Journal of Autism and Developmental Disorders, Vol. 35, No. 6, December 2005 (© 2005)
DOI: 10.1007/s10803-005-0031-8

Brief Report: Relations between Prosodic Performance and Communication and Socialization Ratings in High Functioning Speakers with Autism Spectrum Disorders

Rhea Paul,[1,2,4] Lawrence D. Shriberg,[3] Jane McSweeny,[3] Domenic Cicchetti,[1] Ami Klin,[1] and Fred Volkmar[1]

Shriberg *et al.* [Shriberg, L. *et al.* (2001). *Journal of Speech, Language and Hearing Research*, *44*, 1097–1115] described prosody–voice features of 30 high functioning speakers with autistic spectrum disorder (ASD) compared to age-matched control speakers. The present study reports additional information on the speakers with ASD, including associations among prosody–voice variables and ratings of communication social abilities. Results suggest that the inappropriate sentential stress and hypernasality previously identified in some of these speakers is related to communication/sociability ratings. These findings and associated trends are interpreted to indicate important links between prosodic performance and social and communicative competence. They suggest the need for careful assessment of inappropriate prosody and voice features in speakers with ASD, and for effective intervention programs aimed at reducing the stigmatization of individuals with these conditions.

KEY WORDS: Prosody; autism; Asperger syndrome; communication; socialization.

INTRODUCTION

Speech may be divided linguistically into two domains termed *segmental* and *suprasegmental*. Segmental aspects of speech include the organization, sequencing, and production of the speech sounds of a speaker's language. The term *suprasegmental* refers to all other aspects of the speech signal that modulate meaning and give each speaker unique identity. The term *prosody*, which is often used synonymously with *suprasegmental*, refers to the assignment of relative prominence or *stress* to various units within the signal, changes over speech units in the pitch of the sound wave that comprise its *intonation contour*, and the rhythm and timing patterns that comprise the *phrasing* of an utterance, as expressed by the *rate* and *duration* of speech and *pause* events (Lahiste, 1970; Shriberg, Kwiatkowski, & Rasmussen, 1990). Acoustically, prosody is a composite of the covariation in time of *pitch* (fundamental frequency), *intensity* (amplitude), and *duration* (Stephens, Nickerson, & Rollins, 1983).

Abnormal prosody has been identified as one of the core features of individuals with autism who speak since Kanner's (1943) delineation the autistic syndrome (Baltaxe & Simmons, 1985, 1992; Fay & Schuler, 1980; Ornitz & Ritvo, 1976; Paul, 1987; Pronovost, Wakstein, & Wakstein, 1966; Rutter & Lockyer, 1967; Tager-Flusberg, 1981, 1995). Prosodic differences noted include monotonic or machine-like

[1] Yale Child Study Center, P.O. Box 207900, New Haven, CT, 06520-7900, USA.
[2] Southern Connecticut State University, New Haven, USA.
[3] University of Wisconsin, Madison, USA.
[4] Correspondence should be addressed to: Yale Child Study Center, P.O. Box 207900, New Haven, CT, 06520-7900, USA; e-mail: rhea.paul@yale.edu

intonation, aberrant stress patterns, deficits in pitch and intensity control, and differences in voice quality. When these inappropriate patterns are present, observations suggest that they tend to persist over time, even when other aspects of language improve (DeMyer *et al.*, 1973; Kanner, 1971; Rutter & Lockyer, 1967; Simmons & Baltaxe, 1975). Prosodic deficits have not been universally reported in individuals with Autistic Spectrum Disorder (ASD), however. Simmons and Baltaxe (1975), for example, found that only four out of the seven adolescents (57%) with autism they studied had notable suprasegmental differences in their speech. Consistent with Simmons' and Baltaxe's (1975) findings, Shriberg *et al.* (2001) reported that 14 out of 30 (47%) of participants were ranked as "low" on a measure of overall prosody–voice performance, with the remaining 53% considered to have adequate prosody. When suprasegmental differences are present, however, they constitute one of the most significant obstacles to social integration. Mesibov (1992) and VanBourgondien and Woods (1992) reported anectodally that it is the vocal presentation of individuals with autism that most immediately creates an impression of oddness.

