

## Perception and Production of Prosody by Speakers with Autism Spectrum Disorders

Rhea Paul,<sup>1,2,3</sup> Amy Augustyn,<sup>2</sup> Ami Klin,<sup>2</sup> and Fred R. Volkmar<sup>2</sup>

---

Speakers with autism spectrum disorders (ASD) show difficulties in suprasegmental aspects of speech production, or *prosody*, those aspects of speech that accompany words and sentences and create what is commonly called “tone of voice.” However, little is known about the perception of prosody, or about the specific aspects of prosodic production that result in the perception of “oddness.” The present study examined the perception and production of a range of specific prosodic elements in an experimental protocol involving natural speech among speakers with ASD between 14 and 21 years of age, in comparison with a typical control group. Results revealed ceiling effects limiting interpretation of findings for some aspects of prosody. However, there were significant between-group differences in aspects of stress perception and production. The implications of these findings for understanding prosodic deficits in speakers with autism spectrum disorders, and for future research in this area, are discussed.

---

**KEY WORDS:** autism; prosody; language.

### INTRODUCTION

Since the first delineation of the autistic syndrome (Kanner, 1943), abnormal prosody has been frequently identified as a core feature of the syndrome for individuals with autism who speak (Pronovost, Wakstein & Wakstein, 1966; Rutter & Lockyer, 1967; Ornitz & Ritvo, 1976; Fay & Schuller, 1980; Tager-Flusberg, 1981; Baltaxe & Simmons, 1985, 1992; Paul, 1987). Differences noted in early, observational reports included monotonic or machine-like intonation, deficits in the use of pitch and control of volume, deficiencies in vocal quality, and use of aberrant stress patterns. Speakers with both high functioning autism (HFA) and Asperger

syndrome (AS) have been reported to demonstrate these difficulties (Ghaziuddin & Gerstein, 1996; Shriberg *et al.*, 2001). Prosodic deficits have not been universally reported, however. Simmons and Baltaxe (1975), for example, found that only four out of the seven adolescents with autism they studied had notable suprasegmental differences in their speech. Paul *et al.*, (2004) reported abnormal prosody in 47% of the 30 speakers with autism spectrum disorders (ASD) studied. When such behaviors are present, however, the prosody characteristics of a person with autism constitute one of the most significant obstacles to his or her social integration and vocational acceptance. Prosodic differences are persistent and show little change over time, even when other aspects of language improve (Rutter & Lockyer, 1967; Kanner, 1971; DeMyer *et al.*, 1973; Simmons & Baltaxe, 1975). Paul *et al.*, (2004) report that prosodic differences are significantly related to ratings of ASD speakers' social and communicative competence. Moreover, Mesibov (1992) and

---

<sup>1</sup>Southern Connecticut State University

<sup>2</sup>Yale Child Study Center

<sup>3</sup>Correspondence should be addressed to Rhea Paul, Yale Child Study Center, 230 S. Frontage Rd, P.O. Box 207900, New Haven, CT, 06520-7900, USA; E-mail: rhea.paul@yale.edu

VanBourgondien and Woods (1992) reported that it is the vocal presentation of individuals with autism that most immediately creates an impression of oddness.

Recent reviews of prosodic findings in speakers with ASDs (Shriberg *et al.*, 2001; McCann & Peppe, 2003) emphasize the numerous deficiencies in the current literature on this topic. There has been little research on the ability of speakers with ASD to perceive and understand prosodic cues, except as these cues are used in relation to affect; specifically, the ability to match emotional tone in speech to a facial expression. The focus of research on prosody has typically been on one aspect at a time, without regard to creating a fuller description of the prosodic features of speech in these individuals. There have, for example, been studies of stress (Fay, 1969; Baltaxe, 1984; Baltaxe & Guthrie, 1987; Baltaxe & Simmons, 1985; McCaleb & Prizant, 1985; Fine, Bartolucci, Ginsberg & Szatmari, 1991; Fosnot & Jun, 1999), phrasing (Fine, *et al.*, 1991; Thurber & Tager-Flusberg, 1993), and intonation (Baltaxe, Simmons, & Zee, 1984; Fay & Schuler, 1980; Fine *et al.*, 1991; Paccia & Curcio, 1982); but only one (Fine *et al.*, 1991) that looked across all three areas. Both reviews highlight the fact that methodological difficulties abound, including small sample sizes, absence of normative data and contrast groups, poorly defined prosodic categories, and the use of subjective ratings, rather than objective measures.

Shriberg *et al.*, (2001), in an attempt to address some of these problems, reported on a range of suprasegmental characteristics of continuous speech in speakers with HFA and AS, using a standard assessment method, the Prosody-Voice Screening Profile (Shriberg, Kwiatkowski & Rasmussen, 1990). This study found few differences in prosodic production between speakers with HFA and AS. There were significant differences between these two diagnostic groups and typical speakers; however, these were not widespread, but focused in a few areas, most notably the use of stress and the presence of hypernasal voice quality.

### Functions of Prosody

*Prosody* is defined as the suprasegmental properties of the speech signal that modulate and enhance its meaning. Prosody functions at several levels to enable speakers to construct discourse through expressive language. Crystal (1986), Kent and Read (1992), Merewether and Alpert (1990), McCann and

Peppe (2003) and Panagos and Prelock (1997) provide various accounts of these levels, which can be categorized in three subdomains.

*Grammatical* prosody includes suprasegmental cues that are used to signal syntactic information within sentences (Warren, 1996). Stress can be used grammatically within words to signal, for example, whether a token is being used as a noun (*con vict*) or a verb (*con vict*). Pitch contours signal the ends of utterances and denote whether they are questions (rising pitch) or statements (falling pitch). Grammatical uses of prosody are generally obligatory aspects of the production of the surface structure that are an inherent part of the transformation from deep structure meanings (Gerken, 1996; Gerken & McGregor, 1998).

*Pragmatic* prosody is used to carry social information beyond that conveyed by the syntax of the sentence. It conveys the speaker's intentions or the hierarchy of information within the utterance, and results in optional changes in the way an utterance is expressed (Van Lancker, Canter & Terbeek, 1981; Winner, 1988). Stress, as one example, can be used to highlight an element of information within a sentence as the focus of attention. This pragmatic use of stress, usually referred to as *emphatic* or *contrastive* stress, calls the listener's attention to information that is new to the conversation, unfamiliar, or unexpected within the sentence. Emphatic stress is used to highlight the *comment* or *predicate* of an utterance, the portion that elaborates on the topic established within the discourse (Haviland & Clark, 1974; Bates & McWhinney, 1979).

Finally, *affective* prosody serves more global functions than those subserved by the prior two forms. Affective prosody includes changes in register used for varying social functions (e.g., differences among the ways an individual talks to peers, to young children, and to people of higher social status). Affective prosody is also involved in conveying a speaker's general feeling state (Bolinger, 1989; Hargrove, 1997). For example, a wife would produce the utterance "My husband's plane hasn't landed yet" with different suprasegmental characteristics, depending on whether she were feeling relaxed about having a little time remaining before she had to leave for the airport, or anxious because the time at which the plane should have landed was long past.

It can be hypothesized that the prosodic deficits so frequently attributed to people with autistic syndromes reside primarily in its pragmatic and affective aspects, with grammatical aspects relatively spared.

This hypothesis stems from two sources. First, there is a literature of well-documented grammatical and morphological strengths in individuals with HFA and AS, compared to their reduced abilities in the meaningful use of language for social communication (Tager-Flusberg, 1981, 1995; Landa, 2000). Secondly, the current body of research on prosody in autism can be interpreted to suggest that a majority of the identified deficits reside in pragmatic and affective functions. For example, Ricks (1975) and Lord, Rutter and DeLavore (1996) demonstrated that parents have more difficulty identifying the emotional content of prespeech vocalization in their children with autism than do parents of children with mental retardation or normal language. Several studies (Boucher, Lewis, & Collis 1998; Hobson, Ouston & Lee, 1988, 1989; Van Lancker, Cornelius & Krieman 1989) have shown that children with autism have difficulty matching vocally expressed affect to facial expressions or to emotion words (e.g., *happy, sad, scared*). A few studies have suggested greater problems with pragmatic/affective function than with grammatical use of stress (Fine *et al.*, 1991) and pauses (Thurber & Tager-Flusberg, 1993).

