JOURNAL ON DEVELOPMENTAL DISABILITIES, VOLUME 13 NUMBER 1, 2007

The Effects of Verbal Prosody on Speech Perception in Individuals With Down Syndrome

Suzanne Hurding and James Lyons

Abstract

This study was conducted to assess the degree to which verbal prosody may differentially influence verbal processing in DS relative to age and mental-age matched controls. Nine individuals with DS, 7 mental-age matched (DD), and 10 chronological age matched controls (CG) participated in a dichotic free recall paradigm in which words were presented in either a happy, sad or neutral intonation. Results suggest that for all groups the cerebral hemispheres are indeed differentially affected by the presence of prosody in speech. In addition, the atypical RH hemispheric advantage for auditory processing in DS (e.g., Elliott, Weeks & Elliott, 1987) is mediated when verbal stimuli are delivered with prosody.

Human speech perception is a complex process wherein connotation is often mediated by acoustical parameters that may be functionally separate from the semantic content of the words used. For example, it has been shown that emotion laden speech (verbal prosody) can facilitate greater understanding of verbal stimuli in the general population. Reasons for this facilitation are unclear although it has been suggested that this prosodic advantage may be related to the involvement of the right hemisphere (RH) in emotional processing (e.g., Bulman-Fleming & Bryden 1994). As well, considerable evidence from both behavioural (see Heath, Elliott, Weeks, & Chua, R., 2000 for a review) and neuroimaging studies (e.g., Weeks, Chua, Elliott, Weinberg, Cheyne, & Lyons, 1997) suggest an atypical RH advantage for auditory perception in individuals with Down syndrome (DS). It must be noted, however, that the auditory stimuli used in much of this previous work have been relatively impoverished, consisting primarily of simple tones or one syllable phonemes. Since daily verbal interactions with others are typically far more complex (i.e., the use of pitch, tone, volume etc. to create differing emotional contexts), this study was conducted to assess the degree

to which prosodic factors may differentially influence verbal processing in DS. Indeed, an intriguing possibility exists wherein the atypical RH advantage demonstrated in DS may, in fact, be advantageous for the processing of prosodic speech.

The aim of this research, therefore, was to examine the effect of verbal prosody on speech perception in individuals with DS, and to explore whether the demonstrated RH advantage for linguistic processing in DS is mediated by the RH advantage for prosodic processing in the general population.

Method

Participants

Participants were divided into three groups consisting of either: 9 adults with Down Syndrome (DS); 7 adults with undifferentiated developmental delays (DD); and 10 typically developing adults without developmental delays (TD). Participants from both developmentally delayed populations were recruited from the Dundas Learning Centre and the Etobicoke Training Service Centre where all were all involved in life skills and employment training programs. TD participants were recruited from the McMaster University community. The mean chronological and mental ages the DS participants were 31.6 years (range: 26-38) and 7.9 years (range: 4.7-11.1 years) respectively. The mean chronological and mental ages of the DD participants were 31.1 years (range: 27-37 years) and 8.3 years (range: 6.1-10.7 years) respectively. Mean chronological age of the TD participants was 23 years (range: 18-26 years). For the TD group, mental age was assumed to equal chronological age. Estimates of mental age for both developmentally delayed groups were obtained using the Peabody Picture Vocabulary Test-Revised.

Apparatus and Procedure

A dichotic listening task employing a free recall paradigm was used to examine laterality differences. Four stimulus words (Bower, Dower, Power, and Tower: see Bulhman-Flemming and Bryden, 1994) were presented in contrast simultaneously to each ear (for example, "Tower" to the right ear and "Power" to the left ear). These stimuli were presented to participants either with an emotional intonation (happy and sad) or without (neutral). In the condition with emotion, the emotions were presented either congruently or in contrast. This arrangement resulted in 48 possible word pairs in the emotion condition and 12 in the condition without emotion. Participants

completed 6 experimental blocks in total (3 blocks in the emotion condition: 144 total trials and 3 blocks in the neutral condition: 36 total trials). Regardless of condition, participants were asked to recall all of the words heard during a trial by speaking into a voice reaction time (RT) box with these RTs recorded for each trial.

Data Analysis

Data for proportion of correct responses (%CR) are presented in Table 1. These were analyzed by a 3 (group: DS, DD, TD) x 2 (ear: left, right) x 3 (emotion: neutral, happy, sad) analysis of variance with repeated measures on the last two factors. Multiple level Main Effects and all interactions were subjected to post hoc analyses using Tukey's test of Honestly Significant Difference (HSD). Alpha was established at .05 for all primary and post hoc analyses.

Results

Proportion of Correct Responses (%CR)

Main effects were revealed for group, $F(2,23)=4.00$, $p<.05$, ear, $F(1,23)=5.37$, $p<.05$, and emotion, $F(2,46)=10.37$, $p<.001$. In turn, these effects suggest that: a) individuals from the general population were significantly more accurate ($M=.41$) then both the DS ($M=.37$) and DD ($M=.36$) groups at identifying the correct word; b) independent of group, words presented to the right ear ($M=.43$) were reported more accurately than those presented to the left ear ($M=.33$) and; c) words delivered with either a neutral ($M=.41$) or sad ($M=.39$) intonation were more accurately perceived than those delivered with a happy ($M=.34$) intonation. As well, a significant interaction involving ear and emotion, $F(2,46)=4.24$, $p<.05$, was also evident. Post hoc investigation of this interaction suggests that across all three groups this influence of emotion on recall accuracy became more pronounced when the words were presented to the right ear (left hemisphere). Interestingly, and contrary to our hypotheses, group did not interact with either emotion, $F(4,46)=1.07$, or ear, $F(2,23)=2.47$.