Shriberg *et al.* (2001) described the prosody–voice profiles of fifteen 10–49 year-old male individuals with high functioning autism (HFA), 15 male speakers of approximately the same age with Asperger syndrome (AS), and 53 same-aged male individuals with typical speech development. Findings indicated that, compared to the typically developing speakers, significantly more participants in both the HFA and AS groups had residual articulation distortion errors. Speakers with AS were more voluble than speakers with HFA, but otherwise there were few statistically significant differences between these two groups of speakers with Autism Spectrum Disorder (ASD). Significant differences between subjects with ASD and typical speakers were reported for the percentage of utterances coded as inappropriate within the prosody domains of *phrasing* (i.e., excessive repetitions and revisions) and *stress* (i.e., inappropriate emphasis within and across words), and within the voice domain termed *resonance* (excessive nasality). The present report extends the findings described by Shriberg *et al.* (2001) to determine whether the prosody–voice status of the 30 speakers with ASD was associated with ratings of communicative and social ability, as measured by a standard assessment of adaptive behavior and a standard autism diagnostic instrument. Shriberg and Widder (1990) reported that prosody–voice characteristics, indexed by the PVSP, were significantly correlated with level of independent living in a group of 40 adults with intellectual impairment. If the examined relations are found in the present study, this finding would warrant the development of intervention programs that address prosody–voice deficits, for the purpose of reducing stigmatization of individuals with these conditions, and possibly increasing their potential for independent living.

METHOD

Participants

A data set of 30 male participants with HFA or AS was obtained from cases seen through a large project on the nosology, neuropsychology, and neurobiology of higher functioning autism and related conditions in the Developmental Disabilities Section of the Yale Child Study Center. These subjects are the same ones reported in Shriberg *et al.* (2001), who were shown to have significant differences in prosodic production from typical speakers in the areas of phrasing, stress, and resonance. The protocol for identifying these subjects, as part of the larger study of autism spectrum disorders, included completion of standardized assessments of cognitive, language, and social-adaptive functioning, and a videocassette recording of a conversational speech sample obtained during a semi-structured diagnostic interview. Diagnostic characterization included the Autism Diagnostic Interview-Revised (ADI-R; Lord, Rutter, & LeCouteur, 1994) and the Autism Diagnostic Observation Schedule-Modules 3 & 4-Generic (ADOS-G; Lord *et al.*, 2000). Diagnostic assignment followed DSM-IV criteria for autism and AS (American Psychiatric Association, 1994). In accordance with these criteria, none of the individuals assigned the diagnosis of AS had speech or language delay or marked deviance during the first 3 years of life (Klin & Volkmar, 1997; Volkmar *et al.*, 1994). Clinical diagnoses were confirmed independently by two experienced clinicians (AK and FV) who have demonstrated high interrater reliability in a larger study of the same database from which the present subjects are drawn (Klin, Lang, Cicchetti, & Volkmar, 2000).

Table I includes age and assessment information for the 30 participants. Speakers ranged in age from 10 to 49 years; 18 (60%) were 10–20 years of age, and the remaining 12 (40%) were 20–49 years of age. The mean ages of speakers in the HFA and AS

Table I. Participant Description

	High functioning autism (HFA)			Asperger syndrome (AS)			
Variable	*n*	*M*	*SD*	*n*	*M*	*SD*	*p*
Age (years)	15	21.6	10.8	15	20.7	10.9	0.810
Average words per utterance	15	7.6	4.5	15	9.2	4.3	0.340
Intelligence[a]							
Verbal	15	96.4	25.8	15	106.3	27.7	0.320
Performance	15	91.2	20.9	15	86.9	27.0	0.630
Vineland Adaptive Behavior Scales[b]							
CommSS[c]	15	65.7	19.4	15	78.1	24.3	0.140
DLSS[d]	15	63.1	24.4	15	61.8	22.7	0.880
SocSS[e]	15	49.5	7.0	15	51.2	20.1	0.770
MotorSS[f]	15	91.1	21.2	13	84.1	25.1	0.430
CompSS[g]	15	55.3	14.1	15	58.9	18.6	0.550
Autism Diagnostic Observation Scale[h]							
Communication	15	5.4	1.5	15	3.7	1.3	0.003
Socialization	15	12.0	1.9	15	9.9	1.7	0.004

