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Prosody and its relationship to language in school-aged children with high-functioning autism

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Abstract

Disordered expressive prosody is a widely reported characteristic of the speech of individuals with autism. Despite this, it has received little attention in the research literature and the few studies that have addressed it have not described its relationship to other aspects of communication. This study investigated the prosody and language skills of 31 children with high functioning autism. The children completed a battery of speech, language and non-verbal assessments and a procedure for assessing receptive and expressive prosody. Language skills varied, but the majority of children had deficits in at least one aspect of language with expressive language most severely impaired. All of the children had difficulty with at least one aspect of prosody and prosodic ability correlated highly with expressive and receptive language.

Key Words: autism, prosody, intonation, language.

1. Introduction

Autism

Autism is a pervasive developmental disorder that manifests in the first 36 months of life (Diagnostic and Statistical Manual-IV [DSM-IV], 1994) and has been defined as a triad of impairment in reciprocal social interaction, communication and imagination which includes restricted, stereotyped and repetitive behaviours (Wing & Gould, 1979). It is a spectrum disorder, ranging from severe autism with associated learning difficulties, to high-functioning autism (HFA) with normal non-verbal ability but preschool language delay and Asperger's Syndrome with no clinically important language delay. In Kanner's original description of autism (1943) he detailed several features of disordered communication such as echolalia, pronoun reversal, pragmatic difficulties and unusual expressive prosody. However, while most of these functional aspects of communication have been explored extensively in the literature, prosody has remained relatively under-researched (McCann & Peppé, 2003). In the few studies that have described prosody in autism, few have investigated its relationship to other aspects of language and communication.

Communication: Syntax, Semantics, Pragmatics and Phonology

As part of the communication impairment in autism, children show a pre-school language delay, which often persists into school years and beyond. At this early stage expressive language may be absent or show unusual features such as echolalia and pronoun reversal. Most research has focused on pragmatic and social aspects of language, with almost all children showing difficulties in these areas (Tager-Flusberg, 1996). In contrast, language skills are much more variable, ranging from absence to intact phonological, grammatical and semantic systems with older children and adults often demonstrating fluent speech with large vocabularies. Because of this variability, the syntactical, phonological and lexical aspects of language have received less attention in the literature.

However, a number of recent studies have looked again at speech and language profiles in autism. Kjelgaard and Tager-Flusberg (2001) investigated the communication ability of school-aged children with autism using standardised language measures similar to those used in the present study. They concluded that the language impairment in children with autism is very heterogeneous but that phonology skills are spared. They draw various parallels with the speech and language profiles of children with specific language impairment (SLI) suggesting genetic links between the two conditions.

Rapin and Dunn (2003) concur that children with autism are language disordered in a similar way to SLI and suggest some specific subgroups. They highlight comprehension as being universally impaired in their cohort of pre-school children with autism. This differs from their cohort of children with language disorders, many of whom had expressive language impairments but intact comprehension. The most frequently occurring profile of language impairment in both groups of children was a mixed receptive/expressive disorder with impairments in both syntax and phonology. This may seem surprising given that Kjelgaard and Tager-Flusberg suggest phonology is unaffected in autism, but as the children in the Rapin and Dunn study were all pre-school aged it may be that phonology disorders usually resolve by the time these children reach school.

It seems, then, that language abilities in autism are often disordered, if not universally so. Much of the variation in previous studies is probably due to the inclusion of participants from more than one group on the autism spectrum, including those with low non-verbal

abilities. One objective of the present study was to investigate these language skills in a relatively large group of children diagnosed with only one type of autism, namely HFA.

Communication: Prosody

Prosody is a term that refers to the suprasegmental aspects of speech including variations in pitch/fundamental frequency, loudness/intensity, duration, pause/silence, intonation, rate, stress and rhythm. Disordered expressive prosody is widely reported to occur in the speech of people with autism (for example, Baltaxe, 1884; Fine, Bartoluccim Ginsberg and Szatmari, 1991 and Shriberg, Paul, McSweeny, Klin, Cohen and Volkmar, 2001). It is described as exaggerated, monotonous or singsong but few studies exist to quantify this disorder (see McCann & Peppé, 2003, for a review) despite its presence adding an additional social and communication barrier.

Much of the literature on prosody in autism has focused on prosodic expression for affective or pragmatic purposes and upon the observation that the speech of a child with autism is often characterised by poor inflection and excessive or misassigned stress (Baltaxe, 1984; Baltaxe and Guthrie, 1987; McCaleb and Prizant, 1985; Hargrove, 1997). It is noted that the speech of even highly verbal individuals with autism can be unusual (Fay & Schuler, 1980) but very little is known about the comprehension of prosody in children or adults with autism. Moreover, little is known about what role a receptive impairment might play in prosodic expression or what role it might play in the general comprehension difficulties these individuals face.

