic skills, with clear indications that it is predominantly expressive prosody that is problematic. This gap is consistent with speech motor difficulties, which may have been a contributing factor to the expressive prosodic difficulties of the participants with AS.

Therefore, in the current study the answer to question two (Is prosody impaired across both receptive and expressive prosody areas in individuals with AS?) was negative. Hypothesis one, that participants with AS would have significantly more difficulties with prosodic production tasks than with prosodic comprehension tasks, was confirmed. The difficulties experienced by the AS group when applying English rhythm also confirm their impaired expressive prosody. Additionally, three experienced speech pathologists judged the use of prosody by the individuals with AS to be poorer than that of the CP, particularly the use of a monotonous voice.

Overall expressive prosody results from other studies involving individuals with ASD have also revealed impairments. Peppe et al (2011) found that children with HFA and with AS displayed difficulties expressing prosody when compared with language matched peers, and the level of difficulties was greater when they were compared with peers of the same chronological age. McCann et al (2005) found that prosody results correlated highly with receptive and expressive language measures.

With the exception of understanding pragmatic prosody (contrastive stress) no statistically significant differences were found between the participants with AS and the CP for any of the receptive PEPS-C subtests, including grammatical prosody, affective prosody and prosodic forms. The receptive competency level suggested by the PEPS-C authors was achieved for all participants on all input subtests, including pragmatic prosody. Additionally, no differences were found between the participants with AS and the CP for awareness of English rhythm preferences.

Results of other research involving receptive prosody of individuals with autism, HFA and combined groups of individuals within the spectrum have at times revealed different results from those above, e.g. the 21 children with AS/autism in the study by Jarvinen-Pasley et al (2008) did not reach competency on any of the receptive PEPS-C subtests. Differences in study results may reflect the different chronological and language ages of research participants, and their classification within the autism spectrum. As verbal IQ has been shown to have an effect on prosody scores (Golan et al, 2007), the differences between the results of other individuals with ASD and the individuals with AS in the current study may be due to the fact that the participants with AS were all 15 years old or older, all were diagnosed with AS and although individuals with AS are not a heterogeneous group, none of the participants had been identified with poor language or intellectual levels. Differences in stimuli used in research may also contribute to the diverse results.

Examination of specific prosodic functions and prosodic forms provided additional evidence of expressive prosodic difficulties and speech motor difficulties in AS.

6.3 PROSODIC FUNCTIONS

Although suggesting that it is affective/pragmatic prosody that is problematic in ASD, Shriberg et al (2001) state that if problems with grammatical prosody are also apparent, motor involvement would be indicated. Based upon these assumptions, hypothesis two proposed that affective and pragmatic prosody would be more problematic than grammatical prosody for the group with AS. Results confirmed hypothesis two receptively, but not expressively, as expression of grammatical, affective and pragmatic prosody all proved difficult for the participants with AS, but not for the CP, hence providing increased evidence of impaired motor involvement in the prosody of the AS group. The appropriate receptive grammatical prosody of the participants with AS indicates that their underlying grammatical competency was not compromised and that the issues lie with production of prosody.

6.3.1 GRAMMATICAL PROSODY

Grammatical prosody was assessed by tasks involving understanding and use of phrasing (or chunking) and understanding and use of questions versus statements. The participants with AS did not display difficulties understanding grammatical prosody, or expressing phrasing, but they were not able to express questions and statements as well as the CP. The PEPS-C authors describe expression of questions and statements as interactional/grammatical prosody, on the grounds that there is an inherent pragmatic requirement in these responses. However, an ability to use question and statement forms appropriately is also necessary, hence requiring linguistic/grammatical ability.

Expression of questions and statements revealed a statistically significant difference between the participants with AS and the CP, who commonly reached ceiling levels for this task. Effect size values were exceptionally high for these measures. As well as performing significantly less well than the CP, the individuals with AS in the current study did not perform as well as the typical Scottish adults in the Peppe et al (2007) study who were also tested with the PEPS-C.

Children with HFA have also been found to be significantly less able to use questions and statements on the PEPS-C than TD children (Peppe et al, 2007), while children with AS have achieved competency levels for these tasks (Peppe et al, 2011). Paul et al (2005a) also found well established use of statements and questions in a group of individuals with AS, HFA and Pervasive Developmental Disorder Not Otherwise Specified (PDDNOS).

The differences between the individuals with AS in other studies which used the PEPS-C compared with those of the participants with AS in the current study may have been caused by a subgroup of individuals in this study. Although the mean score for the AS group was at the competency level, 33% of the participants with AS did not achieve competency compared with only 7% of the CP. The differences may also reflect the differences between stimuli presented during testing, e.g. it may be harder to express differences between questions and statements by using a single word as is required in the PEPS-C, than within a short phrase or sentence as used by Paul et al (2005a). Hesling et al (2011) suggested that significantly lower scores for the expressive questions and statements subtest (Turn-End) on the PEPS-C could represent difficulties in producing pitch variations in speech. The correlation found between expression of statements and questions and the sum of the scores of perceived monotone may provide some evidence of this, as regression analysis indicated a moderate relationship between perceived monotone and mean pitch range.

In the current research, although the participants with AS made significantly more errors than the CP, the majority of incorrect responses for both groups were judged as ambiguous (79% of errors for the CP and 50% of errors for the AS group) although the participants with AS were also more likely to use questions instead of statements. This is in agreement with the responses of children with HFA who were significantly more likely to be judged as questioning or ambiguous than TD children (Peppe et al, 2007). In the current study, the correlation of the expression of statements and questions with the perceived use of monotone as judged by the three experienced speech pathologists, may account for the increased ambiguous responses of the individuals with AS, as many of their responses sounded the same. The high incidence of ambiguous responses and inappropriate use of question forms made by the AS group suggests that their communicative attempts may be misunderstood or even ignored, as other people may not be able to interpret their communicative intentions.

The current investigation did not reveal a statistically significant difference between participants with AS and CP in the ability to express appropriate grammatical phrasing. However, while information regarding the control group of Scottish adults in the Peppe et al study (2007) is limited, comparison of mean scores indicates that a significant difference between their scores and the participants with AS in the current study would have resulted. Additionally, although the differences between the participants with AS and the CP were not statistically significant, more than twice as many individuals with AS (22.4%) failed to reach the 75% criterion score than the CP (10%). The main errors for both groups occurred on phrases where socks of particular colours had to be described, e.g. 'red, and black and blue socks' (two socks) rather than stimuli involving groups of food, e.g. 'chocolate, cake and biscuits'. This is not surprising as phrases involving groups of food are common, while describing socks of varied colours is less familiar. However, 36% of the AS participants compared with 26% of the CP made mistakes when describing socks and the majority of errors for the participants with AS were not using pauses at all, e.g. rather than saying 'red and black, and blue socks', or 'red, and black and blue socks', they said 'red and black and blue socks', thus suggesting that there were three socks instead of two. Again, there is a suggestion of a subgroup within the participants with AS.

Expression of grammatical phrasing has not been a problem for other individuals with ASD (Fine et al, 1991; Paul et al, 2005a), or for children with AS and HFA who were matched with children of the same language age (Peppe et al, 2011). However, statistically significant results were obtained when the children with AS and HFA were compared with age matched control children, with the children on the autism spectrum performing more poorly. Participants with HFA and AS also displayed increased phrasing errors in longer utterances according to Shriberg et al (2001), although the phrasing difficulties were considered to be problems of dysfluency and it was suggested that speech motor control and social demands may have been the underlying cause of these difficulties.

Results suggest that while the use of grammatical phrasing was not a specific problem for many of the adolescents and adults with AS in the current study, the possibility of a subgroup who do have difficulties may exist. Knowing the precise language and intellectual abilities of the participants with AS would have been beneficial to help determine whether a subgroup does exist. Although younger individuals with ASD may not display difficulties when compared with language aged peers, incorrect use of grammatical phrasing may be problematic in functional life situations where communication is often based upon interactions with chronological age level peers.

The understanding of grammatical prosody was not found to be a problem in the participants with AS in the current project who performed as well as the CP on tasks requiring <u>understanding of grammatical phrasing</u> and <u>understanding of questions versus statements.</u> Almost all of the AS group and the CP neared ceiling levels on these tasks. These results concur with the only other research to date which has examined understanding of phrasing and of questions versus statements in participants with AS exclusively (Chevallier et al, 2009).

Varying results have been obtained for children across the autism spectrum with some showing ability to understand grammatical phrasing (Paul et al, 2005a: Peppe et al, 2007), while others have not been able to judge grammatical phrasing as well as TD children (Jarvinen-Pasley et al, 2008; Paul et al, 2000 cited by McCann & Peppe, 2003). Contradictory results have also occurred with the use of the PEPS-C. Therefore, while individuals with AS may not have difficulties understanding grammatical phrasing, others on the autism spectrum may not understand it as well. No investigations involving mixed groups of individuals with ASD (including autism, HFA and AS) have indicated significant difficulties in understanding of questions versus statements. Although no significant differences were found between groups of children in their study, Peppe et al (2007) stated that children with autism tended to judge questions as statements more often than control group children, with 12.9% of the children with autism judging all question types as statements (i.e. none as questions) compared with only 2.7% of the TD children. Jarvinen-Pasley et al (2008) also determined a bias towards judging questions as statements for an AS/autism group, although results did not reach statistical significance. Both the group of individuals with AS and the control group in the current research judged questions as statements more often than statements as questions, but none of either group judged all questions as statements.

Therefore, while reports which have included mixed groups of individuals with ASD including autism, HFA and AS have, at times, revealed different conclusions, indications are that in AS understanding of grammatical prosody is preserved but the use of appropriate questions and statements and of phrasing may be compromised, particularly in a subgroup of individuals. In functional environments, less than adequate use of grammatical prosody may not pose as much of a problem or be as apparent as inappropriate use of affective or pragmatic prosody, because lexically ambiguous phrases are "often disambiguated by context rather than prosody" (McCann et al, 2007).