### Rationale and Study Goals

The present study attempts to build on the results of Shriberg *et al.*, (2001). It provides an experimental paradigm in which more controlled contexts for prosodic production were created, in order to examine a larger number of instances of these prosodic elements than may occur in natural speech. Moreover, the study aims to examine the same prosodic elements in perception in order to contrast performance in the two modalities, and attempt to understand more deeply the roots of prosodic production deficits. Finally, we contrast the prosodic elements in grammatical vs. pragmatic/affective contexts. In this way, we attempt to discover whether the same elements are dealt with more effectively by speakers with ASD, as we would predict, when serving a grammatical function. Thus we examine responses to experimental tasks designed to tap both perception and production of three aspects of prosody: stress (emphasis on syllables and words), intonation (pitch changes over the course of phrases and sentences), and phrasing (the pattern of rate and pausing within utterances). We have devised tasks for each element in the service of both a grammatical and a pragmatic/affective function in both an expressive and receptive modality.

## METHOD

### Participants

#### *Subjects with ASD*

Twenty-seven participants with ASD participated in this study. They consisted of all the individuals with any form of ASD who participated in a study of high functioning autism at the Yale Child Study Center's Developmental Disabilities Section within a 1-year time period. To qualify for the high-functioning study, subjects were required to have a diagnosis within the ASD spectrum, a verbal IQ greater than 70 and to have fluent use of spoken language. These individuals had completed an extensive protocol as part of two projects on the neurobiology of autism. The protocol included data from standardized assessments of cognitive, language, and social-adaptive functioning, and a videocassette recording of a conversational speech sample obtained during a semistructured diagnostic interview. Diagnostic characterization included the Autism Diagnostic Interview-Revised (ADI-R; Lord, Rutter & LeCouteur, 1994) and the Autism Diagnostic Observation Schedule-Generic (ADOS-G; Lord *et al.*, 2000). Diagnostic assignment followed DSM-IV criteria for autism, AS, and Pervasive Developmental Disorders-Not Otherwise Specified (American Psychiatric Association, 1994). Clinical diagnoses were confirmed independently by two experienced clinicians (AK and FV) with demonstrated interrater reliability (Klin, Lang, Cicchetti & Volkmar, 2000). Fifty-two percent (14) of the subjects were diagnosed as HFA by these methods; 37% (10) as AS, and 11% (3) as Pervasive Developmental Disorders-Not Otherwise Specified (PDD-NOS). As can be seen in Table I, subjects' average age-equivalent scores for written communication were over 10 years, or fifth grade level. The subject with the lowest written communication score had a written communication age-equivalent of 8 years, or second to third grade level. Participants' average age was 16.8 (SD 6.6).

Table I provides additional information on the 27 participants with ASD. As can be seen, the subjects, on average scored well within the normal range of verbal IQ, and tested within the normal range on standard measures of both expressive and receptive language. However, their adaptive use of communication, as evidenced by their Vineland Adaptive Behavior scores, were significantly low, as were their scores on the Socialization scale of this measure. This profile of normal performance on standard tests, but

**Table I.** Description of Participants with ASD.

|  | Mean (SD)    |
|--|--------------|
| Verbal IQ <sup>a</sup>   | 103.9 (23.8) |
| Performance IQ <sup>a</sup>  | 95.2 (25.6)  |
| ADOS <sup>b</sup> Communication Algorithm Score  | 4.4 (1.4)    |
| ADOS <sup>b</sup> Social Algorithm Score   | 9.9 (2.6)    |
| Clinical Evaluation of Language Fundamentals <sup>c</sup><br>Receptive Standard Score  | 98.6 (21.4)  |
| Clinical Evaluation of Language Fundamentals <sup>c</sup><br>Expressive Standard Score | 94.5 (18.1)  |
| Vineland <sup>d</sup> Communication Standard Score                                     | 64.0 (14.4)  |
| Vineland <sup>d</sup> Socialization Standard Score                                     | 46.4 (12.2)  |
| Vineland <sup>d</sup> Written Communication<br>Age-Equivalent Score                    | 10.9 (3.9)   |

<sup>a</sup> Wechsler Intelligence Scale for Children, 3rd ed. (WISC; Wechsler, 1992) or Wechsler Intelligence Scale for Adults, 3rd ed. (WAIS; Wechsler, 1997), depending on subject's age.

<sup>b</sup> Autism Diagnostic Observation Scale-Module 3 or 4 depending upon subject's developmental level (Lord, *et al.*, 2000).

<sup>c</sup> Wiig & Secord, 1989.

<sup>d</sup> Vineland Adaptive Behavior Scale (Sparrow, Balla, & Cicchetti, 1984).

significant disability in adaptive behavior, is typical of young people with ASD (Loveland & Kelley, 1991; Rodrigue, Morgan & Gefken, 1991; Schatz & Hamdan-Allen, 1995; Carter *et al.*, 1998; Liss *et al.*, 2001; Paul *et al.*, 2004).

### Typically Developing Controls

Thirteen typically developing subjects were recruited through local schools and personal connections. Their average age was 16.7 (SD 3.7). All were enrolled in appropriate age for grade in school, were considered by parents to be achieving normally in school, and had no history of speech, language or learning problems or of special education.

### Procedures

Subjects were seen individually for administration of the prosody protocol by the second author (AA). Each administration took 45–60 minutes. There were 12 sections in the protocol, which appear in Table II. Each section contained a set of two training items. In the first, the examiner provided a typical item and the correct response. In the second, the examiner provided an item, asked the subject for a response, corrected and explained the response if it was incorrect, and praised the subject for a correct answer, whether it was on the first or second try. All subjects were able to perform correctly on the training items for each section.

All spoken stimuli for the perception tasks were prerecorded in live voice so that all subjects heard the same stimuli. All of the subjects' spoken responses for the production tasks were audiorecorded for later

**Table II.** Tasks for Assessing Production and Perception of Grammatical and Pragmatic/Affective Functions of Prosody in Speakers with ASD.

| Grammatical prosody  | Pragmatic/affective prosody   |
|--|---|
| Perception of <i>stress</i>  |   |
| GPeS. Perception of stress within words that signals the grammatical shift from noun ( <i>pre sent</i> ) to verb ( <i>pre sent</i> ) | PPeS. Perception of the pragmatic/affective function of emphatic stress (to highlight or focus listeners' attention on one element) within a sentence |
| Production of <i>stress</i>  |   |
| GPrS. Production of stress within words that signals the grammatical shift from noun ( <i>pre sent</i> ) to verb ( <i>pre sent</i> ) | PPrS. Production of emphatic stress between words to encode pragmatic/affective focus   |
| Perception of <i>intonation</i>  |   |
| GPeI. Perception of the intonation patterns that signal grammatical function in statements vs. questions                             | PPeI. Perception of intonation patterns signaling pragmatic/affective changes in speech style from child-directed "motherese" to adult-directed       |
| Production of <i>intonation</i>  |   |
| GPrI. Production of the intonation pattern that signals grammatical function in statements vs. questions                             | PPrI. Production of intonation patterns signaling pragmatic/affective changes in speech style from child-directed "motherese" to adult-directed       |
| Perception of <i>phrasing</i>  |   |
| GPeP. Perception of the grammatical meaning of pauses (to group words into phrases) within sentences                                 | GPeP. Perception of changes in rate to signify the affective function of anxiety within sentences   |
| Production of <i>phrasing</i>  |   |
| GPrP. Production of pauses to serve the grammatical function of grouping words into phrase) within sentences                         | PPrP. Use of changes in rate to signify the affective function of anxiety within sentences  |

analysis by a rater blind to subject diagnosis. All written responses were recorded on score sheets prepared for the study. Readability of the sentences used in the study was assessed using the Flesch-Kincaid Grade Level procedure that is included in the MicroSoft Word software package. Readability of the written stimuli was rated by this procedure at grade 1.3. Since the lowest functioning subject in the study had a written language grade equivalent of 2–3, and the average grade equivalent for written language was grade 5, the written stimuli used here are appropriate for the reading level of all subjects tested.

### Scoring

For all six Perception sections (grammatical stress, intonation, and phrasing; pragmatic/affective stress, intonation, and phrasing), subjects indicated responses by either marking one of two choices following a written, unpunctuated version of what they heard on the prerecorded stimuli (grammatical stress, intonation, phrasing, pragmatic stress), or pointing to a picture (pragmatic intonation and phrasing). When the subject recorded his own response on the score sheet, these were scored directly later by a rater blind to the subject's diagnostic classification. When the subject indicated a picture, the examiner marked the description of the picture (adult, child; calm, excited) on a score sheet following the subject's choice. (See Appendix for sample score sheets.)