Prosody serves a variety of communicative functions including affective, pragmatic and grammatical. As people with autism are known to have particular difficulty with affect/emotions and pragmatics it seems likely that they will also have difficulty understanding and using affective and pragmatic aspects of prosody. Conversely, if grammar is relatively spared, then it might be predicted that grammatical aspects of prosody may also be unaffected.

Prosody and Theory of Mind

The Theory of Mind (ToM) hypothesis (Baron-Cohen, 1989) proposes that the behavioural characteristics of autism are due to a cognitive deficit in inferring the mental states of others. While other cognitive theories of autism do exist, (the weak central coherence theory, executive dysfunction) ToM has been one of the most popular and widely applied theories. Some preliminary attempts have been made to link deficits in specific types of prosody to impaired ToM (Rutherford, Baron-Cohen & Wheelwright, 2002). For example, in order to understand affect or emotions ToM ability is required (Reiffe, Terwogt & Stockman, 2000) and individuals with autism are known to have a specific difficulty understanding the affect or emotions of others. Affect has primarily been investigated within domains other than prosody; for example, facial expression, gesture and face recognition (Hobson 1986a, Hobson 1986b and Boucher, Lewis & Collis 1998). However, a recent study by Rutherford, Baron-Cohen and Wheelwright (2002) investigated the ability of adults with HFA or Asperger's Syndrome (AS) to understand vocally expressed affect. Their results showed that the HFA and AS groups were impaired on this task compared with the performance of a large number of typical adults. The authors interpret their findings in the context of ToM, suggesting that in order to identify vocally expressed affect the listener must use cues in vocalisation to interpret the speaker's mental state or affect. Clearly this is suggesting that the understanding of prosody for affective purposes is a ToM task. No studies explore other aspects of prosody, such as the pragmatic use of contrastive stress, in

relation to the ToM hypothesis but it seems a reasonable possibility that other aspects of prosody, with the exception perhaps of grammatical aspects, might also require ToM skills.

Prosody holds an interesting position in vocal communication in that, although it has several important functions, it is not always essential in conversation. For example, lexically ambiguous phrases such as 'chocolate biscuits and jam' (three simple nouns or a compound and a simple noun) are often disambiguated by context rather than prosody. On the other hand, where affective function (e.g. sarcasm) is concerned, prosody can be more persuasive than lexical or syntactic content. People with autism are known to have difficulty with pragmatic knowledge and non-literal use of language, and it would not be surprising if the inexplicit nature of prosody caused them problems, especially in cases where either prosody is not supported by the more explicit levels of language (e.g. lexis, syntax, segments), or where prosody is the main cue to meaning. Furthermore, due to a deficit in ToM skills, people with autism may not use prosody appropriately because they do not know that the information it carries is important and useful to the listener. They may not understand prosody because it carries information about a speaker's mental state and point of view, be it affective or that an utterance is a question rather than a statement. In short, we propose that both the understanding and expression of some aspects of prosody can be viewed as theory of mind skills.

Prosody and Language

Wells and Peppé (2003) suggest that prosody is relatively discrete from other areas of language. Their study used PEPS-C (Profiling Elements of Prosodic Systems-Children, Peppé & McCann, 2003, see below) to measure prosodic ability in children with SLI and found very few correlations between PEPS-C subtests and measures of receptive and expressive language and phonology. However, as a group, the children with SLI's performance was significantly below that of chronological age matched peers, but in-line with language-matched peers, suggesting that language disability did have a detrimental effect on prosodic skills. Because children with autism have similar language skills to children with SLI, we might expect to find a similar pattern, with language skills bearing few relations to prosody skills. Alternatively, as people with autism have been identified as a population particularly vulnerable to expressive prosodic disorder (and children with SLI are not) we might expect this group to have a prosodic deficit that is at least commensurate with language impairment, if not more severe. If this were the case then a deficit in another skill, such as ToM, rather than language, may underpin prosodic deficits.

Although language skills combine with prosodic ones in most communicative acts, their different contributions have not been distinguished in experimental work in this area (see McCann and Peppé, 2003); in fact, no studies have directly addressed the relationship between prosody and other areas of communication in people with autism and this was therefore the primary aim of this study. The study was designed to address the following questions: First, what is the nature and relationship of expressive and receptive language, phonology, pragmatics and non-verbal ability in school-aged children with HFA? Second, how does prosody relate to the above abilities and which aspects of prosody are most affected? Third, does prosodic profiling of children with HFA support the notion that the language impairment of children with autism is similar to that of groups of children with SLI previously reported in the literature?

2. Method

Participants

Thirty-one children with HFA living within a 10-mile radius of the city of Edinburgh, Scotland, participated in the study. The children were aged 6-13 years (mean age 9;9), and included 25 boys and 6 girls. All of the children had undergone multi-disciplinary assessment of their communication disorder and a consultant paediatrician (the 4th author) had diagnosed the children during their pre-school years as having autism, with normal cognitive ability and early delay in speech/language development, according to ICD-10 (World Health Organisation, 1993) and criteria described by Gillberg and Coleman (2000). The majority of the children were in receipt of special educational provision either in a special school for children on the autism spectrum or in a language class attached to a mainstream school.