[a] Wechsler Intelligence Scale for Children, 3rd ed. (WISC; Wechsler, 1992) or Wechsler Intelligence Scale for Adults, 3rd ed. (WAIS; Wechsler, 1997).
[b] Sparrow, Balla, and Cicchetti (1984).
[c] Communication Scale Standard Score.
[d] Daily Living Scale Standard Score.
[e] Socialization Scale Standard Score.
[f] Motor Scale Standard Score.
[g] Adaptive Behavior Composite Standard Score.
[h] Lord *et al*. (2000).

groups, respectively, were 21.6 and 20.7 years. Statistical tests (*t* tests) for differences between the ages of speakers in each group, as well as for differences on all other variables in Table I, were nonsignificant, with the exception of two subscales of the Autism Diagnostic Observation Schedule-G (Lord *et al*., 2000). This difference reflects the generally better formal language performance (also reflected in the higher, though not significantly higher, verbal IQ and Vineland Communication scores) in the AS group, as well as the significant correlation found between verbal IQ and ADOS Socialization and Vineland Communication scores in this sample (See Table II). In general, the differences between the two groups' ADOS scores reflect a somewhat lower level of disability in the AS sample.

There was no significant difference on PVSP total scores between the 46.7% of subjects under 16 years of age, and the 53.5% of the subjects who were 16 and older ($t = 1.92$; $p < .07$).

Measures

Prosody–Voice Screening Profile

Data for this report were derived from videotaped structured interview samples analyzed using the *Prosody–Voice Screening Profile* (PVSP; Shriberg *et al*., 1990), an instrument that has been used with a variety of children and adults with communicative disorders (McSweeny & Shriberg, 2001; Odell & Shriberg, in press; Shriberg, Aram, & Kwiatkowski, 1997a; Shriberg & Widder, 1990). The data used in the present study consist of the same ratings reported in Shriberg *et al*., (2001) for the subjects with ASD. The PVSP provides reference data (used in Shriberg, 2001 to compare subjects to typical speakers) for

Table II. Correlations Among Prosody–Voice Variables and Communication and Socialization Scores

	Vineland Comm.	*Vineland* Soc.	ADOS-G Comm.	ADOS-G Soc.	Verbal IQ
Phrasing	−.10	.22	.23	.13	−.31
Stress	.17	.04	−.38*	−.29	.22
Resonance	.25	.35*	.27	.15	.27
Verbal IQ	.68*	.10	−.33	−.47*	1.0

* Significant at $p < .05$.

conversational speech samples from typical speakers (Shriberg, Kwiatkowski, Rasmussen, Lof, & Miller, 1992), and has appropriate psychometric characteristics for use as a screening instrument (cf. McSweeny & Shriberg, 2001; Shriberg *et al.*, 1990). PVSP analytic conventions provide information in each of seven prosody–voice domains, expressed as a percentage of utterances judged to be appropriate for each domain. Utterances are judged qualitatively and quantitatively, based on guidelines and audio training exemplars that account for the age and sex of speakers and the content of utterances. These domains are briefly described as follows:

Phrasing: the smoothness or fluency of speech (part-and whole-word repetitions and revisions).
Rate: the overall pace of speech (too slow or too fast, as measured by syllables/second).
Stress: the relative emphasis on syllables and words (intensity, pitch, duration).
Loudness: the intensity with which utterances are produced (too loud, too soft).
Pitch: the average frequency of the voice (too high, too low).
Voice quality: the sound produced by the larynx (e.g., harsh, strained).
Resonance: the sound produced by the vocal tract (e.g., nasality, denasality, pharyngeal resonance).

Speech sample data for the present study consisted of the same material used in Shriberg *et al.* (2001). Phonetic transcription and prosody–voice coding of the 30 speech samples, described in more detail in Shriberg *et al.*, (2001), were completed by an experienced research transcriber (JM) using a Panasonic AG520B videocassette playback system and protocols referenced to adolescent and adult speakers (Shriberg, 1993; Shriberg, Austin, Lewis, McSweeny, & Wilson, 1997b). The transcriber had participated in intra- and interjudge agreement studies for both narrow phonetic transcription and prosody–voice coding (McSweeny & Shriberg, 1995). Interjudge agreement for the current study at the summative level of prosody–voice coding was 89.6% based on appropriate versus inappropriate prosody–voice codes for each of the six domains and 85.6% based on exact agreement for both appropriate and all inappropriate codes. Interjudge coding agreement for the three prosody–voice domains of specific interest in this study—Phrasing, Stress, and Resonance—was as follows for the four levels of agreement (from item level to summative level): Phrasing: 73.6–95.8%; Stress: 14.3–86.8%; and Resonance: 43.4–83.3%. Thus, as in other studies using this screening instrument (McSweeny & Shriberg, 1995, in press), certain prosody–voice codes have marginal or inadequate interjudge reliability at the most detailed levels of comparison (generally involving relatively few occurrences of each code). Whereas findings at the summative level appear to have adequate reliability, code-level reliability findings in some domains must be interpreted with caution.