For all six production sections, subjects' spoken responses were prerecorded and scored at a later time by an examiner blind to the subject's diagnostic classification.

### Task Description

The tasks listed in Table II are described below. Sentences within each set were presented in randomized order. There were 24 items in each task, consisting of 12 pairs of contrasting stimuli (e.g., *con vict*; *con vict*).

*Grammatical Perception of Stress (words chosen from Quirk, Greenbawn, Leech & Svartivik 1990)*

#### Instructions

Mark the sentence on your paper that contains the correct way of saying word you hear on the tape. For example, if you heard the word **recall** (re **call**) you would mark the first sentence in this pair:

I can't recall his name.

They had a recall on this model car.

But if you heard the word **recall** (*re call*), you would mark the second sentence.

[Each word is heard twice, once with the first syllable stressed (as a noun) and once with the second (as a verb). The same pair of sentence choices was presented for each of the two pronunciations.]

*Grammatical Production of Stress (words chosen from Quirk et al., 1990)*

#### Instructions

Read each sentence on your paper to yourself. Then read the underlined word aloud. For example, if you see the sentence

I can't recall his name.

You will read the underlined word as re **call**.

But if you see the sentence

They had a recall on this model car.

You will read the underlined word as **re call**.

*Grammatical Perception of Intonation (procedure based on Patel, Peretz, Tramo & Lebreave 1998)*

#### Instructions

Listen to each sentence on the tape, and mark on your paper whether the speaker is asking or telling. For example, if you hear "She has a dog," you would mark "telling." But if you hear, "She has a dog?" you would mark "asking."

*Grammatical Production of Intonation (procedure based on Patel, Perez, Tramo & Lebreque, 1998)*

#### Instructions

Listen to me tell you how to say each sentence written on your paper. Then read the sentence aloud the way I told you. For example, if I say, "For sentence #1, tell what he likes." You would read the sentence this way: "He likes ice cream." But if I say, "For sentence # 2, ask what he likes." You would read the sentence this way: "He likes ice cream?"

*Grammatical Perception of Phrasing (procedure based on Patel et al., 1998)*

#### Instructions

Listen to each sentence on the tape, then circle the correct answer to the question that follows it on

your paper. For example, if you hear “Ellen, the dentist, is here,” and the question reads “Is she talking to Ellen?” you would circle “no.” But if you hear “Ellen, the dentist is here,” and the question reads “Is she talking to Ellen?” you would circle “yes.”

*Grammatical Production of Phrasing (procedure based on Patel et al., 1998)*

#### Instructions

Listen as I read the first sentence in each pair. Then read the second sentence so that the one I read is true. For example, if I read this sentence:

Ellen is a dentist,

you could make that true by reading the second sentence like this:

“Ellen, the dentist, is here.”

But if I read

You are talking to Ellen,

you could make that true by reading the second sentence like this:

“Ellen, the dentist is here.”

*Pragmatic Perception of Stress (procedure based on Patel et al., 1998)*

#### Instructions

Read the two sentences on your paper to yourself. Then listen to the one on the tape. Check off the sentence that should come **before** the one you hear. For example, if you hear, “I want *chocolate* ice cream,” a sentence like “Do you want vanilla?” would have come before it. But if you hear, “I want chocolate *ice cream*,” the sentence before it is, “Do you want chocolate cake?”

*Pragmatic Production of Stress (procedure based on Patel et al., 1998)*

#### Instructions

Listen to me read the first sentence in each pair. Then read the second one aloud the way it would be spoken if you were answering me. For example, if I read, “Do you want vanilla?” the next sentence would sound like “I want *chocolate* ice cream.” But if I read, “Do you want chocolate cake?” the next sentence would sound like, “I want chocolate *ice cream*.”

#### *Pragmatic Perception of Intonation*

##### Instructions

Here is a picture of a baby, and here is a picture of an adult. Listen to each sentence on the tape, then point to the picture of the person the sentence is spoken to. For example, if I say, “You look nice {normal intonation}” you would think I was talking to this one {adult picture}. But if I say, “You look nice {motherese intonation},” you would think I was talking to this one {baby picture}.

#### *Pragmatic Production of Intonation*

##### Instructions

Read each sentence as if you were talking to the person in the picture by the sentence. For example, if you were talking to the adult, you would say, “You look nice {normal intonation}” But if you were talking to the baby, you would say, “You look nice motherese intonation.

#### *Pragmatic Perception of Phrasing*

##### Instructions

Here is a picture of a lady feeling calm, and here is a picture of a lady who is excited. Listen to each sentence on the tape, then point to the picture of the one who would be saying that sentence. For example, you hear

“You’re going to be late for school.”

you would think it was the calm-looking lady talking, so you would point to this picture. But your hear,

“You’re going to be late for school!!”

you would think it was the excited lady talking, so you would point to that picture.

#### *Pragmatic Production of Phrasing*

##### Instructions

Read each sentence as if it were said by someone who feels the way the person in the picture next to the sentence does. If you see a calm person, like this, you will read the sentence calmly, like this:

You’re going to be late for school.

But if you see the excited person, like this, you will read the sentence as if you were hurried and excited, like this:

You’re going to be late for school!!

*Reliability*

As stated earlier, responses to prosodic perception tasks were written by subjects on score sheets. These responses were entered into the study database directly from the subject’s response sheets. All responses to the prosodic production tasks produced by subjects with ASD were double scored by a second rater, as were the responses of 25% of the subjects with typical development (TD). Agreement was computed by dividing the score given by the first rater on each item for each subject on each production task by the score given by the second rater. Average agreement on the six production tasks computed in this way ranged from 82.3 to 99.6%. Overall agreement averaged across the six tasks was 90.0%.

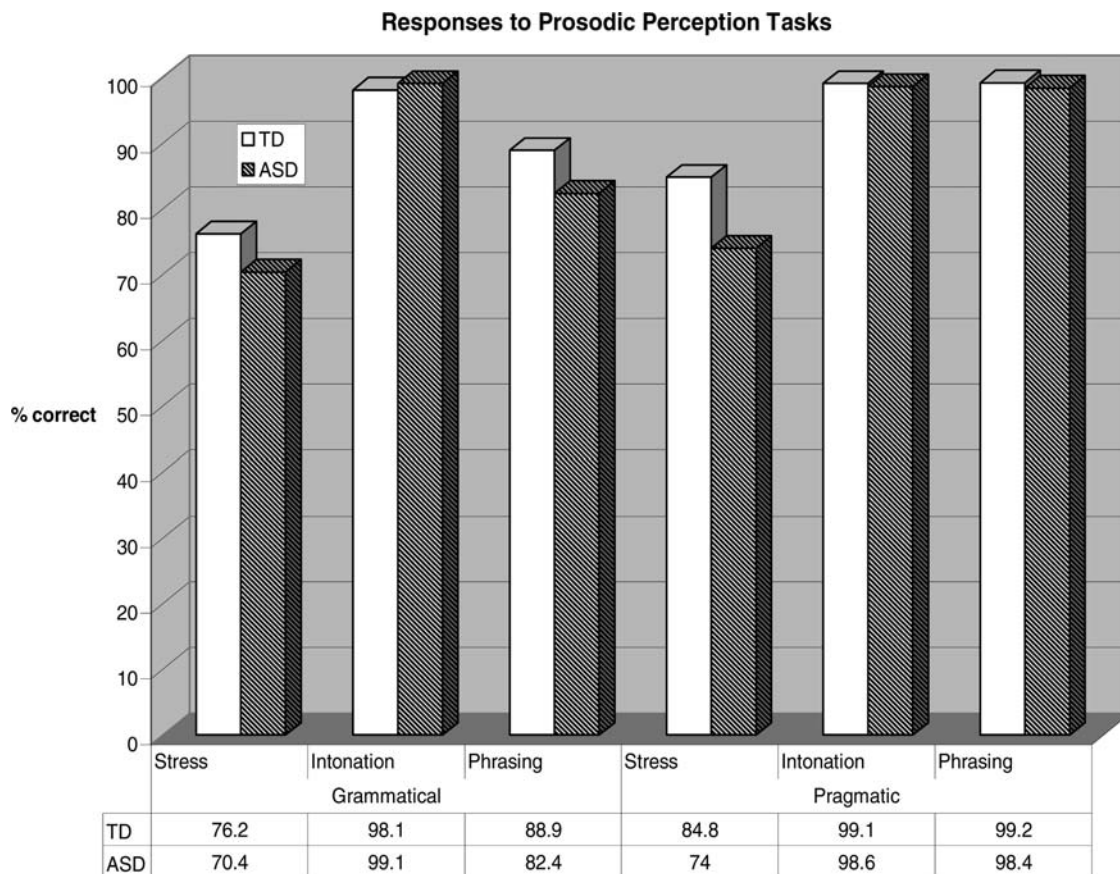
**RESULTS**

Figures 1 and 2 display the mean percentage correct scores on the six perception (Fig. 1) and six production (Fig. 2) tasks in the study.