The prosody assessment (PEPS-C) used in the study is not standardised and so a control group of 72 typically developing children matched for verbal-mental-age (using the BPVS-II, Dunn, Dunn, Whetton & Burley, 1997), sex and socio-economic status were recruited. These children were aged 4-11 years (mean age 6;9 years) and verbal-mental aged between 4-12 years (mean VMA 7;6 years). This group was comprised of 54 boys and 18 girls.

Children were excluded from both groups if any of the following 5 criteria applied: (1) English was not the child's first language and the main language of the home; (2) there was evidence of current hearing loss; (3) receptive language skills were <4 years; (4) there was a major physical disability or structural abnormality of the vocal tract; or (5) the family had lived in Scotland for <3 years (to minimise the affect unfamiliarity with the Scottish accent might have on understanding of prosody). Children were excluded from the control group if they had any history of cognitive, speech or language impairment. Four children were excluded from the control group on the grounds that they had standard scores on the BPVS-II<85 and age-equivalent scores<4;0years.

Language, Speech and Non-Verbal Assessments

The children with autism completed a battery of standardised speech, language and non-verbal assessments as follows:

Receptive Vocabulary

The British Picture Vocabulary Scales-II (BPVS-II, Dunn et al., 1997) was used as a measure of verbal mental age, or more specifically receptive vocabulary. This assessment covers a wide age range and is a well-established tool for measuring verbal mental age. It is a multiple-choice test where participants select one of four pictures to match a single word spoken by the tester.

Receptive Grammar

The Test for Reception of Grammar (TROG, Bishop, 1983) is a measure of verbal comprehension of syntax. Again this is a multiple-choice test where participants are asked to select one of four pictures to match a sentence spoken by the tester.

Expressive Language

The three expressive subtests of the Clinical Evaluation of Language Fundamentals-3UK (CELF-3UK, Semel, Wiig & Secord, 2000) were used to measure expressive language.

The Recalling Sentences subtest requires participants to repeat sentences of increasing length and complexity; the Formulated Sentences subtest requires participants to construct sentences relating to a picture and containing a target word (for example, 'make a sentence about this picture using the word children'). In addition to these two subtests the children completed one of two further subtests depending on age. For children between 6-8 years the Word Structure subtest was used: this is a sentence completion task, for example a picture of one book then two books accompanied by the prompt 'here is one book and here are two…'. Children aged 9 and above completed the Sentence Assembly task, which requires children to construct grammatically correct sentences from written phrases/words.

Articulation/Phonology

Articulation was measured using the Goldman Fristoe-2 Test of Articulation (GFTA-2, Goldman & Fristoe, 2000). This is a measure of consonant production in single words, covering most of the consonants in English in word initial, medial and final positions. As articulation ability is not normally distributed in school-aged children, the standardisation of this test is modelled linearly rather than on the normal-distribution (bell-shaped curve).

Pragmatics

Pragmatic ability was assessed using the Children's Communication Checklist (CCC, Bishop, 1998), completed by each child's Speech and Language Therapist and/or class teacher. The checklist was originally designed to determine whether children with Specific Language Impairment (SLI) have a specific difficulty with pragmatic aspects of language (Pragmatic Language Impairment, PLI) or should be considered for a diagnosis of Autism Spectrum Disorder. It is therefore not specifically designed for assessing pragmatic ability in children with autism, but as few tests of pragmatics exist, it was chosen to give an indication of which children were most pragmatically impaired. The checklist in the original form used here is not standardised, but Bishop suggests that scores below 132 in the pragmatic composite indicate pragmatic impairment. Moreover, scores for children with autism, Asperger's Syndrome and typically developing children have been published for comparison (Bishop & Baird, 2001). It is important to note that unlike the other language assessments, the checklist is not based on a normal developmental pattern; rather it is a checklist of abnormal behaviours with lower scores indicating increased pragmatic impairment.

Non-Verbal Ability

The Raven's Progressive Matrices were used (RM, Raven, Court & Raven, 1986) as a measure of non-verbal ability. This is a pattern completion test, which has very low verbal demands. All the children with autism were reported as having normal non-verbal ability in their pre-school years and so it was expected that all the children would have RM scores within the normal range.

Prosody Assessment

Profiling Elements of Prosodic Systems in Children (PEPS-C, Peppé & McCann, 2003) was used as a measure of both receptive and expressive prosody. The computerised version of this assessment procedure is described in detail in Peppé and McCann (2003). The test is based on a psycholinguistic framework, incorporating parallel expressive and receptive tasks. It assesses the ability to discriminate between and produce prosodic forms, and to understand and express four prosodic functions. In designing the tasks, cues from other language parameters are excluded; for example, phrase-breaks are not signalled by conjunctions (chocolate AND biscuits and jam); this ensures that what is being assessed is

prosodic skill independent of contributions from syntax and lexis. Details of each PEPS-C subtest are set out in Appendix One.