The *Vineland Adaptive Behavior Scales-Survey Form* (Sparrow *et al.*, 1984), a nationally standardized semi-structured caregiver interview instrument that assesses day-to-day adaptive functioning, was administered to primary caregivers by research assistants well-trained in Vineland interview and scoring procedures. Scoring was accomplished using software supplied by the publisher. For the present study, standard scores on the Communication and Socialization scales of this measure were used to index participants' functional abilities in communication and social skills as perceived by their primary caregivers.

Communication items on the Vineland include caregiver report of the subject's ability to ask questions, talk about abstract concepts, relate experiences, use appropriate syntactic forms and articulation, to provide information such as age, birthday, address, directions and to articulate long-range plans. Socialization items include queries on interpersonal skills, such as initiation of conversations, cooperating with others, having friends and belonging to clubs and other groups; leisure skills such as playing games, having hobbies, engaging in group activities and going places independently; and coping skills such as using table manners, apologizing, borrowing and returning, and keeping appointments. Higher scores on these scales indicate higher levels of ability.

The *Autism Diagnostic Observation Schedule-Generic* (ADOS-G, Lord *et al.*, 2000) uses a structured interview format to evoke communicative and social behaviors. Communication behaviors examined include amount of echoed speech, stereotyped/idiosyncratic language use, difficulties in using language to ask for and give information or report events, and abnormal use of gestures. Social interaction behaviors observed include unusual eye contact or facial expression, limitations in nonverbal communication, difficulties in expressing and responding to emotions, insight, understanding personal responsibility for actions, quality of social overtures, responses and rapport, amount of reciprocal social

interaction, use of imagination, and extent of stereotyped and restricted interests. These responses are scored according to detailed coding criteria, with *higher scores* indicating *higher levels of pathology*, which are then entered into a quantitative algorithm used to assign presence of absence of a diagnosis of autism. Thus, higher scores on the Communication and Socialization sections of this measure indicate higher levels of disability.

RESULTS

Regression Analysis

Regression analyses using the SPSS statistical package (SPSS for Windows, version 10) were completed to determine whether specific prosodic variables were related to communication and socialization ratings. The prosodic variables identified by Shriberg *et al*. (2001) as differentiating subjects with ASDs from typical speakers—Phrasing, Stress, and Resonance—were entered as predictors in regression equations with *Vineland* Communication and Socialization standard scores and ADOS-G Communication and Socialization raw scores as outcome measures.

Using *Vineland* Communication standard score as the outcome, no significant association with any of the three prosody variables was found. It should be noted that the range of standard scores on this scale was quite broad (38−113), and nearly half (47%) the subjects, with representatives from both diagnostic groups, scored within the normal range (> 70). This may be due to the fact that Vineland Communication scores in subjects with ASDs are inflated by these subjects' high levels of written language performance. Since Expressive, Receptive, and Written language scores are averaged to obtain the Communication scale score, some of the variance in Expressive and Receptive communication may have been masked by the relatively high performance in written language that is characteristic of this population (Paul *et al*., 2004).

Using Vineland Socialization standard score as the outcome variable, however, regression results indicated a significant R value of .43. The model revealed that % appropriate Resonance score was a significant predictor ($p < .05$); and the correlation between % appropriate Resonance and Vineland Socialization was significant at $p < .05$, $r = .35$ (See Table II). There was a broad range of variability on the Vineland Socialization standard scores (32−95), but only three subjects scored within the normal range on this measure, all with a diagnosis of AS.

Regression analysis using ADOS-G Communication score as the outcome variable also revealed a significant R, at .64. The model showed % appropriate Resonance to be a significant predictor ($p < .02$), and % appropriate Stress to approach a significant level of prediction ($p < .07$). Correlational analysis revealed that ADOS-G Communication score was significantly related to % appropriate Stress ($r = .38$, $p < .04$).