To analyze results, a Mixed Model Repeated Measures Analysis of Variance was used, with diagnostic group as the between-subjects factor with two levels (ASD, TD). Within-subject factors were:

- Prosodic function, with two levels (grammatical, pragmatic/affective),
- Prosodic element, with three levels (stress, intonation, phrasing), and
- Prosodic mode, with two levels (perception, production).

Table III presents the outcome of this analysis. There were significant main effects for function and element, suggesting that all subjects responded differently to the grammatical vs. pragmatic/affective items, and to the three prosodic elements: stress, intonation and phrasing. There was also a non-significant trend toward an overall difference between the diagnostic groups. As seen in Figs 1 and 2, the subjects with TD, as a group, performed better than those with ASD on nine



**Fig. 1.** Percentage of correct responses to prosodic perception tasks in two diagnostic groups.

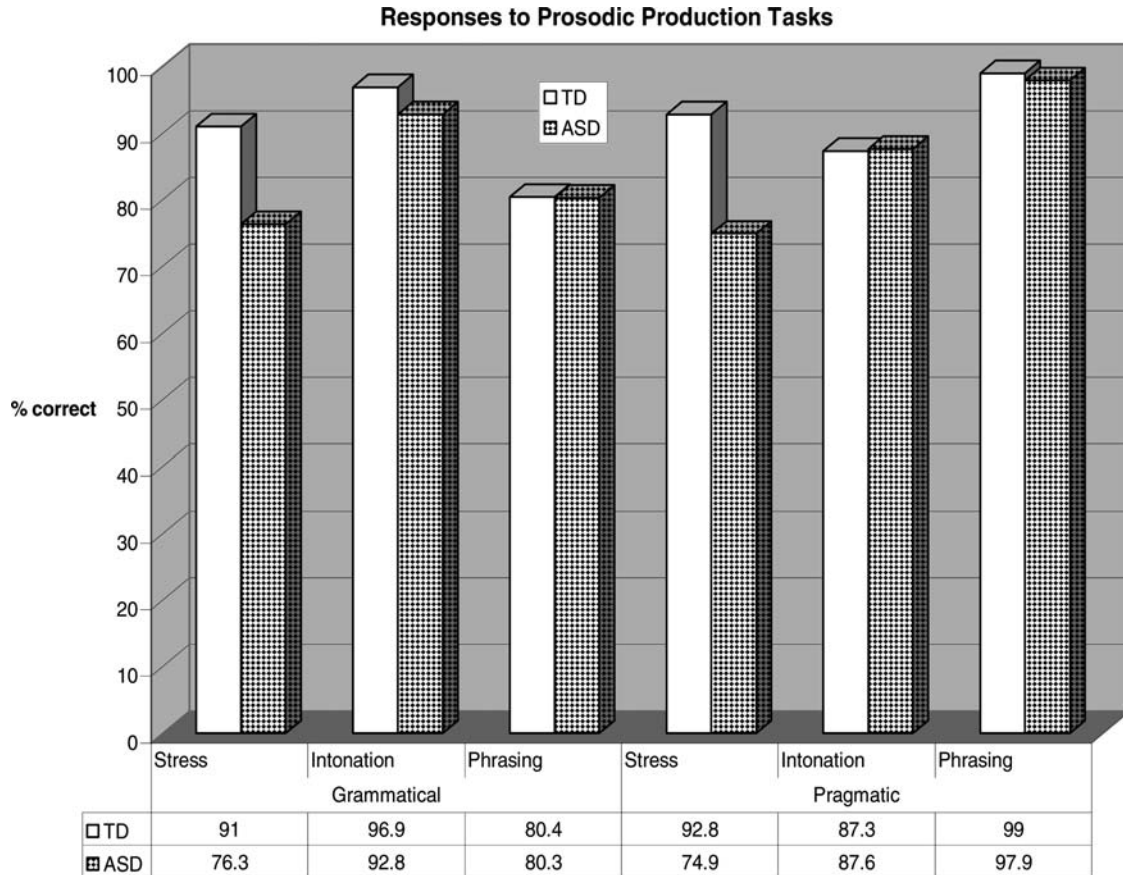


Fig. 2. Percentage of correct responses to prosodic production tasks in two diagnostic groups.

Table III. ANOVA results.

|                                | <i>F</i> | <i>p</i> < |
|--------------------------------|----------|------------|
| <i>Main effects</i>            |          |            |
| Diagnosis                      | 3.3      | .08**      |
| Function                       | 24.8     | .001*      |
| Element                        | 43.3     | .001*      |
| Mode                           | .31      | .58        |
| <i>Two-way interactions</i>    |          |            |
| Function × Dx                  | .01      | .93        |
| Function × element             | 20.71    | .001*      |
| Function × mode                | 3.14     | .001*      |
| Element × Dx                   | 6.90     | .002*      |
| Element × mode                 | 33.7     | .001*      |
| Mode × Dx                      | .56      | .46        |
| <i>Three-way interactions</i>  |          |            |
| Function × element × Dx        | .30      | .74        |
| Function × element × Mode      | 6.57     | .002*      |
| Function × mode × Dx           | .02      | .89        |
| Element × mode × Dx            | 3.80     | .09        |
| <i>Four-way interaction</i>    |          |            |
| Function × element × mode × Dx | 1.00     | .37        |

\*Significant at *p* < .002, \*\* Approaches significance.

of the twelve tasks, and on the other three performances was similar in the two groups.

Several significant interaction effects were also seen:

1. Element × mode: suggesting there were differences in responses among the three prosodic elements depending on the modality (perception or production) of response.
2. Element × function: suggesting there were differences among the three prosodic elements depending on prosodic function (grammatical vs. pragmatic/affective).
3. Function × mode: suggesting there were differences between the two functions (grammatical vs. pragmatic/affective), depending on the modality.
4. Element × Dx: The two diagnostic groups showed different patterns of response to the three prosodic elements.

There was not, however, the predicted interaction between diagnostic group and prosodic function,



suggesting the subjects with ASD did not show different response patterns from peers with TD to grammatical vs. pragmatic/affective prosody tasks. It should be noted, however, that there were ceiling effects in these data. As can be seen in Figs 1 and 2, five of the twelve tasks showed performance in both groups near 100%:

- Grammatical perception of intonation
- Grammatical production of intonation
- Pragmatic/affective perception of phrasing
- Pragmatic/affective production of phrasing
- Pragmatic perception of intonation

These tasks would appear to be too easy for these subjects to tap their underlying competence in the constructs of interest, and may be obscuring differences that would be present in more difficult prosodic activities.

In order to look more closely at between-diagnostic group differences, post-hoc tests were carried out for each of the 12 diagnostic group comparisons. The results of this analysis appear in Table IV. It can be seen there that there were significant differences between the two groups in the grammatical production of stress, as well as in the pragmatic/affective perception and production of stress. Moreover, there was a trend toward significance in the difference between groups on the grammatical perception of stress, and this difference was larger than any other non-significant finding. No other between-group differences reached significance.

**Table IV.** Post-hoc Tests for Differences Between Diagnostic Groups.

| Prosodic Task                                | t      | p <  |
|--|--------|------|
| Grammatical perception of stress             | 1.58** | .12  |
| Grammatical production of stress             | 3.51*  | .001 |
| Pragmatic/affective perception of stress     | 2.16*  | .038 |
| Pragmatic/affective production of stress     | 3.02*  | .004 |
| Grammatical perception of intonation         | -.73   | .47  |
| Grammatical production of intonation         | 1.05   | .30  |
| Pragmatic/affective perception of intonation | .38    | .71  |
| Pragmatic/affective production of intonation | -.05   | .96  |
| Grammatical perception of phrasing           | 1.31   | .20  |
| Grammatical production of phrasing           | .011   | .99  |
| Pragmatic/affective perception of phrasing   | .47    | .64  |
| Pragmatic/affective production of phrasing   | .63    | .54  |

\*significant at  $p < .004$ , \*\*Approaches significance.