A new computerised version of PEPS-C with Scottish-English accent stimuli was used here (Peppé and McCann, 2003). All the participants were familiar with the Scottish-English accent and had lived in the accent area for at least three years. As all of the items in the input tasks are binary choice, the pass-criterion is set at scores above 75%. All output tasks require the tester to rate responses as either right (1 point), wrong (zero) or ambiguous (zero). Pass-criteria is again set at 75% correct because often a child will produce all test items with the same prosodic form resulting in 50% correct because each output function task has two prosodic function targets. For example, in the Turn-End Output task it was common for young children to produce all the items with prosody suggesting all the items were statements. As half the stimuli were statements and half were questions this resulted in a score of 50% correct but clearly a child who performs in such a way has not yet acquired the prosodic skills required to complete this task.

Procedure

Children were tested individually in a quiet room by a certified Speech and Language Therapist (the 1st author). The children with autism required two one-hour testing sessions and the typically developing children required one session.

3. Results

Background Data

The groups were matched on verbal mental age, so it was unsurprising to find that the groups did not differ significantly on BPVS age equivalent scores (HFA mean= 7.09, SD=2.01; TD mean=7.53, SD=1.55; BPVS-II age equivalent, $p=0.302$). As expected, the HFA group was significantly older than the TD group ($p<0.001$) and so the BPVS-II standard scores were also significantly lower in the HFA group ($p<0.001$).

Language and Non-Verbal Measures

Table 1 shows the group results for all measures, numbers are standard scores unless otherwise stated. Not all the children were able to complete all the measures so the number of children is given in each instance. For each standardised measure the percentage of children performing within normal limits (standard score 85 or more), with mild impairment (scores between 70 and 84) and with more significant impairment (scores of 69 or less) was calculated. Paired t-tests were used to determine which aspects of language were most impaired (because CCC is not standardised it was not possible to include these results in this calculations).

INSERT TABLE 1 HERE

Receptive Language

Almost half (48%) of the children with HFA scored within normal limits on the BPVS-II, with the remaining children divided equally between mild and more significant impairment (26% in each category). For the TROG, 39% of the children scored within normal limits, with 32% showing mild impairment and 29% more significant impairment. A paired t-test showed that the BPVS-II scores and TROG scores were not significantly

different (p=0.835). This may seem surprising given that the TROG is a more complex task (comprehension of phrases/sentences rather than single words), and in fact TROG scores were generally lower than BPVS-II scores.

Expressive Language

A minority of the children with autism (10%) scored within normal limits on the CELF-3UK expressive subtests; 26% had a mild impairment; 58% had a more severe impairment and 6% could not complete the test at all. Paired t-tests confirmed that performance on the CELF-3UK was significantly lower than both the BPVS-II and TROG (p=0.000 in both cases) suggesting that in general expressive language is more severely impaired than receptive language. This is an unexpected finding, apparently quite different from the results of the study by Kjelgaard and Tager-Flusberg (2001) who found that receptive and expressive abilities were comparable in children with autism. The discrepancy may be due to a difference in methodology, with the present study using different measures or it may be due to the fact that they selected participants within a wider diagnostic category.

Articulation/ phonology

Results from the GFTA-2 confirm that children with autism generally do not have difficulty with articulation or phonology. 84% scored within the normal range, 10% had a mild impairment and 6% had a more significant impairment. Paired t-tests show that GFTA-2 standard scores were significantly higher than BPVS-II, TROG and CELF (p=0.004, 0.014 and 0.000 respectively). The developmental characteristics of the children's phonological errors from the GFTA-2 are analysed in further detail in Gibbon, McCann, Peppé, O'Hare and Rutherford (under review).

Pragmatic Ability

Because pragmatic difficulty is thought to be universal in autism it was expected that all the children would score below the pragmatic composite cut-off point of 132. This was mostly the case with the majority of children (74%) falling into this category. Of the 26% scoring above this level, a small % (10%) scored within the range specified by Bishop and Baird (2001) for typically developing children.

Non-verbal Ability

The majority (73%) of children had non-verbal ability within the normal range (standard score >85); of this group, 13% had superior non-verbal ability (standard score >115). Although 27% of the children had standard scores between 75 and 85; they were not excluded from the study because they had previously been reported to have normal non-verbal ability and these scores do not represent a severe learning difficulty. Low scores may have been a result of attention difficulties, especially when the longer Raven's Standard Progressive Matrices was used with older children. Paired t-tests showed that RM scores were significantly higher than BPVS-II, TROG and CELF (p=0.000, p=0.001 and p=0.000 respectively). There was no significant difference between the GFTA standard scores and RM scores (p=0.647) as in general these scores were both within normal limits.