No significant prediction was found for ADOS Socialization Score. This may be related to the fact that these subjects' ADOS-G Socialization scores clustered at the high end of the scale, from 6 to 14 with a mean at 12 and *SD* of 1.9. With a possible range of 0−14 on this measure, there was little variance among the present subjects, whereas ADOS-G Communication scores spanned a larger portion of the range of possible scores (from 2 to 7, in a possible range of 0−8) and fell closer to the midpoint of the range, at 5.4. Thus the small degree of variability in ratings of social disability among all the current subjects on this scale may have made it difficult to detect relationships between this variable and prosody−voice performance. No other significant predictors were found. The correlations associated with these analyses are presented in Table II.

It should be noted that, since correlational analyses showed that the three predictor variables were relatively independent, with low correlations among them (See Table II), collinearity diagnostics was not considered necessary.

Distribution Analyses

Participants' scores on the prosody−voice and the communication and socialization measures in each of the two instruments were dichotomized to form *high* and *low* clinical classifications. Participants with 85% or more appropriate utterances on each of the three prosody−voice variables were classified as *high* on the respective variable; those with fewer than 85% appropriate utterances were classified as *low*. The 85% PVSP cut-off point was motivated by two considerations. First, this screening instrument considers percentages in the 80−90% region as *questionable*, relative to the regions for *pass* (> 90%) and *fail* (≤ 80%). Second, the 85% criterion met distributional requirements for the present analysis, with

approximately equal numbers of participants with scores above and below this cut-off point and no scores falling from 84 to 86% on any of the three variables. It should be noted that there was no significant difference in verbal IQ of subjects ranked high vs. low on any of the three prosody–voice domains, nor were there any significant correlations between verbal IQ and any of these three prosody ratings. There were, however, correlations between verbal IQ and scores on both *Vineland* Communication and ADOS Socialization (See Table II).

The cut-off point to dichotomize *Vineland* scores was a standard score of 55, or three standard deviations below the mean of the typical population, because 90% of the participants scored below 70. Thus, scores above 55 on the *Vineland* (Vld.) were *high;* those at or below 55 were considered *low*. The high/low cut-off scores for the ADOS-G scales were set at the mean scores for the present sample and adjusted to accommodate the directional difference (i.e., higher Communication and Socialization scores reflect increasing disability). Thus, Communication scores for these speakers ranged from 2 to 7, with a mean of 5.4 ($SD = 1.5$). In order to make reading Figs. 1–3 easier, ratings of 5 or below were classified as *high* (i.e., less disability) and scores above 5 were classified as *low* (more disability). It must be remembered, however, that on the ADOS-G scales a nominal score of *high* represents a *lower numerical* score (less disability) than do the nominal scores of *low*, which represent *higher numerical* scores (more disability).

ADOS-G Socialization scores ranged from 6 to 14, with a mean score of 12.0 ($SD = 1.9$). Scores at 12 or below were classified as *high* (i.e., less disability) and scores above 12 were classified as *low* (more disability). The same cautions apply in interpreting these scores in Figs. 1–3 as were stated above.

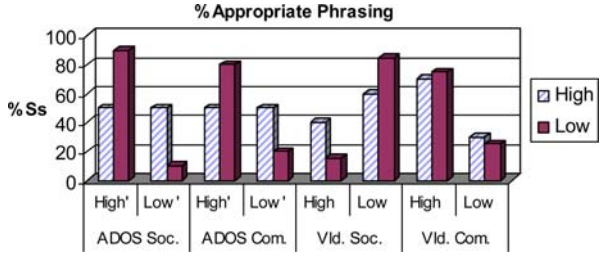

Fig. 1. Subjects with high/low % appropriate phrasing scores categorized by communication/socialization performance. ′: nominal ratings: "low" represents a higher numerical rating indicative of more disability, or lower functioning on the ADOS-G; while "high" represents a lower numerical rating indicative of less disability or higher functioning on the ADOS-G.