6.3.2 PRAGMATIC PROSODY

In the literature, assessment of pragmatic prosody has concentrated on the understanding and use of contrastive stress, which has consistently been found to be problematic. This was also the case in this study, which confirmed hypothesis three, that the participants with AS would not understand or use contrastive stress as well as the CP.

Although the AS group did achieve scores above the criterion level of 75% for understanding of contrastive stress, this was the only PEPS-C receptive prosodic function that revealed a significant difference between the participants with AS and the CP, with a medium effect size calculated. Scores for the CP in the current study were similar to those of the Scottish adults in the Peppe et al study (2007). The results for the participants with AS are consistent with the conclusion of Paul et al (2005a) who found that 27 individuals with ASD aged 14 to 21 years could not understand contrastive stress as well as control participants and with the case study of a seven year old boy with HFA whose scores for understanding contrastive stress on the PEPS-C were more than three SD below those of TD children (Peppe et al, 2006).

Conversely, the results for the participants with AS differ from some previous research using the PEPS-C. Jarvinen-Pasley et al (2008) and Peppe et al (2007) did not find significantly different results for understanding of contrastive stress for a combined group of children with HFA/AS, and children with HFA respectively when compared with TD children. However, like the children with ASD, the control group children in both of these projects did not achieve competency levels, which may be an indication of their prosodic developmental levels, therefore reducing the likelihood of statistically significant differences.

Peppe et al (2007) reported that with the use of the PEPS-C, children with HFA made more errors understanding contrastive stress when the accent was placed on the first element (a colour). The reverse was true for the CP in this study, while the participants with AS almost as often indicated that contrastive stress occurred on the first colour when it was actually on the second colour. Inappropriate use of contrastive stress may mean that listeners do not focus on the most salient information to be conveyed in a message, and hence may miss the main point of a communication.

Difficulties with expression of contrastive stress have been indicated consistently in individuals with autism, HFA and combined ASD groups (Baltaxe & Guthrie, 1987; Fine et al, 1991; Fosnot & Jun, 1999; Paul et al, 2005a; Peppe et al, 2007; Peppe et al, 2011; Shriberg et al, 2001). Varied results were obtained for the participants with AS in the current research. Like the individuals with AS in the Peppe et al (2011) study, expression of contrastive stress in the PEPS-C did not reveal significant differences between the participants with AS and the CP. Both groups achieved higher scores for this subtest than the Scottish adults although Peppe et al (2007) comment that the scores for this subtest were the lowest their adults attained. Contrary to this, a significant difference between the participants with AS and the CP was obtained when comparing their use of contrastive stress in the Rhythm Rule 'Focus' sentences.

Previous research (Baltaxe, 1984; Fine et al, 1991; Fosnot & Jun, 1999) has indicated that some individuals with autism and HFA place stress inappropriately on function words that don't usually bear stress. This has not been found in individuals with AS and was not apparent in the current research. All of the errors made for both the AS group and the CP in the Rhythm Rule 'Focus' task were either placing stress on the following word or on the last word of the utterance (default stress) with default stress predominating. Nevertheless, the participants with AS made significantly more errors than the CP and several of the participants with AS produced all of their utterances using default stress, whereas this was not common for the CP. The development of default stress is a precursor to the development of contrastive stress, with children of less than three years of age using default stress predominantly (McCann & Peppe, 2003).

Inappropriate application of stress is associated with motor problems (Mackay, 1987; Velleman et al, 2010). Shriberg et al (2011) claim that in ASD stress is misplaced, (as opposed to the equal/excessive stress which is characteristic of acquired apraxia of speech), suggesting signs of motor impairment rather than motor planning (dyspraxia) per se. Like the participants in the Shriberg study, the participants with AS in the current study did not display typical dyspraxic stress difficulties, but consistently used the default stress mode suggesting, as described by McCann and Peppe (2003), that a possible cause of the stress difficulties is that "speakers with autism assign stress unintentionally, i.e. have a problem at the execution level" (p.338).

Compared with phrasal or lexical stress, contrastive stress is relatively open to choice, whether the choice is conscious to the speaker or not. Therefore it may be argued that due to this optional control, contrastive stress may be more vulnerable to perceptual-motor deficits than more grammatically controlled aspects of prosody. The use of contrastive stress provides the focus for listeners to interpret the meaning of utterances, therefore, those speakers with AS who do not use appropriate contrastive stress may be misunderstood and the important information to be relayed may not be perceived by their audience.

6.3.3 AFFECTIVE PROSODY

Affect is considered to be a specific difficulty in ASD. Unexpectedly, the participants with AS in the current study performed as well as the CP when determining like from dislike, but the ability of the participants with AS to express affective prosody was significantly impaired when compared with the CP.

Expression of affective prosody was the one task where the PEPS-C scores for the AS group did not reach the 75% criterion level. While the CP reached the criterion level, their mean score (although not as low as the AS group) was considerably lower than the mean score for the Scottish adults in the study by Peppe et al (2007). The children with HFA in the Peppe et al study had particular difficulties using affective prosody as well as understanding affective prosody. They judged like as dislike and vice-versa and had more ambiguous ratings than the TD children, with their "expression of affect" being described as "fairly inscrutable" (p.1022). This conclusion was also confirmed in the PEPS-C results of a single case study of a seven year old boy with HFA (Peppe et al, 2006) whose use of affective prosody scored more than three SD below the mean of the TD children. Alternatively, recent use of the PEPS-C (Peppe et al, 2011) revealed that children with AS did not have difficulties expressing prosodic affect.

In the current study more than twice as many individuals with AS scored below the criterion level than the CP. Differences in the type of errors made by each group were identified. While the CP had evenly distributed errors of expressing like for dislike, dislike for like and ambiguous responses, the AS group displayed mainly ambiguous responses. 15.5% of the participants with AS used almost all ambiguous responses, compared with none of the CP.

Difficulties with expressive affective prosody may be more apparent than inappropriate use of grammatical prosody within every day functioning, as affective prosody can be subtle and nuanced and may not be "supported by the more explicit levels of language (e.g. lexis, syntax, segments)" (McCann et al, 2007, p.686).

These factors may also contribute to the generally held impression that expression of affect is a dominant prosodic feature of AS. The particular difficulties of the individuals with AS to produce appropriate affective prosody indicate that it is likely that other people would not be able to tell how they are feeling from their prosody alone. Therefore, the affective state of individuals with AS should not be assumed solely by the tone of their voice. Additionally, as individuals on the autism spectrum may also lack facial expression, or alternatively, have exaggerated facial expressions, difficulties ascertaining their emotions may be exacerbated. Sidtis and Van Lancker-Sidtis (2003) state that deficits in the production of affective prosody are apparent in motor speech disorders, hence evidence of impaired speech motor processing difficulties in the affective prosody of the participants with AS may be implied, particularly as they were able to understand affective prosody.

No statistically significant differences were found between the participants with AS and the CP for understanding of affective prosody and this concurs with results of a number of projects involving children with autism and HFA (Boucher et al, 2000; Grossman et al, 2010; Magnee et al, 2007; Paul et al, 2000 cited by McCann & Peppe, 2003).

Alternatively, a number of studies using the PEPS-C (Jarvinen-Pasley et al, 2008; McCann et al, 2005; Peppe et al, 2006; Peppe et al, 2007) have found significant differences in understanding of affective prosody between groups of control children and children with HFA, or combined groups of individuals with HFA/AS. Rutherford et al (2002) and Golan et al (2007) also found that participants with HFA and AS did not understand emotive words as well as control groups, although all but four of fifty participants with HFA/AS in the Golan et al study achieved above chance scores.

Lindner and Rosen (2006) concluded that the 5 to 16 year olds with AS in their study may have been relying on verbal cues as a compensatory strategy to understand emotion. The children with AS performed as well as TD children when identifying emotion in verbal content and in combined modalities, but performed more poorly than the TD children when determining emotion from static and dynamic facial expressions and from prosody only tasks. McCann and Peppe (2003) suggest that if affect is assessed through facial expressions, gesture, voice and face recognition, stimuli may not be controlled linguistically. Grossman et al (2010) also determined that children with HFA and TD children understood affective prosody better when verbal content was included than when verbal content had been filtered to maintain prosody only. The PEPS-C allows those being tested to concentrate on verbal aspects and does not rely upon participants identifying facial expressions or mixing modalities, e.g. identifying emotions by pointing to pictures of facial expressions. When comparing the results of their study with the results of participants in the Peppe et al by (2007) study, Grossman et al (2010) concluded that the reason their subjects didn't have difficulties understanding affective prosody was because longer sentences were used to assess affect, (contrasting with single words in the PEPS-C) and their subjects were approximately 3 years older and didn't have language impairments like the participants in the Peppe et al study. However, the participants with AS in the current study did not have difficulties understanding affect from single words hence suggesting that the shorter length of the stimuli presented did not contribute to the differences found, but they were considerably older than participants in most other studies, so possibly age, language ability and level of prosodic development may be more predictive of affective ability.

Although significant differences were not found between the participants with AS and the CP in the current research, comparisons of their means for understanding affective prosody with those of the Scottish adults assessed with the PEPS-C (Peppe et al, 2007) indicate that the responses of both the Australian groups were poorer than the Scottish adults. Perhaps the disparity between the Scottish and Australian participants may have resulted from differences in cultural language with the recorded stimuli also playing a role.

6.4 ENGLISH RHYTHM

The assessment of the understanding and use of English rhythm also did not confirm research question two (Is prosody impaired across both receptive and expressive prosody areas in individuals with AS?) as the participants with AS did not have difficulties understanding English rhythm preferences. Hypothesis six was confirmed as the participants with AS were not able to produce speech rhythm productions as well as the CP.

No significant differences were found between the participants with AS and the CP when required to make linguistic judgments regarding the understanding of English rhythm. The results for the AS group were also similar to those of over two hundred adult native speakers of English who have taken the test used in the current study, thus indicating that the participants with AS followed the typical English rhythm preferences of alternating stressed and unstressed syllable patterns.