Prosody

An independent samples t-test revealed that the children with autism performed significantly poorer on the PEPS-C than VMA matched peers (p=0.000, for total PEPS-C raw score). At subtest level, Affect Input, Affect Output, Intonation Input, Intonation Output,

Focus Output, Prosody Input and Prosody Output scores were all significantly lower (see table 2 for significance levels). As PEPS-C is not standardised, it is not possible to determine if this is a more significant deficit than in the standardised language assessments. However, because the HFA and TD groups were matched on BPVS and the HFA group scored lower than the TD group, prosodic ability appears to be more impaired than receptive vocabulary. The majority (74%) of the HFA group scored below the pass criterion of 75%, suggesting a significant difficulty with prosody. However, these results must be interpreted with caution as almost half the younger TD children also scored below this level (of children aged <7 years, 47.7% scored below 75%).

INSERT TABLE 2 HERE

Comparing Language, Pragmatics, Speech and Prosody

Pearson's Correlations were used to test for significant correlations between all the measures. Because standard scores were not available for all measures, raw scores were used where stated. A threshold of $p<0.01$ was taken as significant unless otherwise stated.

Language and Non-Verbal Measures

BPVS-II standard scores correlated highly with TROG ($r=0.631$; $p<0.000$) and CELF ($r=0.589$; $p=0.001$) but not with RM ($r=0.287$; $p=0.125$) or GFTA ($r=0.084$; $p=0.654$). In addition, GFTA and RM did not correlate with each other or TROG or CELF. This suggests that receptive and expressive language are related but that non-verbal ability and phonological ability are independent of other language skills.

CCC raw scores (pragmatic composite) correlated weakly (at the $p<0.05$ level) with TROG and CELF ($r=0.382$; $p=0.049$ and $r=0.412$; $p=0.041$ respectively) perhaps suggesting a relationship between increased language skills and pragmatic ability.

RM scores correlated negatively with age ($r=-0.480$; $p=0.007$) as did BPVS albeit at the $p<0.05$ level ($r=-0.402$; $p=0.025$). This suggests that the older children have relatively poorer receptive vocabulary and non-verbal ability when compared with typically developing peers. This may be due to skills reaching a plateau in older children, but this is not possible to confirm without a longitudinal study.

Prosody: Overall PEPS-C Scores

Raw scores were used to calculate correlations with PEPS-C scores. In addition to calculating correlations with overall PEPS-C scores, receptive, expressive, function, form and subtest raw scores were all tested for correlation with each of the measures. Table 3 shows the correlation co-efficient and probability values for each language measure and PEPS-C measure where the result was significant at the $p<0.01$ level.

PEPS-C total scores correlated highly with BPVS, CELF and TROG but not with age, suggesting that prosody is indeed related to language ability. The total PEPS-C score did not correlate with GFTA or non-verbal ability or with pragmatic ability (CCC).

INSERT TABLE 3 HERE

Prosody: Input and Output

Similarly, PEPS-C input scores correlated highly with BPVS, TROG and CELF. In addition, PEPS-C input scores correlated with RM and age. Regarding output tasks, there was a significant correlation with TROG and CELF. Again, the GFTA and the CCC did not correlate with any of the prosody measures.

Prosody: Function and Form

Function tasks assess the ability to use prosody meaningfully whereas form tasks assess the ability to discriminate and produce prosody without reference to meaning. The PEPS-C function tasks correlated with BPVS, TROG and CELF, whereas the form tasks did not correlate with any of the measures or chronological age. Closer inspection revealed that Input Form (Prosody Input and Intonation Input) did correlate with BPVS and age. This is a same/different auditory discrimination task and it may be that the correlation is due to increased attention and auditory memory in older children. However, there is no correlation between Output Form (Prosody Output and Intonation Output) and any of the other measures, suggesting that the ability to imitate prosodic forms is unrelated to language or age.

Prosody: Subtests

Table 3 shows that most of the subtests correlated with at least two language measures (BPVS, TROG or CELF). Exceptions to this are Intonation Output and Prosody Output (see above), Affect Output and Chunking Output.

4. Discussion

Language, Articulation, Pragmatics and Non-Verbal Ability

Although there was heterogeneity among the autism group, all of the children except one had a score outwith the normal range on one or more of the language measures (BPVS, TROG, CELF and GFTA).

Overall, the children had more difficulty with expressive language than receptive language. For some children this was a dramatic discrepancy of two standard deviations, or in one case three standard deviations. This is contrary to Kjelgaard and Tager-Flusberg's (2001) finding that children with autism do not show a receptive/expressive discrepancy. However, their study included children with a wider diagnosis of autism and it may be that an expressive deficit is a particular characteristic of children with HFA. That is, children with additional learning difficulties (children with autism that is not defined as high functioning) may have additional language comprehension difficulties that therefore result in similar expressive/receptive abilities. Indeed, Kjelgaard and Tager-Flusberg found a significant relationship between IQ and language ability suggesting that children with additional learning difficulties do indeed have additional language difficulties.

The results demonstrated that phonology is not a common area of difficulty in children with autism. However, it is premature to conclude that phonological skills are spared in all children with autism, as Kjelgaard and Tager-Flusberg suggest. The developmental characteristics of the phonological errors produced by the children are described by Gibbon, McCann, Peppé, O'Hare and Rutherford (under review). They found that the nature of the consonant errors of the children with HFA and comorbid phonological disorders was qualitatively different from the errors of the children with HFA but with normal phonological abilities. In the current study, phonological disorders were not related to other language or non-verbal abilities, although where a disorder exists, it may be severe, resulting in speech that is largely unintelligible.