Verbal Reaction Time

No significant effects or interactions were revealed.

Table 1. Proportion of Correct Responses as a Function of Group, Emotion and Ear

	Happy		*Sad*		*Neutral*	
	Right	*Left*	*Right*	*Left*	*Right*	*Left*
	0.47	0.31	0.58	0.29	0.58	0.31
	0.44	0.31	0.44	0.43	0.64	0.31
	0.51	0.24	0.60	0.26	0.50	0.39
General	0.47	0.36	0.47	0.29	0.42	0.39
Population	0.38	0.36	0.46	0.40	0.58	0.19
	0.43	0.18	0.56	0.19	0.56	0.81
	0.36	0.28	0.61	0.33	0.67	0.25
	0.31	0.25	0.60	0.39	0.83	0.08
	0.57	0.28	0.47	0.22	0.61	0.22
	0.40	0.26	0.49	0.22	0.61	0.22
	0.47	0.19	0.74	0.24	0.58	0.28
	0.33	0.26	0.40	0.32	0.50	0.28
Undifferentiated	0.11	0.82	0.04	0.83	0.06	0.83
Developmental	0.24	0.28	0.35	0.29	0.50	0.28
Delay	0.38	0.28	0.31	0.26	0.64	0.22
	0.36	0.25	0.38	0.24	0.36	0.33
	0.19	0.28	0.47	0.42	0.42	0.31
	0.36	0.31	0.42	0.26	0.44	0.28
	0.46	0.31	0.49	0.26	0.50	0.28
	0.24	0.50	0.18	0.40	0.33	0.42
Down	0.32	0.38	0.42	0.44	0.44	0.39
Syndrome	0.49	0.26	0.63	0.28	0.58	0.25
	0.35	0.31	0.25	0.28	0.28	0.31
	0.33	0.32	0.47	0.33	0.47	0.39
	0.35	0.43	0.40	0.49	0.42	0.39
	0.35	0.39	0.39	0.39	0.42	0.36

Discussion

It has been known for quite some time that individuals with Down syndrome exhibit an atypical cerebral lateralization for the processing of receptive language. Although it was originally postulated that these effects originated as the result of a more or less complete left-right reversal of cerebral function in DS (e.g., Pipe, 1988), more recent evidence suggests that while individuals with DS exhibit Right Hemisphere (RH) specialization for

speech perception, they remain dependent on Left Hemisphere (LH) neural systems for the organization and control of movement. Indeed, this specialization has been shown to generalize to include both the visual and haptic processing of linguistic material (Weeks, Chua, Elliott, Lyons, & Pollock, 1996). This study sought to explore whether this RH advantage for language reception in DS was mediated when verbal stimuli were delivered with emotional prosody: an acoustical parameter that typically involves the RH in the general population. Results from this study are consistent with others that have examined the influence of prosody in the general population. Specifically, happy and sad intonations affect the right and left hemispheres differentially. Of greater interest, however, was the absence of a group by ear interaction. This suggests that the atypical left-ear/right-hemisphere lateralization usually observed for DS in these types of dichotic tasks was absent. In other words, the inclusion of prosody created a situation in which DS processed verbal stimuli in a manner similar to both mental-age and chronological-age matched controls. Given the free recall nature of task, however, it is possible that individuals may have compensated for lack of specialization by shifting attention to the disadvantaged ear. Because this limits the scope of the present study, we are currently employing a directed attention paradigm to determine whether this mediation of RH specialization in DS persists. If so, there is at least putative evidence to suggest that individuals with DS may experience some benefit to the presence of prosody in verbal speech perception.

References

Bulman-Fleming, M.B, & Bryden, M.P. (1994). Simultaneous Verbal and Affective Laterality Effects. *Neuropsychologia, 32* (7), 787-797

Elliott, D., Weeks, D.J., & Elliott, C. (1987). Cerebral specialization in individuals with Down syndrome. *American Journal of Mental Retardation, 92* (3), 263-271

Heath, M., Elliott, D., Weeks, D.J., & Chua, R. (2000). A functional -systems approach to movement pathology in persons with Down's syndrome. In D. Weeks, R. Chua & D. Elliott (Eds.), *Perceptual-Motor Behavior in Down Syndrome*, (pp. 305-320). Champaign IL: Human Kinetics Publishing.

Pipe, M.E. (1988). Atypical laterality and retardation. *Psychological Bulletin, 104*, 343-349.

Weeks, D.J., Chua, R., Elliott, D. Lyons, J., & Pollock, B.J. (1996). Cerebral specialization for receptive language in individuals with Down syndrome, *Australian Journal of Psychology, 47* (3), 137-140.

Weeks, D.J., Chua, R., Elliott, D., Weinberg, H., Cheyne, D., & Lyons, J. (1997). The use magnetoencephalography to (MEG) to investigate cerebral specialization in Down syndrome. *Journal of Sport and Exercise Psychology, 19*, S117.

Correspondence

James Lyons
Department of Kinesiology
McMaster University
1280 Main Street West
Hamilton, Ontario

lyonsjl@mcmaster.ca