## DISCUSSION

This study suggests that speakers with ASD show differences from typical age-mates in select areas of prosodic performance. It provides support, first, for the finding reported by Shriberg *et al.*, (2001) that stress is an area of particular difficulty for these speakers. Tasks involving stress that were most affected included both production and perception of pragmatic/affective, or emphatic stress. Production of grammatical, or lexical stress was also affected, and perception of lexical stress showed a difference that approached significance. Thus both understanding and producing appropriate stress patterns appear to be difficult for these speakers with ASD, regardless of whether stress is used in the service of grammatical or pragmatic/affective functions.

Stress appeared to be the only area of prosodic function in which significant differences were found. However, in examining the data in Figs 1 and 2, it is clear that for five of the 12 tasks, both groups scored above 90% correct. This finding suggests that these tasks were simply too easy for the present subjects. Examining the tasks that fell in this group, it appears that both grammatical understanding and use of the intonation pattern that distinguishes statements from questions (grammatical perception and production of Intonation) are well established in both diagnostic groups. Both groups also appeared able to distinguish child-directed from adult-directed speech (pragmatic/affective perception of intonation) consistently.

There were no differences between the groups on pragmatic/affective production of intonation, or the ability to use child-directed and adult-directed speech styles appropriately. Performance for neither group reached a ceiling; both groups scored in the 80–90% correct range. However, it was our impression that the teenagers with TD were frequently embarrassed to produce a child-directed speech style in the presence of the relatively unknown and only slightly older examiner (AA). The speakers with ASD, on the other hand, gave us the impression that they were trying their best to comply with the task and did not show any noticeable signs of embarrassment at this task. It is possible, then, that in a different testing circumstance, such as in the presence of a more compelling child-addressee than the pictures provided here, and without the presence of another person to make the TD speakers feel foolish, a greater difference on this task might have been seen. Only further experimentation will allow for the verification of this speculation.

For pragmatic/affective perception and production of phrasing, we again saw near-ceiling performance in both groups. Clinical impressions lead us again, however, to raise questions about the validity of these findings. Here we observed that the speakers with ASD appeared to adopt a “strategy” for approaching this task. That is, in the recordings of the “excited” versions of the sentences in the task, the rate of speech was very rapid and pause time within sentences was reduced. In the “calm” versions, speech was at a slightly slower-than-normal rate with normal pauses. It was our observation that subjects with ASD “cued in” to the rate difference and used it exclusively to solve the problem posed in these tasks. We were led to this impression by the fact that, unlike the TD subjects, ASD subjects frequently did not listen to the whole sentence before choosing the “calm” or “excited” picture in response to the perception items. As soon as they were able to discern the rate in the stimulus, often after only the first or second word in the prerecorded sentence, they made their choice. The TD teenagers, on the other hand, listened to the entire sentence and make their judgment based on a more wholistic assessment of the emotion conveyed. In the production of pragmatic phrasing task, we observed a similar phenomenon. The speakers with ASD often produced sentences in a somewhat rote, speeded up production when an “excited” version was indicated. Although these versions were considered correct by the blind rater, they often lacked, subjectively, some portion of the affective quality of excitement, beyond the rapid rate.

The other tasks in which there were neither differences nor ceiling effects involved grammatical perception and production of phrasing, examined here by the ability to use pauses to signal referential vs. non-referential phrases within sentences [*Ellen, the dentist, (appositive phrase) is here* vs. *Ellen, (addressee) the dentist is here*]. Here it appeared that the task was a bit difficult for both groups, with accuracy again between 80 and 90% correct. We did not observe any noticeable difference in the way the two groups approached this task, however.

To summarize the findings of this study, then, it could be said that all aspects of stress examined appeared to pose some difficulty for speakers with ASD. In grammatical areas of areas of intonation and phrasing, we did not observe differences either quantitatively or qualitatively, but there were ceiling effects on both perception and production of grammatical intonation that may have affected results. Ceiling effects may also have limited the ability to find differ-

ences in the pragmatic perception of intonation. For pragmatic production of Intonation, contextual factors, i.e., the TD teenagers’ reluctance to talk “baby talk” with an unfamiliar young examiner may have limited their performance in this task. For pragmatic phrasing, qualitative observations suggest that speakers with ASD may have achieved a ceiling level on these tasks by the adoption of a “talk fast/talk slow” strategy for solving the problem of identifying and producing agitated affect, rather than using a more wholistic approach to understanding and expressing prosodic cues to the feeling of excitement.

Thus, it would be possible to suggest that even though we failed to find the predicted interaction effect between diagnostic group and prosodic function in these data, further research with more refined tasks may yet show that speakers with ASD do have more difficulty with some aspects of pragmatic/affective prosody than they do with these same elements in grammatical contexts. Only additional experimental work in this area can determine whether or not this suggestion is borne out. The finding that although there were differences in both grammatical and pragmatic/affective stress tasks, the differences between speakers with ASD and TD were consistently larger on the pragmatic/affective than the grammatical tasks tends to lend some support to this speculation.

### Clinical Implications

Suggestions for addressing the prosodic deficits of speakers with ASDs can be drawn from both the quantitative and qualitative results of this study. Quantitatively, it appears that learning to understand and use stress to express a variety of meanings is a reasonable goal for speakers with ASD who evidence prosodic oddities. For these speakers, focus on the communicative value of stress, to highlight important elements in the message, by making them louder and longer than other words would seem a reasonable approach. Metalinguistic activities in which students with ASD identify important words in sentences, then experiment with ways to vocally highlight those words, using both clinician feedback and self-monitoring through review of recordings of the various methods of emphasis tried, might be helpful.

The qualitative observations regarding the ways in which speakers with ASD approached the tasks in this study are also revealing. Just as these subjects can score quite high on standard language measures, at the same time as they perform remarkably lower on measures of adaptive communication, they appear to

be able to focus on a limited number of cues in order to solve the problems posed by these items, without necessarily possessing the full panoply of prosodic tools that result in natural-sounding expression. This finding suggests a danger in focusing too narrowly on one aspect of prosody when attempting to change prosodic performance. A metalinguistic approach, which features talking about what prosody is, what it is used for, using examples that serve a range of functions with a range of prosodic elements may be a better approach than treating one element in one context before moving on to another.

### Future Research

Although this study attempted to address some of the shortcomings of the earlier literature on prosody in ASD, it has by no means solved them all. In addition to the limitations reflected in the ceiling effects and qualitative observations discussed here, it must be remembered that the present study continued to use simple perceptual judgments for deciding when a prosodic production was correct or not. In addition, natural, uncontrolled speech was used as the stimuli for perception tasks. Research that involves more controlled stimuli, perhaps using advanced synthesized speech, and more objective measures of prosodic output, incorporating acoustic analyses would clearly be an improvement on the present methods. Similarly, using non-ASD contrast groups would extend our understanding of the role of prosody in this and other disorders. Several studies have shown, for example, that children with specific language disorders (Baltaxe, Simmons & Zee, 1984; Hargrove, 1997; Gerken & McGregor, 1998) and mental retardation (Shriberg & Widder, 1990) also exhibit prosodic deficits. Learning more about the similarities and differences in prosody across these diagnostic groups would clearly enhance understanding of its role in communication in these populations.

### ACKNOWLEDGMENTS

Preparation of this paper was supported by Research Grant P01-03008 funded by the National Institute of Mental Health (NIMH); by the STAART Center grant U54 MH66494 funded by the National Institute on Deafness and Other Communication Disorders (NIDCD), the National Institute of Environmental Health Sciences (NIEHS), the National

Institute of Child Health and Human Development (NICHD), and the National Institute of Neurological Disorders and Stroke (NINDS); by a MidCareer Development grant to Dr. Paul, K24 HD045576 funded by NIDCD, as well as by the National Alliance for Autism Research. We wish to extend our thanks to Kate Elliott for completing the blind scoring and reliability studies for this project.

## APPENDIX 1

### Appendix. Samples of Scoresheets and Items for Prosody Tasks.

#### Grammatical Perception of Stress (from Quirk *et al.*, 1990)

*Instructions:* Mark the sentence that contains the correct way of saying word you hear on the tape.

#### conduct

- Your conduct in school should be better.
- You must conduct yourself quietly in the library.

#### convict

- The convict escaped from prison.
- The jury voted to convict him.

#### decrease

- Working after school led to a decrease in her GPA.
- He was able to decrease his time on the job.