It is generally thought that pragmatic skills are universally disordered in autism spectrum disorders, but a significant proportion of children scored above the CCC pragmatic impairment cut-off point suggested by Bishop (1998). While the checklist confirms that

pragmatics is a particular area of difficulty for these children, because some of the children score above the cut-off point (132) it is difficult to know if the checklist gives a true indication of which children are the most pragmatically impaired. Bishop and Baird (2001) found that 87% of children with autism scored below 132, compared with only 56% of children with Asperger's Syndrome. It may be the case, then, that the cut-off point is set too low. Bishop and Baird report that the lowest score obtained by a typically developing child was 140 and only one child with autism in their study scored above this (total sample 15). The present study found five children scoring above 140 (16% compared to 7% of Bishop and Baird's sample) this difference may simply be due to the small sample size in the study. Alternatively, as Bishop and Baird did not limit their sample to HFA, it may be that the profile detailed here is intermediate between that for "autism" and that for "Asperger's Syndrome". The mean pragmatic composite for this group of children indeed sits halfway between the mean for Bishop and Baird's two groups, emphasising the spectrum nature of the disorders. It seems then, that the checklist does give some indication of pragmatic ability but that scores should be interpreted with caution, especially with regard to the cut-off point.

The relationship between pragmatics and other areas of language is unclear. There was some correlation with CELF and TROG suggesting a possible relationship but the correlation was at the $p<0.05$ level only and there was no correlation with BPVS or age. It is important to remember that the CCC is not a developmental checklist: whereas the other tests show increasing scores with increasing age in typical children the CCC is a checklist of abnormal behaviours. It is probable that these abnormal behaviours are independent of language level. Where there is a correlation between language skills and the CCC score it may be that children with better language skills are able to use them to compensate for some of their pragmatic difficulties.

Prosody and its Relationship to Language

Most of the children showed a significant deficit in prosody and all of the children had difficulty with at least one of the PEPS-C subtests. By comparing the children with autism to verbal mental age matched controls we see that, as a group, prosodic ability was poorer in the children with autism. Comparisons with the typically developing group will be dealt with in more detail elsewhere (Peppé, McCann, Gibbon, O'Hare and Rutherford, in preparation) but in summary this suggests that children with autism have a specific difficulty with prosody, which is more severe than their deficit in receptive vocabulary. Had the children been compared with chronological age matched peers (as is the case in any standardised assessment) the difficulty with prosody would have been much more pronounced.

The finding that prosody correlates highly with language ability rather than age suggests that for children with autism, unlike those with SLI in the study by Wells and Peppé (2003), prosodic ability is highly related to language ability. This idea is further supported by the correlations with most of the PEPS-C subtests. However, it is perhaps the areas in which no correlations were found that are most interesting.

Firstly, the CCC did not correlate with any of the PEPS-C scores. This is unexpected given that many of the PEPS-C subtests investigate pragmatic aspects of prosody and the CCC is a measure of pragmatic ability. However, the explanation may lie in the design of the CCC as a checklist of abnormal behaviours. The PEPS-C is designed to assess a range of prosodic functions/forms that develop at different ages in typically developing children; it does not (at least at the level analysed here) measure prosodic difficulties that are the result of atypical expressive prosody. For example, some of the children in the study had unusual expressive prosody that was no doubt an added social barrier but did not result in any loss of

communicative function and therefore many of these children were able to distinguish prosodic functions (for example, distinguish a question from a statement, although possibly in an atypical way). It is possible that had PEPS-C been compared with a measure of developmental level of pragmatic ability some positive correlations would have been found between prosodic and pragmatic ability. It therefore remains unclear whether prosody is related to pragmatic ability.

Phonology is another area that did not relate to any of the prosody scores. This suggests that prosodic abilities are relatively discrete from phonological ones, confirming Wells and Peppé's findings.

Some correlations were found for non-verbal ability and age but these were fewer or smaller than for the language measures. It is likely that these correlations are a result of generally higher ability (in terms of raw scores, not standard scores) among the older children. That is, the correlations can be explained by a further correlation with BPVS scores.

Four of the twelve PEPS-C subtests did not correlate with any of the measures. The two Output Form tasks, Intonation Output and Prosody Output, appear to be relatively independent of other language abilities. These tasks are imitation tasks, not requiring any knowledge of prosodic functions on the part of the testee. Comparison with the control group revealed that these tasks were a particular area of difficulty for the children with autism. This is not surprising given that imitation is thought to be impaired in people with autism (Rogers, Hepburn, Stackhouse and Wehner, 2003).