Alternatively, when compared with the CP, significant differences were found in the ability of the AS group to apply appropriate English rhythm, confirming hypothesis six that participants with AS would not be able to produce speech rhythm as well as CP. As testing to assess production of the Rhythm Rule in English contained contrastive stress stimuli that blocked the application of the RR by a speaker, and as results from this study confirmed previous research showing impaired use of contrastive stress in ASD, examination of the application of the RR was conducted with contrastive stress stimuli removed. Even after these stimuli were removed, statistically significant differences indicated that the AS group was not as able to apply the Rhythm Rule as well as the CP and that placement of contrastive stress is a definite problem in AS. A number of the individuals with AS expressed all Rhythm Rule stimuli with the same flat intonation, therefore perhaps explaining the correlation found between errors made on Rhythm Rule tasks and the sum of monotone scores rated by the three experienced speech pathologists.

Baltaxe (1981) states that the maintenance of regular rhythm in English assumes central nervous system control with rhythmic patterning being central to speech programming. English is a stress-timed language and speech rhythm is particularly motivated and underpinned by speech timing therefore, as the participants with AS were not able to adjust their speech to accommodate the Rhythm Rule, speech motor processing difficulties may again be implied.

6.5 ACOUSTIC CHARACTERISTICS

Research question three queried whether the acoustic characteristics of individuals with AS differ from other individuals in the population. Diehl et al (2009) suggested that when assessing prosody it would be useful to utilize spontaneous speech samples to provide ecological validity and standardized speech samples which are "more reliably similar in content across participants" (p.399). Therefore, acoustic analysis of spontaneous speech samples and samples of reading tasks (standardized speech samples) was conducted. No differences were found between the groups for spontaneous speech tasks, but results of the analysis of reading speech which included pitch characteristics, intensity and duration of utterances did reveal some statistically significant differences between the participants with AS and the CP.

The AS group took longer to produce specific utterances (longer duration) and used a higher mean minimum pitch in the reading tasks. Timing, pitch and intensity difficulties are often associated with speech motor disorders (Love & Webb, 1992), adding further evidence of possible impaired speech production in the prosody of individuals with AS.

Other studies have found that subjective rating is more reliable in identifying affective content than acoustic analysis (Hubbard and Trauner, 2007). Although few statistically significant differences were found in the acoustic analysis in the present study, perceptual analysis indicated that the three adjudicators perceived the AS group to be more monotone than the CP and to display more rate, dysfluency and intensity difficulties. Hubbard and Trauner (2007) suggest that the impression of unusual prosody in ASD may be accounted for by the use of longer durations, misplaced pitch peaks and flatter amplitude (loudness). In the current research regression analysis identified pitch range as the most significant factor in the perception of monotone.

6.5.1 DURATION

Results of the current acoustic analysis confirmed hypothesis five that durational differences would be found between the participants with AS and the CP, as the participants with AS took a statistically significant longer time to produce specific Rhythm Rule stimuli. Examination of the duration of utterances has provided the most consistent acoustic information regarding people with autism spectrum disorders with longer durations and variability of durations being found in individuals with autism, HFA and AS (Bagshaw, 1978; Baltaxe, 1981; Fosnot and Jun, 1999; Velleman et al, 2010). Longer durations have also been verified in individuals with HFA and AS by Shriberg et al (2001) and Grossman et al (2010) who confirmed these difficulties through acoustic and perceptual analyses which indicated exaggerated pauses between syllables and slow, laboured speech.

Shriberg et al (2001) suggested that social demands and difficulties with speech motor control influenced the longer durations of the participants in their study, which were often related to dysfluency. Increased fluency and rate difficulties in the participants with AS were also noted by the three experienced speech pathologists who conducted the perceptual analysis component of the current study, offering additional support for the fact that impaired speech production is present in the prosody of individuals with AS. The longer durations of the AS group also implicate motor problems and provide evidence that it is not only output phonological difficulties that are apparent in the prosody of individuals with AS.

6.5.2 PITCH

Varied results have been found in previous research involving examination of pitch, and this was also the case in the current study. The only statistically significant pitch difference between the participants with AS and the CP was mean minimum pitch, which was 10Hz higher for the participants with AS (60Hz compared with 50Hz for the CP) in the Rhythm rule reading tasks (that provided a standard format for analysis across subjects). Higher pitch levels in individuals with autism and HFA have also been recorded by other researchers, (Adam, 1993; Fosnot & Jun, 1999; Schoen et al, 2010; Shriberg et al, 2011). Schoen et al suggest that "failure to move pitch into the more typical speech register may reflect excessive tension in the vocal folds, which could be related to poor motor control, or may be another example of a failure to tune in to the characteristics of speech produced by others" (p.200). As the participants with AS were able to tune into speech characteristics in receptive prosodic tasks, perhaps motor control may have played a role in the statistically significant higher minimum pitch used by the AS group while reading, although, comparisons of the mean minimum pitch used by both groups in spontaneous speech only differed by 0.5Hz.

The participants with AS used a 4.5Hz narrower mean pitch range in the Rhythm Rule tasks than the CP, while the mean pitch range in spontaneous speech was 13.1Hz narrower for the AS group. These results were not statistically significant, therefore hypothesis four was not confirmed. Baltaxe (1981) and Unger (2006) also found that children with autism and teenagers with AS (respectively) used a narrower pitch range, but their results were also not statistically significant. Alternatively, despite hypothesizing that children with autism and AS would use a narrower pitch range, Hubbard and Trauner (2007), found that the children with autism in fact used a wider pitch range. A significantly wider pitch range has also been found in children with HFA (Diehl et al, 2009). When examining the individual results of the current acoustic analysis, although many of the individuals with AS did use a narrower pitch range, others also used a wider pitch range, and this was also consistent with the pitch range results for the CP.

Couper-Kuhlen (1986) states that below 1000Hz, pitch changes can be perceived when the fundamental frequency varies by as little as 2 to 3 Hz. When exploring the differences in the intonation contours of children with autism, TD and aphasia, Baltaxe et al (1984) chose 5 Hz as a minimum difference. While the differences in pitch measures between the participants with AS and the CP were not all statistically significant, the majority of mean pitch measures between both groups in the Rhythm Rule and spontaneous speech tasks varied by more than 6 Hz. Adams (1993) suggests that listeners may be attuned to subtle acoustic differences which may not be captured by acoustic measurements, so perhaps these subtle differences are able to be perceived. Perceptual analysis identified 34% of the participants with AS in this study as monotone, with correlations being found between perception of monotone and mean pitch range, thereby suggesting that the subtle differences discerned above may in fact have provided perceptual evidence of pitch differences between the AS group and the CP. Children and adolescents with HFA who displayed higher levels of pitch variations in Diehl et al’s (2009) project were judged perceptually as having greater levels of communication impairment. Peppe (2009) states that in general the greater the span of pitch, the greater the emotional involvement, therefore, perhaps a narrower pitch range, higher minimum and lower maximum pitch in the speech of the participants with AS may have been a factor in their poorer ability to express affective prosody.

6.5.3 INTENSITY

No statistically significant differences were found between the participants with AS and the CP for use of intensity in the Rhythm Rule stimuli or in spontaneous speech, although it was noted that some individuals with AS spoke very loudly while others had very soft voices. These results concur with those of Grossman et al (2010) and Adams (1993) who assessed adolescents with HFA and children with HFA, respectively. Although Hubbard and Trauner's (2007) results for individuals with autism were comparable with TD participants, they found that individuals with AS used intensity unreliably, particularly when encoding emotion.

Although differences in intensity between the two groups were not found to be statistically significant, correlations between perception of monotone and intensity measures were significant. Thus again indicating that acoustic analysis may not pick up subtle acoustic changes that may be perceived by the human ear. However, these results should be considered with caution as the data collection protocol did not include the careful standardization of the microphone to mouth distance across subjects.

6.6 SPEECH DISORDERS

Shriberg et al (cited in Shriberg et al, 2011) defined persistent speech disorders (PSD), as speech disorders that persist past 9 years of age and stated that they have an estimated prevalence rate of 2.4 to 3.9% of the population (p.408). In this study the residual articulatory substitution rate of 4% for the CP was quite consistent with the estimated prevalence rate. On the other hand, like the 15 individuals with HFA and 15 with AS in Shriberg et al's (2001) study, 33.3% of whom displayed articulation distortions, 22.4% of the AS group in the current research displayed PSD (5 to 6 times the rate of occurrence to be expected in the general population). (Further information about Shriberg's classification system is provided on p.56).

Cleland et al (2010) concluded that the cause of the delayed articulation of the children with HFA and AS in their study could be an underlying neuro-motor difficulty and this seems a likely cause of the PSD in the current participants with AS, who are all well past the age of typical articulation development.

Many authors have described individuals on the autism spectrum as dysarthric or more commonly as dyspraxic (Anzalone & Williamson, 2000; Dziuk et al, 2007; Rogers & Bennetto, 2000; Wetherby et al, 2000), while Velleman et al (2010) suggest that it is more common for apraxia and dysarthria to co-occur in ASD. Page and Boucher (1998) propose that as oral and manual dyspraxia tends to be reduced in older children with ASD, it may reflect a maturational delay which may resolve over time. All of the participants with AS in this study were over 15 years of age and many were adults although evidence of speech motor difficulties was still apparent in their use of prosody and articulation. Assessment of developmental speech motor disorders has proven to be difficult as criteria for acquired adult disorders are used although they are not necessarily appropriate, particularly for children whose neurological development and neurological plasticity are still developing (Velleman et al, 2010). Regardless of the term or terms used, motor planning and motor production difficulties have been identified in the current research and in previous research and should be considered when working with individuals AS and autism.

6.7 NEUROLOGICAL IMPLICATIONS

Given the motor difficulties associated with the autism spectrum in general, combined with the evidence of impaired prosodic and segmental speech production identified in the individuals with AS in this study, what neurological impairments are likely contributors to these problems?