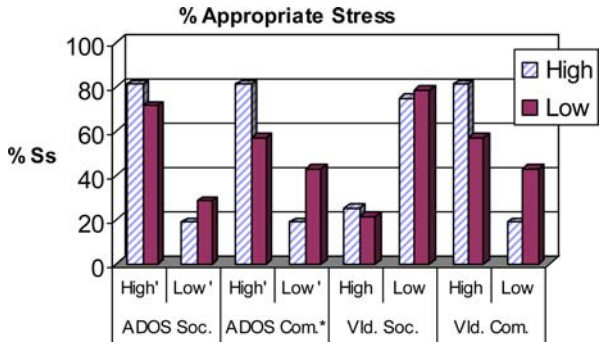

Fig. 2. Subjects high/low % appropriate stress scores categorized by communication/socialization performance. *χ^2 approaches significance at 2.1; $\phi = .26$; $p > .10$; $t = 2.0$ $p < .05$. ′: nominal ratings: "low" represents a higher numerical rating indicative of more disability, or lower functioning on the ADOS-G; while "high" represents a lower numerical rating indicative of less disability or higher functioning on the ADOS-G.

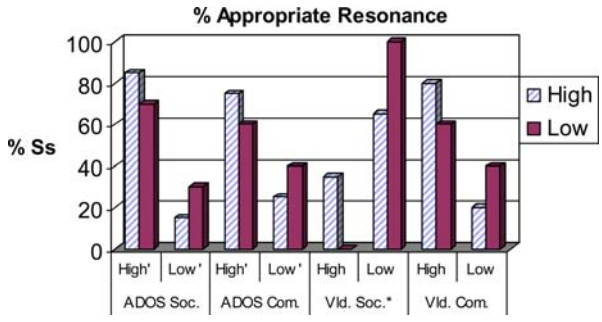

Fig. 3. Subjects with high/low % appropriate resonance scores categorized by communication/socialization performance. *$\chi^2 = 5.45$; $\phi = .42$; $p < .05$; $t = 2.55$; $p < .025$. ′: nominal ratings: "low" represents a higher numerical rating indicative of more disability, or lower functioning on the ADOS-G; while "high" represents a lower numerical rating indicative of less disability or higher functioning on the ADOS-G.

The proportion of subjects in each diagnostic group whose scores resulted in designations of "high" and "low" on the *Vineland* and ADOS-G Communication and Socialization Scales are given in Table III. Figures 1–3 illustrate the percentages of children within each PVSP classification category cross-tabulated by their communication and socialization nominal ratings, as explained above. The number of subjects who scored high vs. low on each prosody domain and each communication or socialization variable was tabulated. Phi correlation coefficients derived from chi-squared procedures were used to examine the extent of the relationship among each of

Table III. Percentage of Subjects with "High" and "Low" Designations on Social and Communicative Measures

	Subjects rated "High" (%)	Subjects rated "Low" (%)
Vineland Communication	73.3	26.7
Vineland Socialization	23.3	76.7
ADOS-G* Communication	70	30
ADOS-G* Socialization	63.3	36.6

*"High" ratings are nominal scores indicating better functioning; numerical scores on this measure are low, indicating less disability; "low" ratings are nominal scores indicating poorer functioning; numerical scores on this measure are high, indicating more disability.

these three prosody variables and communication and socialization scores.

As shown in Fig. 1, no relationship is seen between the distribution of subjects on Phrasing performance and their ratings on communication and socialization measures, as the regression analysis indicated. For Stress, there was a marginally significant phi value for ADOS-G Communication score, indicating that subjects with high levels of appropriate Stress were more likely to receive better (i.e., lower) Communication ratings on the ADOS-G than subjects with low Stress scores. For Resonance, there was a significant phi value for Vineland Socialization score, indicating that subjects with high levels of appropriate Resonance were more likely to receive better Socialization ratings on the Vineland than subjects with low Resonance scores. Despite the fact that these were the only two statistically significant comparisons, Figs. 2 and 3 demonstrate that all the comparisons for Stress and Resonance trended in a similar direction. That is, more subjects with higher levels of appropriate prosody–voice scores received better ratings on the Communication and Socialization variables, whereas more subjects with lower levels of prosody–voice performance received poorer ratings on the Communication and Socialization variables.