The Affect Output task also did not correlate with any measures. This task requires the testee to produce single words (food-items) with prosody suggesting either likes or dislikes. It was predicted that children with autism would have particular difficulty with this task because affect/emotions are a well-known area of difficulty for people with autism. This was indeed the case, highlighting that both the understanding and use of affect is particularly problematic in children with autism.

The final task that showed no relationship with language was again an output task. The Chunking Output task requires the testee to prosodically disambiguate lexically ambiguous utterances. For example, he or she must make a distinction between the prosodic minimal pair "chocolate, biscuits and jam" and "chocolate-biscuits and jam". Interestingly, this is one of only two tasks where the testee's attention is not specifically drawn to the necessity to make a prosodic distinction, the other task being the focus output task. That is, the other output tasks involve in their instructions "say the word in a way which means…" whereas in these tasks the child is simply asked to say what is on the test picture. As mentioned before, prosody is not always relied upon in conversation, especially for utterances such as those in the chunking task, and thus successful completion of the task may depend on the testee realising, without being told, that the purpose of the task is to make a distinction. This is potentially more difficult for children with autism who may lack the theory of mind required to appreciate that the prosodic information is useful to the listener.

Some general patterns emerged regarding which aspects of prosody correlate most strongly with language. The function input tasks (Affect Input, Chunking Input, Turn-end Input and Focus Input) were all related to at least two of the three language measures whereas the output tasks were more variable. It might have been predicted that expressive language would relate to expressive prosody and receptive language to receptive prosody but because of the high correlations between the three language measures it was not possible to draw any such conclusions.

Prosodic Impairment in HFA: A Type of SLI or a Theory of Mind Skill?

The results of the language assessments support Kjelgaard and Tager-Flusberg (2001) who suggest that the language impairment in autism is similar to that of SLI. However, the results here suggest that unlike Kjelgaard and Tager-Flusberg's participants, expressive language is a particular difficulty for children with HFA. Clearly more research is needed to look at the language profiles of children belonging to specific groups on the autistic spectrum.

The results of this study demonstrate a clear connection between language level and prosodic ability but this link was not found in Wells and Peppé's (2003) study with children with SLI. This may be due to the relatively small and very heterogeneous group in the Wells and Peppé study and indeed this makes the results difficult to interpret. The results appear to conflict: on the one hand it appears that prosody is simply another aspect of language and thus the language impaired children with autism show a prosodic deficit. On the other hand, in the Wells and Peppé study prosody appeared to be relatively discrete from language. While it is tempting to conclude from the present study that language impairment causes prosodic impairment it is possible that the correlations are caused by some other factor, which we propose to be theory of mind skills.

Work by Rutherford, Baron-Cohen and Wheelwright (2002) has already suggested that the understanding of at least one aspect of prosody can be considered to be an advanced test of ToM and it is generally accepted that ToM correlates highly with language skills (Astington and Jenkins, 1999). Leslie and Frith (1988) demonstrated that deficits in ToM are not simply a consequence of language impairments by matching children with autism to children with SLI. They found that school-aged children with autism had severe difficulty with ToM tasks whereas the children with SLI performed at ceiling. A limitation of the present study was that ToM tasks were not included in the protocol and future studies investigating prosody in autism should consider this as a possible contributing factor. If prosody is relatively discrete from language then the current evidence supports the notion that the communication component of the autism triad is a form of SLI. Moreover, if prosody can be viewed as a theory of mind skill rather than solely a language skill, this would explain why many high-functioning individuals with autism or Asperger's Syndrome and normal language continue to display disordered prosody.

5. Conclusions

The results of this study show that prosody relates closely to language skills, with input skills appearing to have the greatest relationship. More research is needed to clarify whether prosodic impairments are a direct result of language impairments or an autism-specific difficulty relating to theory of mind impairment, however. The language skills of children with HFA are very heterogeneous, but most children show major difficulties. This difficulty is particularly severe for expressive language with the majority of children scoring more than two standard deviations below the mean. The language profile is independent of non-verbal ability and various parallels can be drawn with the similar profiles shown by children with specific language impairment. Investigating prosody and its relationship to language in autism is clinically important because expressive prosodic disorders add an additional social and communication barrier for these children and problems are often life-long even when other areas of language improve. Furthermore, a receptive prosodic impairment may have implications not only for understanding the many functions of prosody but also for general language comprehension.

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Appendix 1. PEPS-C Subtest Descriptions.