#### increase

- I received an increase in pay.
- This movie will increase her chances for an Oscar.

#### insult

- It is an insult to call someone stupid.
- You may insult them if you don't invite them.

#### present

- She gave me a present.
- I present you with this award.

#### permit

- He got his permit on his sixteenth birthday.
- Her parents won't permit her to date.

#### produce

- I go to the farmers' market for fresh produce.
- They produce lots of shoes in China.

#### protest

- He led a protest against the dress code.
- She may protest the principle's decision.

#### progress

- The students made a lot of progress this year.
- He is not ready to progress to Algebra II.

#### record

- They set a new world's record.
- He plans to record a new CD.

## Appendix. Continued.

**refill**

- \_\_\_ You get a free refill on this drink.  
 \_\_\_ Ask the waitress to refill my coffee.

Grammatical Production of Stress

*Instructions:* Read each sentence to yourself. Then read the underlined word aloud, the way it would sound in that sentence.

1. Your conduct in school should be better.
2. The jury voted to convict him.
3. Ask the waitress to refill my coffee.
4. I received an increase in pay.
5. It is an insult to call someone stupid.
6. This movie will increase her chances for an Oscar.
7. She gave me a present.
8. A vacation will decrease my stress level.
9. You must conduct yourself quietly in the library.
10. I present you with this award.
11. The convict escaped from prison.
12. He marched in an animal rights protest.
13. They produce lots of shoes in China.
14. The students made a lot of progress this year.
15. Her parents won't permit her to date.
16. I go to the farmers' market for fresh produce.
17. He got his permit on his sixteenth birthday.
18. You get a free refill on this drink.
19. He plans to record a new CD.
20. He is not ready to progress to high school.
21. You may insult them if you don't invite them.
22. She will protest the principle's decision.
23. He got a decrease on his taxes.
24. They set a new world's record.

Grammatical Perception of Intonation (from Patel *et al.* 1998)

*Instructions:* Listen to each sentence on the tape, and check off whether the speaker is asking or telling. For example, if you hear "She has a dog," you would check off "telling." But if you hear, "She has a dog?" you would check off "asking."

*Stimuli*

- |   |               |
|---|---------------|
| He speaks French                                    |               |
| asking _____  | telling _____ |
| Francis is at the restaurant                        |               |
| asking _____  | telling _____ |
| She drinks three large cups of coffee every morning |               |
| asking _____  | telling _____ |
| He wants to leave now                               |               |
| asking _____  | telling _____ |
| She plays the flute                                 |               |
| asking _____  | telling _____ |
| He likes to drive fast cars                         |               |
| asking _____  | telling _____ |
| He wants to buy a house next to the beach.          |               |
| asking _____  | telling _____ |
| She forgot her book                                 |               |
| asking _____  | telling _____ |
| He has been in Paris for three months               |               |
| asking _____  | telling _____ |

## Appendix. Continued.

- |                                     |               |
|-------------------------------------|---------------|
| The supermarket is closed on Sunday |               |
| asking _____                        | telling _____ |
| He works ten hours a day,           |               |
| asking _____                        | telling _____ |
| The telephone doesn't work          |               |
| asking _____                        | telling _____ |

Grammatical Production of Intonation (from Patel *et al.*, 1998)

*Instructions:* Listen to me read the first sentence in each pair. Then read the second sentence aloud the way I've told you. For example, if I read, "Tell what he likes." You would read the following sentence this way: "He likes ice cream." But if I read, "Ask what he likes." You would read the sentence this way: "He likes ice cream?"

*Stimuli*

Tell what he speaks.

**He speaks French**

Tell where Francis is.

**Francis is at the restaurant**

Ask about what she drinks.

**She drinks three large cups of coffee every morning**

Tell what he wants

**He wants to leave now**

Ask about what she plays.

**She plays the flute**

Ask about what he likes.

**He likes to drive fast cars**

Ask about what he wants.

**He wants to buy a house next to the beach**

Tell what she forgot.

**She forgot her book**

Tell where he's been.

**He has been in Paris for three months**

Ask about when the market is closed.

**The supermarket is closed on Sunday**

Ask about how long he works.

**He works ten hours a day**

Tell what went wrong

**The telephone doesn't work**

Pragmatic Perception of Stress (based on Patel *et al.*, 1998)

*Instructions:* Read the two sentences to yourself. Then listen to the one on the tape. Check off the sentence that should come before the one you hear. For example, if you hear "I want *chocolate* ice cream," a sentence like "Do you want vanilla?" would probably have come before it. But if you hear "I want chocolate *ice cream*," the sentence before it is probably, "Do you want chocolate cake?"

*Stimuli.*

- \_\_\_ I waited for you out back.  
 \_\_\_ I waited by the grocery store.

**Go in front of the bank, I said./Go in front of the bank, I said.**

Appendix. Continued.

\_\_\_ He wore the red tie for you.  
 \_\_\_ He wore the blue scarf for you.  
**I like blue ties on gentlemen./I like blue ties on gentlemen.**

\_\_\_ Which exam do you want to take?  
 \_\_\_ When do you want to take the exam?  
**Give me the math exam today, if you can./Give me the math exam today, if you can.**

\_\_\_ Did you like my singing or my dancing?  
 \_\_\_ How did you like my concert?  
**You sing well, Paul./You sing well, Paul.**

\_\_\_ Which flowers do you like?  
 \_\_\_ Do the flowers or the cologne smell better?  
**The orange flowers smell very sweet./The orange flowers smell very sweet.**

\_\_\_ Shall I take the train?  
 \_\_\_ Shall I take it to New York?  
**Take the bus to Boston, Anne./Take the bus to Boston, Anne.**

\_\_\_ Whose book was left there?  
 \_\_\_ What did he forget?  
**Paul's book is at my house./Paul's book is at my house.**

\_\_\_ Which umbrella is cheaper?  
 \_\_\_ Shall I get the umbrella or the raincoat?  
**The pink umbrella is less expensive./The pink umbrella is less expensive.**

\_\_\_ Does he read romances?  
 \_\_\_ What kind of books does he like to talk about?  
**He likes to talk about romance novels./He likes to talk about romance novels.**

\_\_\_ Whose sister is that?  
 \_\_\_ Who is that?  
**It's Jack's sister, isn't it?/It's Jack's sister, isn't it?**

\_\_\_ You can take a week off next month.  
 \_\_\_ You can take a couple days off.  
**I need two weeks of vacation./I need two weeks of vacation.**

\_\_\_ Shall I read my lines now?  
 \_\_\_ When shall I do the song?  
**Sing now, please./Sing now, please.**

Pragmatic Production of Stress

*Instructions:* Listen as I read the first sentence to you. Then read the second sentence as if you were answering

He wore the red tie for you.  
**I prefer blue ties on gentlemen.**

Shall I get the umbrella or the raincoat?  
**The pink umbrella is less expensive.**

Did you like my singing or my dancing?  
**You sing well Paul.**

Which test will you take first?  
**Give me the math exam today if you can.**

What did he forget?  
**Paul's book is at my house.**

Appendix. Continued.

Shall I take the train?  
**Take the bus to Boston, Anne.**

Do the flowers or the cologne smell better?  
**The orange flowers smell very sweet.**

Does he read romances?  
**He likes to talk about romance novels.**

I waited by the grocery store.  
**Go in front of the bank I said.**

You can take a week off next month.  
**I need two weeks of vacation.**

Who is that?  
**It's Jack's sister, isn't it?**

When do you want to take the exam?  
**Give me the math exam today if you can.**

Shall I read my lines now?  
**Sing now, please.**

You can take a couple days off.  
**I need two weeks of vacation.**

I waited for you out back.  
**Go to the front of the bank, I said.**

Whose sister is that?  
**It's Jack's sister, isn't it?**

When shall I do the song?  
**Sing now, please.**

How did you like my concert?  
**You sing well Paul.**

Whose book was left there?  
**Paul's book is at my house.**

What kind of books does he like to talk about?  
**He likes to talk about romance novels.**

Which umbrella is cheaper?  
**The pink umbrella is less expensive.**

He wore the blue scarf for you.  
**I prefer blue ties on gentlemen.**

Which flowers do you like?  
**The orange flowers smell very sweet.**

Shall I take it to New York?  
**Take the bus to Boston Anne.**

Pragmatic/Affective Perception of Intonation

*Instructions:* Listen to each sentence on the tape. After you hear it, point to the picture of the person the lady is talking TO.