Neurological difficulties have been confirmed in ASD including a higher incidence of epilepsy and ‘soft’ neurological signs, for example clumsiness and unusual gait (Rinehart et al, 2006) and it is the cerebellum which provides the most consistent evidence of neuroanatomical abnormality in ASD (Akshoomoff, 2000; Allen, 2006; Bauman & Kemper, 2005; Dziuk et al, 2007; Lathe, 2006). Using Magnetic Resonance Imaging Ritvo et al (1986) and Courchesne, Yeung-Courchesne, Press, Hesseling and Jernigan (1988) found evidence of hypoplasia (reduced size) of the posterior vermis of the cerebellum (particularly vermal nodules VI and VII) in individuals with autism. A reduction in the number and size of Purkinje cells in the cerebellar vermis has also been reported by other researchers (Courchesne et al, 1994a; Hashimoto et al, 1995) and has been confirmed in recent postmortem studies (Courchesne & Pierce, 2005).

Clinical signs of cerebellar dysfunction can be seen in ASD including unusual gait, low muscle tone (hypotonia), dysfluency, motor speech disorders and impaired prosody (Allen, 2006; Hodge et al, 2010; Rinehart et al, 2006). The speech motor processing difficulties observed in the participants with AS in the current research also suggest involvement of the cerebellum. Significant findings for the participants with AS in the current research identified imitation difficulties, problems using prosody, particularly affective prosody, timing problems, difficulties applying English rhythm, differences in use of pitch, residual articulation substitutions and inappropriate use of stress. Ataxic dysarthria (a specifically cerebellar motor speech disorder) includes timing problems, inappropriate use of stress, and unusual loudness and pitch (Love & Webb, 1992), while deficits in production of prosody (particularly affective prosody) also accompany the motor speech disorders (Sidtis & Van lancker Sidtis, 2003). As the prosodic difficulties in individuals with AS are reasonably subtle, one may conclude that if the difficulties in the cerebellum were more pronounced, the condition may lead to more severe prosodic and/or communication impairment, including a possible absence of speech as is often observed in autism.

6.7.1 THE ROLE OF THE CEREBELLUM

The role of the cerebellum in planning and coordinating the smooth execution of motor acts, including speech, has long been recognized (Murdoch, 2010a). Allen (2006) suggests that motor functions in ASD represent cerebellar dysfunction rather than any other central nervous system disorder, while Dziuk et al (2007) state that the decreased Purkinje cell count in the cerebellum of individuals with ASD “prompts speculation that abnormalities in the cerebellum and/or connections between the cerebellum and frontal/parietal regions may contribute to impaired development of motor skills” (p.737).

Advanced neuroimaging techniques and neurophysiological and neuropsychological experimentation (Beaton & Marien, 2010; Murdoch, 2010a; Timmann et al, 2010) have confirmed an expanded role for the cerebellum. The most current indications are that the cerebellum is implicated in the regulation of timing (Beaton & Marien) and linguistic, cognitive and affective functions (Murdoch; Timmann et al).

The cerebellum is “one of the most widely connected brain structures, receiving projections from and/or sending projections to all major divisions of the central nervous system” (Allen, 2006 p.2011) and it plays a role in coordinating all of the systems interconnected with it (Courchesne et al, 1994a). Cerebellar afferent and efferent connections with areas of the cerebrum, act as critical modulators of neuronal function by reinforcing or diminishing sensory and motor impulses (Love and Webb, 1992). A lack of inhibition caused by faulty connections could explain the lack of deactivation of cortical areas by adults with HFA in the study by Hesling et al (2010). It could also explain why many of the individuals with ASD in neurological studies of prosody in ASD have performed above chance, and have used the same neural areas as control participants, but have at times shown increased activity in neural areas while at other times some areas have lacked activation.

Damage to the cerebellum can also lead to reduced metabolic activity (called diaschisis) and hence to reduced or lost function in contralateral (Beaton & Marien, 2010; Murdoch, 2010b) and ipsilateral cerebral hemispheres (Murdoch, 2010a).

Diaschisis and evidence of bilateral cerebellar influences in the regulation of language (Murdoch, 2010b) may be related to high level or complex language processing difficulties (Murdoch, 2010a), problems which are common in HFA and AS. Reduced metabolic activity has been detected in individuals with ASD, therefore perhaps diaschisis could also play a role in the reduced cerebral activity or lack of inhibition detected in some individuals with ASD.

Akshoomoff (2000) suggests that "the degree of abnormality within a certain structure [of the cerebellum] is correlated with certain aspects of language processing, which in turn is related to the overall IQ score" (p.170). Akshoomoff adds that individuals with autism who have the most deviant vermis measures tend to have the lowest IQ scores, while those with more typical vermis measures tend to have higher IQ scores. This could also pertain to prosody in ASD. Given that individuals with AS are generally considered to be higher functioning than many individuals with autism and to have better language abilities, one may expect less prosodic difficulties in AS than in autism. This was often the case when comparing the results of the participants with AS in the current study with individuals with autism and HFA in previous research. Therefore, it is postulated that cerebellar involvement may, to a more or less degree, affect severity of symptoms in ASD, including prosody.

6.7.1.1 The cerebellum and rhythm/timing

The cerebellum plays an important role in rhythm and timing (Petersen, 2002; Sidtis & Van lancker Sidtis, 2003) and prominent cerebellar activation in individuals who stutter has been detected by Kent (2000), who suggested associations between stuttering and Tourette syndrome. Tourette syndrome (Bernet & Dulcan, 1999) and dysfluency (Shriberg et al, 2001) are present in a number of individuals with AS, with a high incidence of stuttering being noted in the AS group (18.6%) in the current study. Statistically significant differences between the participants with AS and the CP also indicated that the AS group displayed disturbances of expressive rhythm when applying the Rhythm Rule to specific texts, and used longer durations to produce the specified utterances.

6.7.1.2 The cerebellum and emotion

As regions in the cerebellum and the frontal lobe were activated during a task requiring identification of emotions from spoken words, Imaizumi et al (1997) suggested a functional relationship between these two regions involved in emotion. Riva and Giorgi (2000) concluded that "vermal lesions were associated with major affective alterations, whereas those involving the cerebellar hemispheres (particularly the posterior lobes) were crucial for the generation of altered cognitive behaviours" (p.1058). As the vermis has been determined as the area of the cerebellum most affected in ASD, the significantly reduced ability of the AS group to express affective prosody in the current research could possibly be reflective of anomalies in the cerebellar vermis.

Furthermore, Akshoomoff (2000) states that the regions of the cerebellum which are activated during shifting attention tasks are different from those activated during motor tasks. Courchesne et al (1994) found that participants with autism displayed similar impairments to participants with acquired cerebellar lesions on tasks requiring rapid and accurate shifting of attention between auditory and visual stimuli.

As individuals with ASD have performed better when discerning affect or emotion from prosody alone, than when having to match vocally expressed emotions with facial expressions or pictures of faces expressing emotions (Boucher et al, 2000), there is suggestion that cross-modal difficulties may have been involved. The fact that understanding of affective prosody in the PEPS-C which was used in this study does not require cross-modal processing may be an indication as to why the adolescent and adult participants with AS were able to understand affective prosody as well as the CP.

6.7.1.3 Mutism of Cerebellar Origin

Studies of children with cerebellar anomalies and/or post cerebellar surgery have provided evidence in support of impaired cerebellar activity in ASD as most of the resulting post surgical impairments are also apparent in individuals with ASD.

Surgery necessitated by cerebellar lesions involving the vermis, both cerebellar hemispheres and deep nuclei of the cerebellum, (areas known to be problematic in ASD, Courchesne et al, 1994a) with no loss of higher cognitive functions, no motor paralysis and no cranial nerve dysfunction have been reported to lead to a total absence of speech (Daniels, Moores & DiFazio, 2005; Rekate, Grubb, Aram, Hahn, & Ratcheson, 1985). The phenomenon of mutism, which usually develops within a few days of posterior fossa surgery, is more common in children (Ildan et al, 2002) and most cases resolve within six months. During the recovery phase, all children present with dysarthria, while some may also present with dyspraxia (Beaton & Marien, 2010). Some children are left with residual cerebellar dysarthria (Ildan et al, 2002; Rekate et al, 1985), impaired prosody and/or decreased rapidity of speech

(Daniels et al, 2005). Residual ataxia (Frim & Ogilvy, 1995) or impaired ability to initiate and complete motor activities appropriate to their age (Pollack, Polinko, Albright, Towbin & Fitz, 1995) has also been reported and one child is reported to have met the criteria for autism after cerebellar surgery involving the lower vermis (Riva & Giorgi, 2000).

Like individuals with ASD, not all children who had posterior fossa surgery became mute, and/or displayed cognitive or behavioural changes and the degree of impairment in those who did present with mutism was varied.

6.7.2 THE CEREBELLUM AND ASD

The above descriptions of posterior fossa mutism and its subsequent impairments are reminiscent of the difficulties found across the autism spectrum. A vast number of individuals with autism are mute, while many others never achieve speech which is functional. Many of those who are able to speak have variously been described as dyspraxic and/or dysarthric, while the majority has impaired prosody. Ataxia and impaired imitation and motor abilities are also prominent in autism as well as AS. Therefore, like the range of post-operative differences in children who have undergone cerebellar surgery, the differences between the individuals with AS in this study and across the autism spectrum could perhaps be explained by deficits in the functioning of the cerebellum and its vast connections.

Therefore it is postulated that the area or areas of the cerebellum affected, as well as the degree of impairment in the cerebellum and of the connections with other neurological areas, may be reflected in the degree of impairment of the individual with an autism spectrum disorder. This could possibly also explain the communication deficits found across the autism spectrum, including mutism, language disorder, dysfluency, dysarthria, dypraxia and severe or mildly disordered prosody.