DISCUSSION

Both regression and distributional analyses in this study reveal weak but converging relationships between certain prosody–voice deficits and ratings of social and communicative abilities. Although some individuals with ASDs have more difficulty in appropriate Phrasing than typically speaking peers, their Phrasing errors do not appear to have any significant effect on listeners' judgments of their social/communication skill. Stress and Resonance problems do, however, appear to have some effect on how listeners perceive their social and communicative competence. Although Stress and Resonance explain small portions of the variance in social and communication ratings, and clearly other factors are involved in determining attributions of social and communicative competence, the consistent trends reported here suggest some contribution of these suprasegmental characteristics to perceptions of social-communicative skills in this population.

Only 33% (10/30) of participants in the current sample were coded as having inappropriate Resonance. Forty-seven percent (14/30) were ranked "low" in their use of appropriate stress. Moreover, these prosodic deficits are relatively independent of each other, so that individuals may be quite disordered in some aspects of prosodic production, but relatively typical in others. Further, these skills do not appear to be related to verbal IQ. This dissociation is most likely explained by the well-documented findings (e.g., Emmorey, 1987; McNeely & Parlow, 2001; Mitchell, Elliott, Barry, & Cruttenden, 2003; Plante, Creusere, & Sabin, 2002) that prosodic and linguistic functions are to some degree differentially lateralized and that prosodic processing is somewhat independent of semantics and syntax.

These findings suggest that careful assessment of the suprasegmental features of speech in individuals with ASDs will be necessary in order to identify which individuals demonstrate prosodic difficulties. For the substantial minority of individuals with ASDs that do, these findings emphasize the need for intervention aimed at addressing the prosodic differences that may be associated with listeners' perception of these speakers' interpersonal competence. Although more research on the prosodic characteristics of speakers with ASDs is clearly needed, an equally urgent need is for the development of methods of remediating prosody–voice differences that can be shown to result in more favorable perceptions on the part of social partners.

ACKNOWLEDGMENTS

Our thanks to Amy Augustyn, Stephanie Miles, and Chad Allen for their assistance. Preparation of this paper was supported by Research Grant P01-03008 funded by the National Institute of Mental Health (NIMH); and 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), the National Institute of Neurological Disorders and Stroke (NINDS); a Mid-Career Development grant K24 DC006619 from the National Institute on Deafness and Other Communication Disorders (NIDCD); as well as by the National Alliance for Autism Research.

REFERENCES

American Psychiatric Association. (1987). *Diagnostic and Statistical Manual of Mental Diseases-IIIR*. Washington, DC: Author.

American Psychiatric Association. (1994). *Diagnostic and Statistical Manual of Mental Diseases-IV*. Washington, DC: Author.

Arthur, G. (1962). *The Arthur Adaptation of the Leiter International Performance Scale*. Washington, DC: Psychological Service Center.

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.

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.

DeMyer, M., Hingtgen, J., & Jackson, R. (1981). Infantile autism reviewed: A decade of research. *Schiophrenia Bulletin*, *7*, 388–451.

Fay, W., & Schuler, A. (1980). *Emerging language in autistic children*. Baltimore: University Park Press.

Kanner, L. (1943). Autistic disorders 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.

Kaufman, A., & Kaufman, N. (1983). *Kaufman Assessment Battery for Children*. Circle Pines, MN: American Guidance Co.

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.

Klin, A., & Volkmar, F. (1997). Asperger syndrome. In: D. Cohen, & F. Volkmar (Eds.), *Handbook of autism and pervasive developmental disorders*. (2nd ed., pp. 94–122). New York: Wiley.

Klin, A., Volkmar, F., & Sparrow, S. (1992). Autisitc social dysfunction: Some limitations of the theory of mind hypothesis. *Journal of Child Psychology and Psychiatry*, *33*, 861–876.

Lahiste, I. (1970). *Suprasegmentals*. Cambridge, MA: MIT Press.

Lord, C., & Paul, R. (1997). Communication. In: D. Cohen, & F. Volkmar (Eds.), *Handbook of Autism and Pervasive Developmental Disorders*. (2nd ed., pp. 195–225). N.Y: Wiley.

Lord, C., Risi, S., Lambrecht, L., Cook, E. H., 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.

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*, 659–685.

McSweeny, J. L. & Shriberg, L. D. (1995). *Segmental and suprasegmental transcription reliability* (Tech. Rep. No. 2). Phonology Project, Waisman Center on Mental Retardation and Human Development, University of Wisconsin, Madison.

