The Effects of Sex and Autism Spectrum Disorder on Prosody

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Background. Whereas a large body of research has generally shown that women are better at comprehending and producing affective (emotional) prosody than men [1-2], less is known about how sex affects other forms of prosody. For example, minimal research has investigated sex differences for contrastive stress, in which a speaker places emphasis on new or salient information. An exception is a recent study by Koch & Spalek [3] which suggests that women may be more sensitive to contrastive stress than men, although their use of a word recall task to evaluate contrastive stress is somewhat problematic.

Autism spectrum disorders (ASD) are neurodevelopmental disorders characterized by atypical interests, body movements, social interactions, and communication [4]. Some people with ASD have difficulty using prosody to convey subtle emotions [5] and have incorrect stress placement [6]. Sometimes people with ASD attempt to camouflage or "mask" outward signs of their ASD. Masking techniques include attempting to reduce body movements and mirroring another person's expressions or intonation [7]. Although both men and women with ASD can engage in behavioral masking, the practice is reportedly more common in women [8].

To date, no research has investigated whether there are sex differences in prosodic masking among people with ASD. The current study addresses this gap in the literature. Based on previous research, we expected that women would outperform men on prosody tests, and that participants who were neurotypical (NT) would outperform people with ASD. If women with ASD prosodically mask more than men with ASD, the ASD-NT difference in prosody should be smaller for women than men. Further, this sex difference should be more apparent in production than comprehension, particularly when prosody is used for pragmatic purposes.

Methods. One-hundred eighteen college students participated in the study and completed the Autism Spectrum Quotient (AQ) test [9]. The ASD group was composed of 25 participants who were diagnosed with autism and/or scored above 28 on the AQ test. The NT group was composed of the remaining 93 participants. The sex ratio of 2 female:1 male was roughly the same for NT and ASD groups. To assess prosody, we created the Online Profiling Elements of Prosody in Speech Communication (O-PEPS-C), an online adaptation of the in-person clinical PEPS-C test [10] which is often used evaluate the prosodic abilities of people with ASD. The O-PEPS-C includes tests of prosodic form and 6 prosodic functions. The prosodic function subtests assess comprehension and production of utterances that differed minimally in affect (like/ dislike), question vs. declarative prosody, phrase boundaries (e.g., *chocolate, cake, and cookies* vs. *chocolate cake and cookies*), lexical stress (e.g., *IMport* vs. *imPORT*), phrase stress (e.g., *The green house/greenhouse spoils the view*) or contrastive stress. Only contrastive stress subtests involve pragmatic prosody. In the contrastive stress comprehension subtest, participants listen to a context story (e.g., "Earlier today, the person on the screen bought some socks. But when she got home, she had forgotten to buy one color"). Participants then hear the forgetful shopper say either "I wanted BLUE and black socks" (indicating the shopper forgot to buy blue socks) or "I wanted blue and BLACK socks" (indicating the shopper forgot the black ones). Participants must indicate which color socks the shopper forgot to buy. In the production subtest, participants hear utterances that are not true (e.g., they hear *the green sheep has the ball* while viewing a picture depicting a green cow with a ball) and they must correct the error. Participants'

productions are scored correct if they use contrastive prosody in their corrections (e.g., *No, the green COW has the ball*).

Results. Comprehension accuracy was automatically calculated. At least 2 PEPS-C coders evaluated the accuracy of all production items, and inter-rater reliability was very high (Krippendorf's alpha > 0.82). Accuracy data were analyzed using Sex x ASD/NT Bayesian ANOVAs with item as a random factor [11]. When all production and comprehension data were combined, women did better than men ($BF_{inclusion}$ = 8.77 x10^6), and the best fitting model (BF_{10} = 1.33 x10^7) had a main effect of sex but not ASD, and no interaction between the two factors. Analyses of just the production data yielded similar results (BF_{10} = 2.06 x10^7; BF_{sex} =1.37 x10^7), but when just the comprehension data were analyzed, no model fit better than the null model.

Because ASD particularly affects pragmatics [12], we concentrated our analyses on contrastive stress subtests. When production and comprehension contrastive stress data were combined, the best fitting model (BF_{10} = 4.10 x10^7) revealed that women outperformed men ($BF_{inclusion}$ = 2.95 x10^7, see Figure 1a), but there was no main effect for ASD, and no interaction between the two factors. Analyses of just the contrastive stress comprehension data revealed that women did somewhat better than men (BF_{10} = 6.98; BF_{sex} = 4.72, see Figure 1b). In striking contrast, when just the contrastive stress production data were analyzed, the best fitting model (BF_{10} = 8.13 x10^7) included main effects of both sex ($BF_{inclusion}$ = 5.27 x10^7) and neurological status ($BF_{inclusion}$ = 1.74 x10^1) and an interaction between the two ($BF_{inclusion}$ = 9.88 x10^1, see Figure 1c), with moderate evidence of an NT-ASD difference for men (BF = 8.32), but no evidence for women (BF <2).

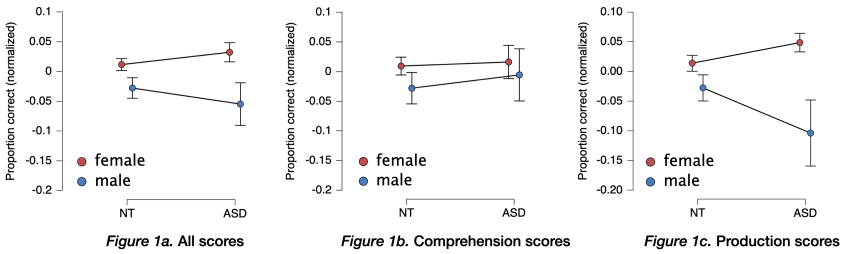

Figure 1. **Contrastive Stress Scores (error bars = 95% credible intervals)**

Discussion. As expected, overall, women outperformed men. However, contrary to our expectations, overall, NT participants did not outperform ASD participants, and there was no interaction between sex and neurological status for overall scores. The failure to find an effect of neurological status on overall prosodic ability may reflect the fact that our participants were college students and, thus, our ASD participants are likely less prosodically impaired than those in previous studies, and only the contrastive stress subtests specifically tap pragmatic uses of stress. Our finding that on contrastive stress, ASD women performed just as well as NT women, whereas ASD men performed much worse than NT men supports the hypothesis that women with ASD engage in prosodic masking more than men with ASD. The fact that this sex difference is more prominent in contrastive stress production than in contrastive stress comprehension is consistent with prosodic masking being a public-facing compensatory display, and not simply that women with ASD are better at contrastive stress then men with ASD.

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