6.8 IMPLICATIONS

This research has shown that participants with AS have speech production difficulties which impact upon their prosodic abilities and that it is not only affective and pragmatic prosody that is problematic as the expression of linguistic prosody is also implicated. These results have significant implications for intervention.

Currently, the predominant theory used in social/communication intervention is ‘Theory of Mind’ (Baron-Cohen et al, 1985). Programs attempt to ameliorate the social/communication difficulties by working on emotions, affect and the perspectives of other people. As speech motor difficulties also play a part in the dysprosody of many individuals with AS, in addition to the social-emotional strategies currently being utilized, intervention for these people should also include the use of techniques to ameliorate the motor difficulties, e.g. allowing additional time, using visual cues and utilizing repetition and prosodic anomalies.

Receptive and expressive prosodic skills should be assessed for each person, to determine which area of prosody is affected. To facilitate intervention, it may be useful to use the PEPS-C to ascertain the specific prosodic difficulties experienced by each individual with AS. In the general population the term prosody is not well known, therefore, information about this aspect of communication should be taught to individuals with AS and HFA. Jarvinen-Pasley et al (2008) suggest that intervention should teach that successful interpretation of communication requires not only attention to linguistic content, but also to perceptual features which enhance the meaning of what is being said.

For those individuals with good receptive prosody, expressive skills could be improved by providing auditory feedback of their own utterances compared with an appropriate model. Visual feedback could also be used. Diehl et al (2009) discussed a program being developed for use with children with autism that acoustically analyses prosody and provides immediate feedback (Kim, Newland, Paul & Scassellati, 2008 cited in Diehl et al). PRAAT (Boersma, 2001), which provides a visual speech wave form, could also be utilized, e.g. wave forms could be compared (visually) to help determine correct pitch and to improve intensity and duration of utterances.

This research has implicated motor difficulties in the prosody of individuals with AS, who are considered to be higher functioning than many others on the spectrum. On a broader level, perhaps the indication of speech motor difficulties that have generally become more apparent in ASD over the last few decades may be considered and could enhance the quality of the communication intervention for individuals with autism as well as those with AS.

6.9 LIMITATIONS OF THE STUDY

When commencing this research, suggestions made by previous researchers were taken into account in an effort to try to eliminate limitations identified. Nevertheless, hindsight allows one to see other limitations, which in future could be alleviated.

Some limitations were identified with the testing utilized in the study. The Neale Analysis of Reading Ability – Second Edition, Revised (Neale, 1999) was chosen as it provides Australian norms. It allows reading comprehension, rate and accuracy of reading to be scored and although at the time of assessment, only reading comprehension was considered to be necessary for the study, information regarding reading rate would have provided opportunities for comparisons with the results for duration and fluency. The PEPS-C (Peppe et al, 2004) has not been standardized on an Australian population, but tests of prosody are scarce and it was considered to be the best available tool at the time of assessment. The PEPS-C authors state that this tool is suitable for use with adults and many of the participants with AS and CP achieved ceiling or near ceiling scores suggesting that it was generally a suitable tool for use in Australia. However, the near ceiling scores were also a limitation of the study. Subtests that extend adult speakers would provide possibilities for a wider range of skills to be assessed.

As sub-groups of individuals with AS were indicated in the study, formal assessment of language skills and intellectual functioning would have been advantageous as they would have facilitated investigations of the nature of the subgroups. None of the CP were identified with language difficulties and all of the participants with AS were considered not to have significantly delayed language skills as determined by the

DSMIV-TR (2000) criteria. Nevertheless, while current assessment tools for AS do not describe impaired language as a requirement, it is now accepted that the range of communicative abilities in AS is diverse and although not previously identified, participants may have had high level language impairments. Knowledge of the language abilities of the participants would also have facilitated comparison of within group and across group results. Additionally, although Paul et al (2005a) found that prosodic deficits do not appear to be related to IQ levels, the intellectual level of participants would have provided additional information for identifying subgroups. Hesling et al (2010) found that more prosodic problems were apparent when children with ASD were matched with chronological age-matched peers than when matched with mental-age matched peers, so matching of language and intellectual skills may have helped to identify if this was a problem for the participants with AS in this study. Alternatively, as the participants were adolescents and adults rather than children and groups were matched by age, the difference may not have been as pronounced.

As subgroups were identified in the AS group the study results cannot be extrapolated to include all people with AS. However results generally concur with previous studies of various groups within the spectrum and that there are difficulties with the expression of prosody in AS is not disputed.

6.10 FUTURE RESEARCH

This study is one of only a few that have researched prosody in AS specifically. To date it is the largest study and unlike most other research it included receptive and expressive prosody as well as acoustic analysis. As reduced ability to produce appropriate prosody was found in the participants with AS in comparison with the CP, further examination including receptive and expressive prosody is supported.

Acoustic analysis of prosody in AS is also particularly scarce and requires more research. As some studies have shown that subjective rating may be more reliable than acoustic analysis, particularly when identifying affective content, (Hubbard and Trauner, 2007) further research analyzing both acoustic and perceptual features of prosody and comparing the two would be beneficial.

The evidence of compromised speech motor skills in the AS group warrants further study of speech production abilities in AS.

CHAPTER 7 CONCLUSION

Motor speech difficulties in ASD are apparent from both my clinical experience and from research (Dawson, 1998; Gillberg & Billsteadt, 2000; Green et al, 2002; Jones & Prior, 1985; Manjiviona and Prior, 1995; Miyahara et al, 1997; Rinehart et al, 2001; Tani et al, 2006; Ungerer, 1989; Velleman et al, 2010). This research was thus undertaken to determine whether speech motor implications could, in part, be attributed to the prosody of participants with AS. Results revealed the presence of a number of speech production difficulties in the prosody of the participants with AS. These included poor imitation abilities when copying prosodic forms, acoustic characteristics involving longer durations and higher minimum pitch than the CP, poor expressive prosody involving difficulties with pragmatic, affective and grammatical prosody despite few difficulties understanding prosody, difficulties applying typical English rhythm, although displaying appropriate awareness of rhythm, and increased dysfluency. The residual articulation substitutions noted in the participants with AS were also five to six times higher than the rate expected in the general population.

As information regarding prosody in ASD and AS in particular is still very limited, it was considered essential to gain increased knowledge of this area. In their review of prosody in ASD, McCann and Peppe (2003) expressed concern that previous research had involved small sample sizes of mixed groups of individuals from across the autism spectrum, had only involved either receptive prosody or expressive prosody and rarely utilized acoustic analysis. Therefore, this research was designed to ameliorate these difficulties.

Groups within the spectrum, e.g. autism, HFA and AS are quite heterogeneous and indeed individuals within the groups may have diverse presentations, but they have been combined in most studies, making it difficult to determine the specific prosodic characteristics of each group. Therefore, this project involved only participants with AS, who were chosen specifically to try to avoid the problems of intellectual disability and language disorder which are more likely to accompany autism/HFA. Prosody research involving individuals with AS specifically is very limited, with only two studies examining understanding of prosody, two examining expression of prosody and two examining the acoustic characteristics of prosody. As 58 individuals with AS took part in the current research, it is, to date, the largest study of the use and understanding of prosody in ASD undertaken internationally, therefore providing extensive information in this area. The results of the prosodic assessments of the participants with AS were compared with results of a large group of control participants (n=50), who had not been diagnosed with autism, AS or language difficulties and who were matched as closely as possible to the participants with AS by age, educational status, gender and social demographics.

Receptive as well as expressive prosody including prosodic form, English rhythm and grammatical, affective and pragmatic prosodic functions were assessed to determine whether both understanding and use of prosody are impaired in AS. Results showed that it was predominantly expression of prosody which was difficult for the participants with AS, as apart from understanding of contrastive stress (pragmatic prosody), other areas of prosody were understood. Although it was hypothesized that the participants with AS would have more difficulties with affective and pragmatic prosody than grammatical prosody, their use of grammatical prosody (particularly appropriate use of question and statement forms) also proved to be problematic, as has been found in some other recent research. The consistent difficulties with understanding contrastive stress (pragmatic prosody) which have been found in many studies of prosody in ASD were also confirmed in the participants with AS in this study, while difficulties expressing contrastive stress were confirmed in one test, but not in the PEPS-C subtest. Not unexpectedly, the use of affective prosody also proved to be more difficult for the participants with AS than the CP. Timing issues were also revealed, as the participants with AS were not able to manage speech rhythm as well as the CP. The participants with AS displayed significantly more errors when applying the Rhythm Rule than the CP, although the type of errors of rhythm used by both groups were similar. Moreover, the participants with AS were unable to copy words and phrases with varying prosody despite being able to understand these forms, thereby corroborating previous evidence of imitation difficulties in ASD and particularly AS.

Acoustic as well as perceptual analysis of expressive prosody was also conducted to ascertain whether there were differences between the participants with AS and other individuals in the population. Although research involving acoustic analysis has increased, there are still only a handful of papers involving acoustic analysis of data from participants with ASD, with all but one of these including less than 12 individuals. By including a large number of research participants, this research has added considerably to the information regarding the acoustic characteristics of prosody in ASD and AS particularly. Results revealed statistically significant durational differences between the two research groups, with the participants with AS taking significantly longer to read specific stimuli than the CP. Thus previous research indicating durational difficulties in ASD was also confirmed. Pitch differences were also found with a statistically significant higher minimum pitch range being used by the participants with AS when reading, although this was not found in their spontaneous speech. Additionally, while they tended to use the hypothesized narrower pitch range than the CP, the results were not significant statistically and some of the individuals in the AS group in fact used a wider pitch range, (as did some of the CP). Again, these varying pitch results concur with previous studies, which have also revealed pitch differences which did not meet statistical significance.