Level	Mode	Task Name	Description
Function	Input	Turn-end Type Input (TI)	Understanding whether an utterance requires an answer or not. Items are single words with intonation suggesting either questions or statements.
	Output	Turn-end Type Output (TO)	Producing single words with either intonation suggesting questioning or stating.
	Input	Affect Input (AI)	Comprehending liking or disliking expressed on single words.
	Output	Affect Output (AO)	Producing affective intonation to suggest either liking or disliking on single words.
	Input	Chunking Input (CI)	Comprehending prosodic phrase boundaries. Items are syntactically ambiguous phrases, for example, "chocolate-biscuits and jam" versus "chocolate, biscuits and jam".
	Output	Chunking Output (CO)	Producing prosodic phrase boundaries in phrases similar to those above.
	Input	Focus Input (FI)	Comprehension of contrastive stress.
	Output	Focus Output (FO)	Production of contrastive stress.
Form	Input	Intonation Input (II)	Auditory discrimination of prosodic forms without reference to meaning. Stimuli consist of laryngograph recordings (which sound like a hum) of items from the affect and turn-end input tasks (single words).
	Output	Intonation Output (IO)	Assesses whether an individual has the voice skills required to imitate various prosodic forms. Stimuli consist of items similar to the affect and turn-end function tasks.
	Input	Prosody Input (PI)	Discrimination of long prosodic forms without reference to meaning. Stimuli consist of laryngograph recordings of the chunking and focus output tasks (short phrases).
	Output	Prosody Output (PO)	Imitation of long prosodic forms. Stimuli consist of items similar to the chunking and focus function tasks.

Table 1. Language and prosody results, group means.

	Children with Autism							TD Children	
Measure	**BPVS-II**	**TROG**	**CELF**	**GFTA**	**RM**	**CCC (Raw)**	**PEPS-C %**	**BPVS-II**	**PEPS-C %**
No. Complete	31	31	29	31	30	27	31	72	72
Mean	81.4	79.6	69.8	93.3	96.4	123.2	64.6	107.5	75.0
SD	16.2	17.9	8.5	18.5	15.9	15.1	11.0	9.3	9.5

Note: Figures are standard scores except CCC, which is a raw score and PEPS-C, which is percentage correct.

BPVS-II= British Picture Vocabulary Scale; TROG= Test for Reception of Grammar; CELF=Clinical Evaluation of Language Fundamentals; GFTA= Goldman-Fristoe Test of Articulation; RM=Raven's Matrices; CCC= Children's Communication Checklist; PEPS-C= Profiling Elements of Prosodic Systems in Children.

Table 2. PEPS-C subtest results.

Subtest	**TI**		**TO**		**AI**		**AO**		**II**		**IO**		**CI**		**CO**		**FI**		**FO**		**PI**		**PO**		**Total**	
Group	HFA	TD	HFA	TD	HFA	TD	HFA	TD	HFA	TD	HFA	TD	HFA	TD	HFA	TD	HFA	TD	HFA	TD	HFA	TD	HFA	TD	HFA	TD
Mean	65.9	64.8	68.1	74.2	71.2	84.5	63.3	79.4	68.8	80.1	64.7	79.9	67.5	69.0	66.5	71.2	59.6	65.9	61.6	84.0	63.5	79.0	65.7	85.4	64.6	76.3
STDEV	21.4	18.1	21.8	18.3	21.6	11.4	26.3	19.2	22.0	17.4	26.4	18.0	15.7	15.6	20.6	11.8	19.0	19.1	26.4	15.0	23.1	13.3	22.0	11.4	11.0	9.5
Sig level	ns		ns		p=0.003		p=0.001		p=0.010		p=0.003		ns		ns		ns		p=0.000		p=0.001		p=0.000		p=0.000	

Note: HFA=High-functioning autism group; TD=Typically developing group; ns= No significant difference between groups. TI=Turn-end input; TO=Turn-end output; AI=Affect input; AO=Affect Output; II=Intonation input; CI=Chunking input; CO=Chunking output; FI=Focus input; PI=Prosody input; PO=Prosody output.

Table 3. PEPS-C, language, non-verbal and age correlations.

PEPS-C Task	BPVS	TROG	CELF	CCC	GFTA	RM	Age
Total	r=0.559;p=0.001	r=0.604;p<0.000	r=0.680;p<0.000				
Input Total	r=0.779;p=0.000	r=0.585;p=0.001	r=0.717;p<0.000			r=0.502;p=0.005	r=0.598;p<0.000
Output Total		r=0.507;p=0.004	r=0.498;p=0.006				
Function Total	r=0.501;p=0.004	r=0.614;p<0.000	r=0.718;p<0.000				
Form Total							
Turn-end Input	r=0.630;p<0.000		r=0.502;p=0.006			r=0.488;p=0.007	r=0.459;p=0.009
Turn-end Output	r=0.568;p=0.001	r=0.480;p=0.007	r=0.678;p<0.000			r=0.517;p=0.005	
Affect Input	r=0.597;p<0.000	r=0.522;p=0.003	r=0.684;p<0.000				
Affect Output							
Chunking Input	r=0.546;p=0.001	r=0.630;p<0.000					
Chunking Output							
Focus Input	r=0.579;p=0.001		r=0.555;p=0.002				r=0.475;p=0.008
Focus Output		r=0.718;p<0.000	r=0.540;p=0.003				
Intonation Input	r=0.579;p=0.001		r=0.542;p=0.002				r=0.514;p=0.003
Intonation Output							
Prosody Input	r=0.460;p=0.009					r=0.508;p=0.005	r=0.584;p=0.001
Prosody Output							

Note: Only correlations significant at the p<0.01 level are reported. Blank cells are not significant.