| Sentence heard on tape in adult- or child-directed speech style | Pictures displayed |       |
|---|--------------------|-------|
|   | Adult              | Child |
| 1. Have fun.  | Adult              | Child |
| 2. I found your car.  | Adult              | Child |
| 3. I need your help.  | Adult              | Child |
| 4. Do you want a drink?   | Adult              | Child |

Appendix. Continued.

|                                      |       |       |
|--------------------------------------|-------|-------|
| 5. Can you come here?                | Adult | Child |
| 6. Your brother is here.             | Adult | Child |
| 7. Do you want ice cream?            | Adult | Child |
| 8. We are going to Aunt Ruth's now.  | Adult | Child |
| 9. What do you need?                 | Adult | Child |
| 10. Get the ball, please.            | Adult | Child |
| 11. Where is your jacket?            | Adult | Child |
| 12. Is this your book?               | Adult | Child |
| 13. Your brother is here.            | Adult | Child |
| 14. What do you need?                | Adult | Child |
| 15. Have fun.                        | Adult | Child |
| 16. Do you want ice cream?           | Adult | Child |
| 17. Where is your jacket?            | Adult | Child |
| 18. I found your car.                | Adult | Child |
| 19. I need your help.                | Adult | Child |
| 20. Is this your book?               | Adult | Child |
| 21. We are going to Aunt Ruth's now. | Adult | Child |
| 22. Get the ball, please.            | Adult | Child |
| 23. Can you come here?               | Adult | Child |
| 24. Do you want a drink?             | Adult | Child |

Pragmatic/Affective Perception of Phrasing

Instructions: Listen to each sentence on the tape. After you hear it, point to the picture of the person who feels like the speaker.

| Sentence heard on tape in calm or excited speech style | Pictures displayed |         |
|--|--------------------|---------|
| She bought huge new car.                               | Calm               | Excited |
| They said they would be back by ten.                   | Calm               | Excited |
| We have a math test today.                             | Calm               | Excited |
| He needs a drink of water.                             | Calm               | Excited |
| Get a clean, white towel.                              | Calm               | Excited |
| It is nearly six o'clock.                              | Calm               | Excited |
| There are animals in the room.                         | Calm               | Excited |
| He left his medicine at school.                        | Calm               | Excited |
| The campfire is out.                                   | Calm               | Excited |
| My keys are in the house.                              | Calm               | Excited |
| She bought huge new car.                               | Calm               | Excited |
| He went sailing on the ocean.                          | Calm               | Excited |
| The engine must be flooded.                            | Calm               | Excited |
| Get a clean, white towel.                              | Calm               | Excited |
| He needs a drink of water.                             | Calm               | Excited |
| The campfire is out.                                   | Calm               | Excited |
| There are animals in the room.                         | Calm               | Excited |
| He went sailing on the ocean.                          | Calm               | Excited |
| The engine must be flooded.                            | Calm               | Excited |
| They said they would be back by ten.                   | Calm               | Excited |
| We have a math test today.                             | Calm               | Excited |
| It is nearly six o'clock.                              | Calm               | Excited |
| My keys are in the house.                              | Calm               | Excited |
| He left his medicine at school.                        | Calm               | Excited |

Pragmatic/Affective Production of Phrasing

Instructions: Read each sentence as if you felt like the person in the picture next to it feels.

|                                  | Picture displayed |
|----------------------------------|-------------------|
| 1. Get a clean, white towel.     | Excited           |
| 2. He went sailing on the ocean. | Calm              |

Appendix. Continued.

|  |         |
|--|---------|
| 3. He needs a drink of water.            | Calm    |
| 4. There are animals in the room.        | Excited |
| 5. He went sailing on the ocean.         | Calm    |
| 6. My keys are in the house.             | Calm    |
| 7. She bought huge new car.              | Excited |
| 8. Get a clean, white towel.             | Excited |
| 9. There are animals in the room.        | Calm    |
| 10. They said they would be back by ten. | Excited |
| 11. We have a math test today.           | Calm    |
| 12. The engine must be flooded.          | Calm    |
| 13. She bought huge new car.             | Excited |
| 14. It is nearly six o'clock.            | Calm    |
| 15. The campfire is out.                 | Excited |
| 16. He left his medicine at school.      | Excited |
| 17. The engine must be flooded.          | Calm    |
| 18. My keys are in the house.            | Calm    |
| 19. He needs a drink of water.           | Excited |
| 20. It is nearly six o'clock.            | Excited |
| 21. We have a math test today.           | Calm    |
| 22. He left his medicine at school.      | Excited |
| 23. They said they would be back by ten. | Calm    |
| 24. The campfire is out.                 | Excited |

REFERENCES

American Psychiatric Association. (1994). *Diagnostic and statistical manual of mental disorders (4th ed)*. Washington, DC: Author.

Baltaxe, C. (1984). Use of contrastive stress in normal, aphasic, and autistic children. *Journal of Speech and Hearing Research* 24, 97-105.

Baltaxe, C., & Guthrie, D. (1987). The use of primary sentence stress by normal, aphasic, and autistic children. *Journal of Autism and Developmental Disorders* 17, 255-271.

Baltaxe, C., & Simmons, J. (1985). Prosodic development in normal and autistic children. In E. Schopler, & G. Mesibov (Eds.), *Communication problems in autism* (pp. 95-125). New York: Plenum Press.

Baltaxe, C., & Simmons, J. (1992). A comparison of language issues in high-functioning autism and related disorders with onset in children and adolescence. In E. Schopler & G. Mesibov (Eds.), *High functioning individuals with autism* (pp. 210-225). New York: Plenum Press.

Baltaxe, C., Simmons, J., & Zee, E. (1984). Intonation patterns in normal, autistic and aphasic children. In A. Cohen, & M. Broecke van de (Eds.), *Proceedings of the Tenth International Congress of Phonetic Sciences* (pp. 713-718). Dordrecht, The Netherlands: Foris Publications.

Bates, E., & McWhinney, B. (1979). A functionalist approach to the acquisition of grammar. In E. Ochs, & B. Schieffelin (Eds.), *Developmental pragmatics* (pp. 167-211). New York: Academic Press.

Bolinger, D. (1989). *Intonation and its uses: Melody in grammar and discourse*. Stanford, CA: Stanford University Press.

Boucher, J., Lewis, V., & Collis, G. (1998). Familiar face and voice matching and recognition in children with autism. *Journal of Child Psychology and Psychiatry* 39, 171-182.

Carter, A., Volkmar, F., Sparrow, S., Wang, J., Lord, C., Dawson, G., Fombonne, E., Loveland, K., Mesibov, G., & Schopler, E. (1998). The Vineland Adaptive Behavior Scales: Supplementary norms for individuals with autism. *Journal of Autism and Developmental Disorders* 28, 287-302.