Many of the participants with AS in this research displayed speech motor difficulties which are characteristic of motor speech disorders. These disorders are commonly related to anomalies in the cerebellum, e.g. inappropriate use of stress and unusual pitch (Love & Webb, 1992) and the cerebellum also plays an important role in rhythm and timing (Petersen, 2002; Sidtis & Van lancker Sidtis, 2003). Prosody difficulties can also be a residual problem in children who have undergone cerebellar surgery and many of the problems experienced by these children during recovery are similar to those experienced by individuals on the autism spectrum. The cerebellum also provides the most consistent evidence of neuroanatomical abnormality in ASD (Akshoomoff, 2000; Allen, 2006; Bauman & Kemper, 2005; Dziuk et al, 2007; Lathe, 2006). Many of the communication deficits found across the autism spectrum, including mutism, language disorder, dysfluency, dysarthria, dypraxia and severe or mildly disordered prosody could also be explained by cerebellar anomalies. Therefore, it is postulated that the degree of impairment of individuals with ASD may be a reflection of the degree of impairment in the cerebellum, the area or areas of the cerebellum affected and the degree to which other neurological areas connected with the cerebellum are also affected.

The speech motor difficulties found in the participants with AS in this study are a likely concomitant cause of the prosodic problems in this population. As 'Theory of Mind' (ToM) difficulties mainly affect pragmatic and affective prosody areas they are not likely to impact upon grammatical prosody. Therefore, in addition to the social-emotional strategies currently being utilized, intervention for people with AS should also include strategies to treat speech motor problems and disordered prosody, including expressive grammatical prosody as well as pragmatic and affective prosody.

APPENDICES

APPENDIX A LETTERS OF ETHICS APPROVAL

Approval from Flinders University Ethics Committee

Approval from Autism SA Ethics Committee

Approval from Flinders University Ethics Committee to modify the project

Approval from Flinders University Ethics Committee

FLINDERS UNIVERSITY
ADELAIDE • AUSTRALIA

Social and Behavioural Research Ethics Committee
Office of Research

GPO Box 2100
Adelaide 5001 Australia

Telephone: (+61 8) 8201 5962
Facsimile: (+61 8) 8201 2035
Email: sandy.huxtable@flinders.edu.au

SBRE3152

21 January 2005

Ms Kate King
122 Sheoak Rd
CRAFERS SA 5152

Dear Ms King

Project 3152 Expression and understanding of prosody in individuals with Asperger Syndrome

Further to my letter dated 15 December 2004, I am pleased to inform you that approval of the above project has· been confirmed following receipt of the additional information you submitted on 17 January 2005.

Approval is valid for the period of time requested and is given on the basis of information provided in the application, its attachments and the information subsequently provided. In accordance with the undertaking you provided in the application, please inform the Social and Behavioural Research Ethics Committee, giving reasons, if the research project is discontinued before the expected date of completion and report anything which might warrant review of ethical approval of the protocol. Such matters include

- serious or unexpected adverse effects on participants;
- proposed changes in the protocol; and
- unforeseen events that might affect continued ethical acceptability of the project.

May I draw to your attention that, In order to comply with monitoring requirements of the *National Statement on Ethical Conduct in Research Involving Humans* an annual and/or final report must be submitted in due course. If a report is not received beforehand, a reminder notice will be issued in twelve months' time. A copy of the report pro·forma is available from the SBREC website htto://wwW.flinders.edu.au/research/office/ethicsfindex.htm\.

Yours sincerely

Sandy Huxtable
Secretary
SOCIAL AND BEHAVIOURAL RESEARCH ETHICS COMMITTEE

c.c. A/Prof Paul McCormack, Medicine (Speech)

NB: If you are a scholarship holder and you receive funding for your research through the National Health & Medical Research Council please forward a copy of this letter to the Head, Higher Degree Administration and Scholarships Office, for forwarding to the NHMRC.

(esr\!etter\3152 finapp)

Location: Sturt Road, Bedford Park, South Australia.

Approval from Autism SA Ethics Committee

IO=HADALTMAILIOU=FIRST ADMINISTRATIVE GROUP/CN=RECIPIENTS/CN=SPP044

From	King, Kate (FMC)
Sent	Thursday, 9 December 2004 12:10
To	Jon Martin
Subject	RE: congrats

Hi Jon

I am pleased to be involved in the conference.

Thanks for your prompt response to the ethics proposal. I will look at the issue around the $50.00. I should hear from the Uni Ethics C'tee by next week, and if that is OK, I would like to send the letters out in late Jan or early Feb if that suits you!

Regards, Kate

-----Original Message-----
From: Jon Martin [mailto:jmartin@autismsa.org .au]
Sent: Wednesday, 8 December 2004 10:21
To: King, Kate (FMC)
Subject: RE: congrats

Thanks for your response to present at the conference. Jacqui Roberts has been confirmed as keynote speaker.

Your research proposal was endorsed by Policy and Ethics last night. There was one comment re the consent form that specifies that the participant ".. may not directly benefit from taking part in this research". However, it was noted that they receive $50 and this should probably be clarified somewhere.

When do you want to do the mail out?

Jon Martin
Chief Executive Officer
Autism SA
3 Fisher Street
Myrtle Bank SA 5064
Ph: (08) 8319 6976 Fax: (08) 8338 1216
E:jmartin@autismsa.org.au W: www.autismsa.org.au

Leading the way through knowledge, understanding and acceptance

Approval from Flinders University Ethics Committee to modify the project

FLINDERS UNIVERSITY
ADELAIDE • AUSTRALIA

Social and Behavioural Research Ethics Committee
Office of Research

GP08ox2100
Adelaide 5001 Australia
Telephone: {+61 8) 8201 5962
Facsimile: (+61 8) 8201 2035
Email: sandy.huxtable@flinders.edu.au

SBRE
3152

21 October 2005

Ms Kate King
122 Sheoak Road
CRAFERS, SA 5152

Dear Ms King

Project 3152 Expression and understanding of prosody in individuals with Asperger syndrome

I refer to your application for a modification of the above project which had been approved previously.

I am pleased to inform you that the Chairperson has approved your request to increase the number of research subjects and to make contact with high school principals and TAFE principals to gain access to their students.

Yours
sincerely

Sandy Huxtable
Secretary
SOCIAL AND BEHAVIOURAL RESEARCH ETHICS COMMITTEE

cc: A/Prof Paul McCormack, Speech Pathology
Dr Robyn Young, Psychology

(3152 modapp)

Location: Sturt Road, Bedford Park, South Australia

APPENDIX B INFORMATION FOR PARTICIPANTS

Letter to participants with Asperger syndrome (AS)

Consent form for participants with AS

Letter to control participants (CP)

Consent form for CP

Letter to participants with AS

FLINDERS UNIVERSITY
ADELAJD[,; • AUSTRALIA

Department of Speech Pathology
School of Medicine

GPO Box2100
Adelaide 5001 Australia

Telephone: (+61 8) 8204 5936
Fax: (+61 8) 8204 5935
Email: paul.mcconnack@flinders.edu.au

LETTER OF INTRODUCTION

Dear Sir/Madam

I hold the position of Associate Professor in the Speech Pathology Department, of the School of Medicine at Flinders University.

This letter is to introduce Kate King who is a post-graduate student in the Speech Pathology Department, of the School of Medicine at Flinders University. She will produce her student card, which carries a photograph, as proof of identity. Some of you will know Kate from her years of working at Autism SA. I am Kate's research supervisor for her project.

She is undertaking research leading to the production of a thesis and other publications on the subject of 'Expression and understanding of prosody in Asperger syndrome'. That is, she will be studying how people with Asperger syndrome use and understand pitch, timing and stress in speech and if it differs from a control group of subjects.

Kate is seeking people with Asperger syndrome who are in the 15 to 45 years age range to participate in the study. All people who meet these criteria and who want to take part in the project will be included.

If you have a diagnosis of Asperger syndrome and are aged 15 to 45 years of age, Kate would be most grateful if you would volunteer to spare the time to assist in this project, by agreeing to –

- be recorded reading 30 sentences, which have been designed to reflect different speech rhythms
- be recorded using informal spontaneous speech
- read 18 sets of2 sentences per set and indicate with a tick, which sentence of the two sounds better
- use a computer program which will require you to listen to pairs of sounds and decide if they are the same or different
- be recorded using a computer program which will require you to listen to various sentences then say some of them
- undertake a reading test.

Approximately 2 and a half hours on one occasion would be required and a fee of $50.00 will be paid to all participants. The study can be conducted in your home or at a place convenient to you, which can be arranged with Kate.

Be assured that any information provided will be treated in the strictest confidence and none of the participants will be individually identifiable in the resulting thesis, report or other publications. Your are, of course, entirely free to discontinue your participation at any time or to decline to participate in particular sections of the study.

As Kate intends to make a tape recording of your responses, she will seek your consent, on the attached Consent Form, to record the interview and to use the recording or a transcription in preparing the thesis, report or other publications, on condition that your name or identity is not revealed. It may be necessary to make the recording available to another person to check the reliability of ratings, in which case you may be assured that your name or identity will not be revealed and that the person respects and maintains the confidentiality of the material.

Please note that parents of people under 18 years of age, will also have to sign the Consent Form.

If you are interested in participating in this project, or are interested in your child of less than 18 years participating in this project, please contact Kate King at the address given above or by telephone on 8204 5961, fax 8204 5935, mobile 0402 134 379 or e-mail Kate.King@ fmc.sa.gov.au.

Any enquiries you may have concerning the project may be directed to me at the above phone or fax numbers or the above postal or email addresses.

This research project has been approved by the Flinders University Social and Behavioural Research Ethics Committee. The Secretary of this Committee can be contacted on 8201 5962, fax 8201 2035, e-mail sandy.huxtable@flinders.edu.au.

Thank you for your attention and assistance.

Yours sincerely,

Dr Paul McCormack
Associate Professor·
Department of Speech Pathology
School of Medicine
Flinders University

KSJ;ksj
Version 1 - 615199

Consent form for participants with AS

FLINDERS UNIVERSITY ADELAIDE • AUSTRALIA
Social and Behavioural Research Ethics Committee

CONSENT FORM FOR PARTICIPATION IN RESEARCH

(by experiment)

I …...

hereby consent to participate, as requested in the Letter of Introduction, for the research project on ‘Expression and understanding of prosody in individuals with Asperger syndrome’.