*McSweeny, J. L. & Shriberg, L. D. (in press). Clinical research with the Prosody–Voice Screening Profile. *Clinical Linguistics and Phonetics*.

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.

Odell, K. H. & Shriberg, L. D. (in press). Prosody–voice characteristics of children and adults with apraxia of speech. *Clinical Linguistics and Phonetics*.

Paul, R., Miles, S., Cicchetti, D., Sparrow, S., Klin, A., Volkmar, F., Coflin, M., & Booker, S. (2004). Adaptive Behavior in Autism and PDD-NOS: Micro-Analysis of Scores on the Vineland Adaptive Behavior Scales. *Journal of Autism and Developmental Disorders*, *34*(2), 223–228.

Rutter, M., & Lockyer, L. (1967). A five to fifteen year follow-up study of infantile psychosis. I: Description of sample. *British Journal of Psychiatry*, *113L*, 1169–1182.

Shriberg, L. D. (1986). *PEPPER: Programs to examine phonetic and phonologic evaluation records*. Hillsdale, NJ: Lawrence Erlbaum.

Shriberg, L. D. (1993). Four new speech and prosody–voice measures for genetics research and other studies in developmental phonological disorders. *Journal of Speech and Hearing Research*, *36*, 105–140.

Shriberg, L. D., Aram, D. M., & Kwiatkowski, J. (1997a). Developmental apraxia of speech: III. A subtype marked by inappropriate stress. *Journal of Speech, Language, and Hearing Research*, *40*, 313–337.

Shriberg, L. D., Austin, D., Lewis, B. A., McSweeny, J. L., & Wilson, D. L. (1997b). The Percentage of Consonants Correct (PCC) metric: Extensions and reliability data. *Journal of Speech, Language, and Hearing Research*, *40*, 708–722.

Shriberg, L. D., Kwiatkowski, J., & Rasmussen, C. (1990). *The Prosody–Voice Screening Profile*. Tucson, AZ: Communication Skill Builders.

Shriberg, L. D., Kwiatkowski, J., Rasmussen, C., Lof, G. L., & Miller, J. F. (1992). *The Prosody–Voice Screening Profile (PVSP): Psychometric data and reference information for children* (Tech. Rep. No. 1). Phonology Project, Waisman Center on Mental Retardation and Human Development, University of Wisconsin, Madison.

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.

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.

Sparrow, S., Balla, D., & Cicchetti, D. (1984). *The Vineland Adaptive Behavior Scales (Survey Form)*. Circle Pines, MN: American Guidance Service.

Stephens, K., Nickerson, R., & Rollins, A. (1983). Suprasegmental and postural aspects of speech production and their effect on articulatory skills and intelligibility. In: Hochberg (Ed.), *Speech of the hearing impaired: Research, training and personnel preparation*. (pp. 35–51). Baltimore: University Park Press.

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. (1995). Dissociations in form and function in the acquisition of language in autistic children. In: H.

Tager-Flusberg (Ed.), *Constrains on language acquisition: Studies of atypical children.* (pp. 175–194). Hillsdale, NJ: Erlbaum.

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.

Volkmar, F., Klin, A., Siegel, B., Szatmari, P., Lord, C., Campbell, M., Freeman, B., Cicchetti, D., Rutter, M., Kline, W., Buitelar, J., Hattab, Y., Fombonne, E., Fuentes, J., Werry, J., Stone, W., Kerbeshian, J., Hoshino, Y., Bregman, J., Loveland, K., Szymanski., L., & Towbin, K. (1994). Field trial for autistic disorderin DSM-IV. *American Journal of Psychiatry*, *151*, 1361–1367.

Volkmar, F., & Lord, C. (1998). Diagnsois and definition of autism and other pervasive developmental disorders. In: F. Volkmar (Ed.), *Autism and pervasive developmental disorders.* (pp. 1–31). Cambridge: Cambridge University Press.

Volkmar, F., Sparrow, S., Goudreau, D., Cicchetti, D., Paul, R., & Cohen, D. (1987). Social deficits in autism: An operational approach using the Vineland Adaptive Behavior Scales. *Journal of the American Academy of Child and Adolescent Psychiatry*, *26*, 156–161.

Wechsler, D. (1991). *Manual for the Wechsler Intelligence Scale for Children—Third Ed. (WISC-III).* San Antonio, TX: Psychological Corporation.