- Crystal, D. (1986). Prosodic development. In P. Fletcher & M. Garman (Eds.), *Language acquisition* (pp. 33–48). Cambridge, UK: Cambridge University Press.
- DeMyer, M., Barton, S., DeMyer, W., Norton, J., Allen, J., & Stelle, R. (1973). Prognosis in autism: A follow-up study. *Journal of Autism and Childhood Schizophrenia* 3, 199–246.
- Fay, W. (1969). On the basis of autistic echolalia. *Journal of Communication Disorders* 2, 38–47.
- Fay, W., & Schuler, A. (1980). *Emerging language in autistic children*. Baltimore, MD: University Park Press.
- Fine, J., Bartolucci, G., Ginsberg, G., & Szatmari, P. (1991). The use of intonation in pervasive developmental disorders. *Journal of Child Psychology and Psychiatry* 32, 771–782.
- Fosnot, S., & Jun, S. (1999). Prosodic characteristics in children with stuttering or autism during reading and imitation. *Proceedings of the 14th International Congress of Phonetic Sciences*. pp. 1925–1928.
- Gerken, L. (1996). Prosody's role in language acquisition and adult parsing. *Journal of Psycholinguistic Research* 25, 345–356.
- Gerken, L., & McGregor, K. (1998). An overview of prosody and its role in normal and disordered child language. *American Journal of Speech-Language Pathology* 7(2), 38–48.
- Ghaziuddin, M., & Gerstein, L. (1996). Pedantic speaking style differentiates Asperger syndrome from high-functioning autism. *Journal of Autism and Developmental Disorders* 26, 585–595.
- Hargrove, P. (1997). Prosodic aspects of language impairment in children. *Topics in Language Disorders* 17(4), 76–83.
- Haviland, S., & Clark, H. (1974). What's new: Acquiring new information as a process in comprehension. *Journal of Verbal Learning and Verbal Behavior* 8, 166–169.
- Hobson, R., Ouston, J., & Lee, A. (1988). Emotion recognition in autism: Coordinating faces and voices. *Psychological Medicine* 18, 911–923.
- Hobson, R., Ouston, J., & Lee, A. (1989). Naming emotion in faces and voices: Abilities and disabilities in autism and mental retardation. *British Journal of Developmental Psychology* 7, 237–250.
- Kanner, L. (1943). Autistic disturbances of affective contact. *Nervous Child* 2, 217–250.
- Kanner, L. (1971). Follow-up of eleven autistic children, originally reported in 1943. *Journal of Autism and Childhood Schizophrenia* 2, 119–145.
- Kent, R., & Read, C. (1992). *The acoustic analysis of speech*. San Diego, CA: Singular Publishing Group.
- Klin, A., Lang, J., Cicchetti, D. V., & Volkmar, F. R. (2000). Interrater reliability of clinical diagnosis and DSM-IV criteria for autistic disorder: Results of the DSM-IV autism field trial. *Journal of Autism and Developmental Disorders* 30(2), 163–167.
- Landa, R. (2000). Social language use in Asperger syndrome and high-functioning autism. In A. Klin, F. Volkmar & S. Sparrow (Eds.), *Asperger syndrome* (pp. 125–158). New York: Guilford Press.
- Liss, M., Harel, B., Fein, D., Allen, D., Dunn, M., Feinstein, C., Morris, R., Waterhouse, L., & Rapin, I. (2001). Predictors and correlates of adaptive functioning in children with developmental disorders. *Journal of Autism and Developmental Disorders* 31, 219–230.
- Lord, C., Rutter, M., & LeCouteur, A. (1994). Autism Diagnostic Interview – Revised: A revised version of a diagnostic interview for caregivers of individuals with possible pervasive developmental disorders. *Journal of Autism and Developmental Disorders* 24(5), 659–685.
- Lord, C., & Pickles, A. (1996). The relationship between expressive language level and nonverbal social communication in autism. *Journal of the American Academy of Child and Adolescent Psychiatry*.
- Lord, C., Risi, S., Lambrecht, L., Cook, E. H. Jr., Leventhal, B. L., DiLavore, P. C., Pickles, A., & Rutter, M. (2000). The Autism Diagnostic Observation Schedule – Generic: A standard measure of social and communication deficits associated with the spectrum of autism. *Journal of Autism and Developmental Disorders* 30(3), 205–223.
- Loveland, K., & Kelley, M. (1991). Development of adaptive behavior in preschoolers with autism or Down syndrome. *American Journal of Mental Retardation* 96, 13–20.
- McCaleb, P., & Prizant, B. (1985). Encoding of new versus old information by autistic children. *Journal of Speech and Hearing Disorders* 50, 30–240.
- McCann, J., & Peppe, S. (2003). Prosody in autism spectrum disorders: A critical review. *International Journal of Language and Communication Disorders* 38, 25–350.
- Merewether, R., & Alpert, M. (1990). The components and neuroanatomic bases of prosody. *Journal of Communication Disorders* 23, 325–336.
- Mesibov, G. (1992). Treatment issues with high-functioning adolescents and adults with autism. In E. Schopler, & G. Mesibov (Eds.), *High functioning individuals with autism* (pp. 143–156). New York: Plenum Press.
- Ornitz, E., & Ritvo, E. (1976). Medical assessment. In E. Ritvo (Ed.), *Autism: Diagnosis, current research, and management* (pp. 7–26). New York: Spectrum Publications.
- Paccia, J., & Curcio, F. (1982). Language processing and forms of immediate echolalia in autistic children. *Journal of Speech and Hearing Research* 25, 42–47.
- Panagos, J., & Prelock, P. (1997). Prosodic analysis of child speech. *Topics in Language Disorders* 17(4), 1–10.
- Patel, A., Peretz, I., Tramo, M., & Lebreque, R. (1998). Processing prosodic and musical patterns: A neuropsychological investigation. *Brain and Language* 43, 4–11.
- Paul, R. (1987). Communication. In D. Cohen, & A. Donnellan (Eds.), *Handbook of autism and pervasive developmental disorders* (pp. 61–84). New York: Wiley.
- Paul, R., Shriberg, L., McSweeney, J., Cicchetti, D., Klin, A., & Volkmar, F. (in press). Relations between prosodic performance and communication and socialization ratings in high functioning speakers with autism spectrum disorders. *Journal of Autism and Developmental Disorders*.
- Pronovost, W., Wakstein, M., & Wakstein, D. (1966). A longitudinal study of speech behavior and language comprehension in fourteen children diagnosed as atypical or autistic. *Exceptional Children* 33, 19–26.
- Quirk, R., Greenbaum, S., Leech, G., & Svartvik, J. (1990). *A comprehensive grammar of the English language*. N.Y.: Longman.
- Rodrigue, J., Morgan, S., & Gefken, G. (1991). A comparative evaluation of adaptive behavior in children and adolescents with autism Down syndrome and normal development. *Journal of Autism and Developmental Disorders* 21, 187–198.
- Ricks, D. (1975). Vocal communication in pre-verbal normal and autistic children. In N. O'Connor (Ed.), *Language, cognitive deficits, and retardation* (pp. 245–268). London: Butterworths.
- Schatz, J., & Hamdan-Allen, G. (1995). Effects of age and IQ on adaptive behavior domains for children with autism. *Journal of Autism and Developmental Disorders* 25, 51–60.
- Shriberg, L. D., & Widder, C. J. (1990). Speech and prosody characteristics of adults with mental retardation. *Journal of Speech and Hearing Research* 33, 627–653.
- Shriberg, L. D., Kwiatkowski, J., & Rasmussen, C. (1990). *The prosody-voice screening profile*. Tucson, AZ: Communication Skill Builders.
- Shriberg, L., Paul, R., McSweeney, J., Klin, A., Cohen, D., & Volkmar, F. (2001). Speech and prosody characteristics of adolescents and adults with high functioning autism and Asperger syndrome. *Journal of Speech, Language and Hearing Research* 44, 1097–1115.

- Simmons, J., & Baltaxe, C. (1975). Language patterns in adolescent autistics. *Journal of Autism and Childhood Schizophrenia* 5, 333–351.
- Sparrow, S., Balla, D., & Cicchetti, D. (1984). *Vineland adaptive behavior scales*. Circle Pines, MN: American Guidance Service.
- Tager-Flusberg, H. (1981). On the nature of linguistic functioning in early infantile autism. *Journal of Autism and Developmental Disorders* 11, 45–56.
- Tager-Flusberg, H. (Ed.) (1995). Dissociation in form and function in the acquisition of language by autistic children. In *Constraints on language acquisition: Studies of atypical children* (pp. 175–194). Hillsdale, NJ: Erlbaum.
- Thurber, C., & Tager-Flusberg, H. (1993). Pauses in the narrative produced by autistic, mentally retarded, and normal children as an index of cognitive demand. *Journal of Autism and Developmental Disorders* 23, 309–322.
- VanBourgondien, M., & Woods, A. (1992). Vocational possibilities for high functioning adults with autism. In E. Schopler, & G. Mesibov (Eds.), *High functioning individuals with autism* (pp. 227–242). New York: Plenum Press.
- Van Lancker, D., Canter, G., & Terbeek, D. (1981). Disambiguation of ditropic sentences: Acoustic and phonetic cues. *Journal of Speech and Hearing Research* 24, 330–335.
- Van Lancker, D., Cornelius, C., & Krieman, J. (1989). Recognition of emotional-prosodic meanings in speech by autistic, schizophrenic, and normal children. *Developmental Neuropsychology* 5, 207–222.
- Warren, P. (Ed.) (1996). Parsing and prosody: An introduction. *Prosody and parsing*. (pp. 1–16). East Sussex, UK: Psychology Press.
- Wechsler, D. (1992). *Wechsler intelligence scale for children (3rd ed)*. San Antonio, TX: Psychological Corp.
- Wechsler, D. (1997). *Wechsler adult intelligence scale (3rd ed)*. San Antonio, TX: Psychological Corp.
- Wiig, E., & Secord, W. (1989). *Test of language competence*. San Antonio, TX: Psychological Corp.
- Winner, E. (1988). *The point of words: Children's understanding of metaphor and irony*. Cambridge, MA: Harvard University Press.