1. I have read the information provided.
2. Details of procedures and any risks have been explained to my satisfaction.
3. I agree to my information and participation being recorded on tape.
4. I am aware that I should retain a copy of the Information Sheet and Consent Form for future reference.
5. I understand that:
    - Although I will receive a payment of $50.00 for taking part in the project, I may not otherwise benefit directly from this research.
    - I am free to withdraw from the project at any time and am free to decline to participate in particular sections of the study.
    - while the information gained in this study will be published as explained, I will not be identified, and individual information will remain confidential.

Participant’s signature ……………………………………Date …………………...

Parental consent is also required for participants under 18 years of age.

I …...

hereby consent to my child’s participation as requested in the Letter of Introduction for the research project on ‘The expression and understanding of prosody in individuals with Asperger syndrome’.

Parent’s signature ……………………………………Date …………………...

I certify that I have explained the study to the volunteer and parent and consider that she/he understands what is involved and freely consents to participation.

Researcher’s name …….KATE LYNETTE KING**……**

Researcher’s signature …………………………………..Date ……………………

Letter to control participants

FLINDERS UNIVERSITY
ADELA!DE • AUSTRALIA

Department of Speech Pathology
School of Medicine

GPOBox2100
Adelaide 5001 Australia

Telephone: (+61 8) 8204 5936
Fax: (+61 8) 8204 *5935*
Email: paul.mcconnack@flinders.edu.au

LETTER OF INTRODUCTION

Dear Sir/Madam

I hold the position of Associate Professor in the Speech Pathology Department, of the School of Medicine at Flinders University.

This letter is to introduce Kate King who is a post-graduate student in the Speech Pathology Department, of the School of Medicine at Flinders University. She will produce her student card, which carries a photograph, as proof of identity. I am Kate's research supervisor for her project.

She is undertaking research leading to the production of a thesis and other publications on the subject of 'Expression and understanding of prosody in Asperger syndrome'. That is, she will be studying how people with Asperger syndrome use and understand pitch, timing and stress in speech and if it differs from a control group of subjects.

Kate has collected data from the research subjects and is now seeking people without a language disorder and who have English as a first language, to participate as control subjects in the study.

Kate would be most grateful if you would volunteer to spare the time to assist in this project, by agreeing to –

- be recorded reading 30 sentences, which have been designed to reflect different speech rhythms
- be recorded using informal spontaneous speech
- read 18 sets of 2 sentences per set and indicate with a tick, which sentence of the two sounds better
- hic use a computer program which will require you to listen to pairs of sounds and decide if they are the same or different
- be recorded using a computer program which will require you to listen to various sentences then say some of them
- undertake a reading test.

Approximately 1¼ hours on one occasion would be required and a fee of $20.00 will be paid to all participants. The study can be conducted in your school, Flinders Medical Centre or at a place convenient to you, which can be arranged with Kate.

Be assured that any information provided will be treated in the strictest confidence and none of the participants will be individually identifiable in the resulting thesis, report or other publications. You are, of course, entirely free to discontinue your participation at any time or to decline to participate in particular sections of the study.

As Kate intends to make a tape recording of your responses, she will seek your consent, on the attached Consent Form, to record the interview and to use the recording or a transcription in preparing the thesis, report or other publications on condition that your name or identity is not revealed. It may be necessary to make the recording available to another person to check the reliability of ratings, in which case you may be assured that your name or identity will not be revealed and that the person respects and maintains the confidentiality of the material.

Please note that parents of people under 18 years of age, will also have to sign the Consent Form.

If you are interested in participating in this project, please contact Kate King at the address given above or by telephone on 8204 5961, fax 8204 5935, mobile 0402 134 379 or e-mail Kate.King@fmc.sa.gov.au.

Any enquiries you may have concerning the project may be directed to me at the above phone or fax numbers or the above postal or email addresses.

This research project has been approved by the Flinders University Social and Behavioural Research Ethics Committee. The Secretary of this Committee can be contacted on 8201 5962, fax 8201 2035, email sandy.huxtable@flinders.edu.au.

Thank you for your attention and assistance.

Yours sincerely,

Dr Paul McCormack
Associate Professor
Department of Speech Pathology
School of Medicine
Flinders University

KSJ: ksj
Version 1 - 615199

Consent form for CP

FLINDERS UNIVERSITY ADELAIDE • AUSTRALIA
Social and Behavioural Research Ethics Committee

CONSENT FORM FOR PARTICIPATION IN RESEARCH

(by experiment)

I …..

hereby consent to participate, as requested in the Letter of Introduction, for the research project on 'Expression and understanding of prosody in individuals with Asperger syndrome'.

1. I have read the information provided.
2. Details of procedures and any risks have been explained to my satisfaction.
3. I agree to my information and participation being recorded on tape.
4. I am aware that I should retain a copy of the Information Sheet and Consent Form for future reference.
5. I understand that:
   - Although I will receive a payment of $20.00 for taking part in the project, I may not otherwise benefit directly from this research.
   - I am free to withdraw from the project at any time and am free to decline to participate in particular sections of the study.
   - while the information gained in this study will be published as explained, I will not be identified, and individual information will remain confidential.

Participant's signature ……………………………………Date …………………...

Parental consent is also required for participants under 18 years of age.

I …..

hereby consent to my child's participation as requested in the Letter of Introduction for the research project on 'The expression and understanding of prosody in individuals with Asperger syndrome'.

Parent's signature ……………………………………Date …………………...

I certify that I have explained the study to the volunteer and parent and consider that she/he understands what is involved and freely consents to participation.

Researcher's name …….KATE LYNETTE KING**…….**

Researcher's signature …………………………………..Date …………………….

APPENDIX C

Neale test form

ID No .... Date .... Neale Revised Form 1

DOB .... Age .... M F

RAW SCORE SUMMARY

Passage Level	No of v,ords	RATE fread	ACCURACY Mox Possible Score	Errors	Passage Score	COMPREHENSION Questions Correctly Answered	TARGET WORDS
1 Bhd	26		16·				
2 Road safety			16·				
3 NI	151		16·				
4 IIIII	247		16·				
5 The Fax	364		16-				
-" Migration	5D5		20·				
TOTAL TIME							

TOTAL RAW SCORES

*Words per min. = WORDS x ..§Q / TI IE 1 ———— 60

STANDARD SCORE SUMMARY

	RATE	ACCURACY	COMPREHENSION
Reading Me			
Age Range			
Percentile Rank			
Stanine			
ale Scaled SCOre			

ERROR COUNT

	Mlsprommciations	Substitutions	RefusaJs	Additions	Omissions	Reversals	Totals
Total count							
%of total count							

Practice •ry"
My friend and I made a tree house. We like to hide in tt. We climb up the rope and pull it up after us. Then no·one knows where we are. We play space-ships. At tea-time we slide down fast and we are always first for tea.

QUESTIONS

What would you say was the best name for that story?

2 Who bunt lhe house in \!le tree?

3 How did the boyslg\rls get up Into the tree house?

How could the children's friends guess that they were playing up in the tree house?

What game did the boys/girls play In lhe tree-house?

How did the nttJ.e boyslgtrls manage to be always first for tea?

Bird (Level1)

A bird hooped uptornywlndow. !mher bread. She madeanestin myti2Y:I:Ilook herlittle

QUESTIONS

Where dld the bird hop to?

2 What dld the little boy!g!rl give the bird?

What did the bird do In the garden?

4 What does \he little boyfgirl do now for the bird?

Mis ronundalions	Substitutions	Refusals	AdOrtions	Ornisslons	Reversals	TOTAL Como(ehension
						Errors Tlm•

Road Safety {Level 2)

Ken stopped on his way to school. In the middle of the traffic lay two cht1dren. Their bicycles had.crashed Into each other. Ken ran qutck\y to J!g!Q. He 'vı that nO+One was hurt The chndren pointed to a television camera. "We are .lEls!n9. part In a road lesson·,they said.

QUESTIONS

Where was Ken going?

2 Why did Ken Stop?

What had happened to the bikes?

4 How do you think Ken felt?

5 What did Ken do?

Were the children hurt?

7 What were the chlldren really doing?

How dld Ke.11ind out what was happening?

Mis ronundations	Substitutions	Refusals	AdOrtions	Omissions	Reversals	TOTAL Com rehension
						Errors Tlm•

Ali (Leve\3)

As All sheltered in an old temple, his shoulder knocked a secret spring. !nstanUy he was thrO'.vn Into an underground room. In !he darkness the warts seemed to be covered with. Ali rested a·Hh!le. He knew that t@ve!lers often Imagined strange things. Later, he explored the place for a way to escape. To his amazement the jewels were stin there. He had found a palace that had been long ago.

QUESTIONS

Why did All go Into Ule temple?

2 How did he lind the secret spring?

3 What happened when he touched the spring?

4 What Old he see there?

WrrJ did Anot rush to look at the jewels?

6 After he had rested, ...nat dklAll try to lind?

Why was he so surprised?

How had the jewe!s come to be there?

Mlsoronundations	Substitutions	Refusals	Additions	Omisskms	Reversals	TOTAL Comprehension
						Errors Time

Kells (Level4)

Skipper Ke!ls buckled on his lfJVing belt of metal we:shts and dropped from the launch. Jan suoervised his air-hose to prevent tanollng, leo, follovling the bubbles, guided the dinotw above the diver, as he searched the mvsteriou5 undeNtater world. Kells surfaced clutching crayfish. The required number of specimens was almost obtained when the grey nurse shark advanced directly towards him. Ke!ls retreated cautiously without signalling for assistance. The creature brushed by, Ignoring him, as baby sharks emerged from some rocky grooves. Their welfare was more Important to the shark than the diver's now figure.

QUESTIONS

1 What equipment assisted Skipper Kells In hIs exploratiorl'under water?

2 What did Jan do to help the Skipper?

3 How did leo know where the dlver was?

4 Wnat do you thin.'< the Skipper was cfiVing for?

5 Wny did it seem that the shar'..: might at!ack him?

How did the skipp€r avoid trouble vlith the shark?

7 What kind of a home protected the baby sharks from enemies?

S Why was the shark not Interested In the Skipper?

Misoronuncla ons	Substitutions	Refusals	Addittons	Omissions	Reversals	TOTAL Comorehension Errors
						T@'

The Fox (Level5)

Among animals the fox has no rival for cunning. Suspidous of man, who Is Its only natural enemy, It win, when perform extra-ordloarv feats, even alighting on the backs of sheep to cl"ivert its scen Parent foxes share the responslbHities of cub-rearing. Through their hunting exoedi!lons they acquire an uncanny knollledge of thetr surroundings which they use in an emergency. This is well mustrated by the story of a hunted fox which led its pursuers to a nealected mine-shaft enclosed by a circular hedge. It appeared to surmount the barrier. The hounds foUowed headlong, only to fainto the accumulated water b !ow. The fox, however, anoarently on familiar tern1ory, had skirted the hedge and subseqw;n!ly escaped.

QUESTIONS

1 Who Is the chief enemy of the fox?

2 Why oes the hunted fox sometimes jump onto the back of a sheep?

3 Who provides food for the cubs?

4 How do foxes know the best hiding places 1n thetr surroundings?

5 To where did the fox In this_story lead the hounds?

6 Wasthem!neworking?

7 How did the fox avoid falling Into the water?

6 Why were the hounds unable to see the danger?

Mis ronunda ons	Substitutions	Refusals	Adcfrtions	Omissions	Reversals	TOTAL Com rehenslon Errors
						T@'

Migration (Level6)

Each Spring, at the reappearance of the swa!!owsln their familiar haunts, bird-watchers must marvel at the accurate flights with which birds span the conslderable distances between their Masone! abodes. What motivates these r ular journeys? The theorv that wintem compelbirds to migrate !s _ as some migrate In summer. Neither can it be argued that the fledgllngs Imitate the older generation, for the offspring generally migrate a!one. One reasonable explanation may be that migrallon Is an Inborn behaviour, probably orlolnating In the distant past when the fli9hts were for survival. Most spades favour particular routes. On one occasion when some stor'.t5 from East Germany were captured and released among stor'.t5ln West Germany, thay cftd not acr:ompeny their relatives a!ong the western migration route. Instead, with unerring Instinct, they rediscovered the traditional south-easterly path of their eastern -

QUESTIONS

1 When can birdwatchers hope to see the swa.l!oo.vs reappear?

2 Why do bird-watchers think that birds ere such remar'1<2ble creatures?

3 Why is it wrong to say that the cold of winter makes all the birds migrate?

4 Do the young birds learn the migration routes from thek parents?

5 What do people thlnk causes the birds to migrate In this way?

Where was an experiment done wtth storks?

7 Vlhat route did the eastern storks usualiy tak.e when migrating?

!n which direction did the eastern storks fly when they were taken to the west?

Misoronunciatlons	Substitutions	Refusals	Additions	Omissions	Reversals	TOTAL Comorehenslon Errors
						Trn•

READING BEHAVIOURS

Needs encouragement to begin reading

Refuses to *tiy* unknown words

Repeats words or phrases habitually ,

Reads In a quiet O Loud O

Mumbled O Hurried O vtJice

Spontaneous language Poor O Average D

Articulation Poor D Average D Good O

Holds reading close to face

Can use finger as pointer Yes O No O

Loses place frequently Yes O No O

Head movements Marked O Sflghl O

APPENDIX D

Adapted Bolinger sentence test form

ID No …………………………….. Date ……………………………
DOB ……………………………… M F

Say the sentence to yourself and then put a tick beside one out of each pair, the one that seems to sound better to you.

1. a) He made a frank and candid remark.
   b) He made a candid and frank remark.

2. a) He looked out across the placid and calm lagoon.
   b) He looked out across the calm and placid lagoon.

3. a) I'd say that all we have are pretty slim and slender possibilities.
   b) I'd say that all we have are pretty slender and slim possibilities.

4. a) It was a dull and lengthy production.
   b) It was a lengthy and dull production.

5. a) She wrote me a curt and hurried reply.
   b) She wrote me a hurried and curt reply.

6. a) They were carried off, as captive and bound survivors.
   b) They were carried off, as bound and captive survivors.

7. a) What a noisy and loud response!
   b) What a loud and noisy response!

8. a) The signal was to raise a red and purple balloon.
   b) The signal was to raise a purple and red balloon.

9. a) Did you hear the wild and crazy demands?
   b) Did you hear the crazy and wild demands?

10. a) What mad and senseless destruction.
    b) What senseless and mad destruction.

11. a) What a tedious and long request.
    b) What a long and tedious request.

12. a) I listened to her soft and quiet remarks.
    b) I listened to her quiet and soft remarks.

13. a) Everyone remembers those joyous and sweet indulgences.
    b) Everyone remembers those sweet and joyous indulgences.

14. a) The chairman made a short and simple request.
    b) The chairman made a simple and short request.

15. a) It was depressing, the lonely and bleak terrain.
    b) It was depressing, the bleak and lonely terrain.

16. a) She's such a thoughtful and shy companion.
    b) She's such a shy and thoughtful companion.

17. a) From the summit you could see the broad, expansive horizon.
    b) From the summit you could see the expansive, broad horizon.

18. a) They all knew that sound. It was a dire and dreadful explosion.
    b) They all knew that sound. It was a dreadful and dire explosion.

APPENDIX E

Rhythm Rule sentences

THIRTEEN

1. Head

Q	How many officers were at the party?
A	There were thirteen of them at the party

2. Focus

Q	At the party, were there seven or thirteen officers?
A	There were thirteen officers at the party.

3. Rhythm 1

Q	At the party, were there ten sergeants or thirteen officers?
A	There were thirteen officers at the party.

4. Rhythm 2

Q	At the party, were there nine volunteers or thirteen officials?
A	There were thirteen officials at the party.

5. Rhythm 3

Q	At the party, were there eight diplomats or thirteen politicians?
A	There were thirteen politicians at the party.

JAPANESE

6. **Head**

Q What sort of tourists were they at the hotel?

A They were Japanese ones at the hotel.

7. **Focus**

Q Were your visitors at the hotel American tourists or Japanese Tourists?

A They were Japanese tourists at the hotel.

8. **Rhythm 1**

Q Were your visitors at the hotel American students or Japanese Tourists?

A They were Japanese tourists at the hotel.

9. **Rhythm 2**

Q Were your visitors at the hotel American businessmen or Japanese developers?

A They were Japanese developers at the hotel.

10. **Rhythm 3**

Q Were your visitors at the hotel American businessmen or Japanese politicians?

A They were Japanese politicians at the hotel.

SARDINE

11. Head

Q What sort of sandwich would you like for lunch?

A I'd like a sardine one for lunch.

12. Focus

Q For lunch, do you want an egg sandwich or a sardine sandwich?

A I'd like a sardine sandwich for lunch.

13. Rhythm 1

Q For lunch, do you want a hamburger or a sardine sandwich?

A I'd like a sardine sandwich for lunch.

14. Rhythm 2

Q For lunch, do you want a hamburger or a sardine croquette?

A I'd like a sardine croquette for lunch.

15. Rhythm 3

Q For lunch, do you want a vegetable lasagna or a sardine cannelloni?

A I'd like a sardine cannelloni for lunch.

BAMBOO

16. Head

Q Which chair did Sally buy at the shop?

A Sally bought the bamboo one at the shop.

17. Focus

Q Did Sally buy the wooden chair or the bamboo chair at the shop?

A Sally bought the bamboo chair at the shop.

18. Rhythm 1

Q Did Sally buy the bark painting or the bamboo chair at the shop?

A Sally bought the bamboo chair at the shop.

19. Rhythm 2

Q At the toyshop, did Sally buy the wooden monkey or the bamboo giraffe?

A Sally bought the bamboo giraffe at the shop.

20. Rhythm 3

Q At the shop, did Sally buy the Christmas tree or the bamboo decorations?

A Sally bought the bamboo decorations at the shop.

APPENDIX F

Score sheet for perceptual analysis

RATER'S NAME ………………………………….

Please circle a value of 0-4 for each of the dimensions listed below **0 = normal, 1 = mild, 2 = moderate, 3 = marked, 4 = severe** **When appropriate use + to indicate excessive/high, and – to indicate reduced/low**

CLIENT ID ……….

MONOTONE 0 1 2 3 4 OVERALL LOUDNESS 0 1 2 3 4

SPEED/RATE 0 1 2 3 4 VOICE QUALITY 0 1 2 3 4

ARTICULATION (Comments)	FLUENCY (Comments)

CLIENT ID ……….

MONOTONE 0 1 2 3 4 OVERALL LOUDNESS 0 1 2 3 4

SPEED/RATE 0 1 2 3 4 VOICE QUALITY 0 1 2 3 4

ARTICULATION (Comments)	FLUENCY (Comments)

APPENDIX G

Educational status and age of participants in Rhythm Rule and spontaneous speech analyses

Category	Age	AS = n	CP = n
1	35	1	
	33		1
	30		1
	25	1	
	23	1	
	20	1 (1 female)	1
	19	1	3 (1 female)
	18	4 (1 female)	1 (1 female)
	17	7	12
	16	15 (2 females)	10 (2 females)
	15	2	4
2	42		2
	40	3 (1 female)	1 (1 female)
	34		1
	31	2 (1 female)	
	28	1	2 (1 female)
	27	1	
	23		1

Category	Age	AS = n	CP = n
3	21	1	
	20		2
	19	1	
	16	1	1
No of participants		**43**	**43**
Average age		**20.4**	**20.4**

1 = Still at or completed high school or TAFE (Technical And Further Education)

2 = Attended university

3 = Did not complete high school

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