Is there an Influence of Autistic Traits on Audio-Visual Speech & Song Emotion Perception?

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Abstract

Autistic individuals are reported to have atypical emotion perception. Evidence indicates this may be domain specific. However, most previous studies have used unimodal stimuli and have not explored perception of emotions in sung vocals. This study thus examined whether emotion recognition differs as a function of autistic traits using audio-visual speech and song stimuli. We found no general impairment in emotion perception across domains as a function of autistic traits, though higher autistic traits were associated with slower reaction time for some emotions. Findings are interpreted in light of methodological differences with previous studies, particularly our use of audio-visual stimuli.

Index Terms: Autism, emotion, music, speech, song, audio-visual

1. Introduction

Autism spectrum condition is a neurodevelopmental condition characterised by differences in social communication and the presence of restricted, repetitive, and stereotyped behaviours [1]. Though not a formal diagnostic criterion, various studies have indicated that autistic individuals find emotion processing more challenging than neurotypical (NT) individuals, which could exacerbate the challenges autistic individuals face in social communication [2]. (In this paper, we respectfully use the term 'autistic individuals', a term that seems to be preferred by most individuals with autism [3].)

Autistic individuals appear to find emotion perception challenging across most modalities and stimuli. Poorer performance in emotion recognition among autistic individuals or individuals with higher levels of autistic traits has been repeatedly demonstrated with static photographs and dynamic video-only clips of human faces as stimuli (see [4] for a meta-analysis on this topic). Curiously, group differences seem to disappear when recognising emotions in nonhuman/cartoon-like faces [5], suggesting that performance could be modulated by how socially meaningful the stimuli are. Similar to findings with human faces as stimuli, autistic individuals tend to show atypical perception of emotions in speech, when compared to NT individuals (see [6] for a review). While this could be due to language difficulties in some autistic individuals [7], even when matched to their NT counterparts on verbal ability, autistic individuals seem to have found decoding of emotions in speech more challenging [8]. Given that emotions in speech are mostly conveyed through acoustic features such as pitch, amplitude, and tempo/duration [9], some suggest that speech emotion processing ability may be related to one's basic auditory perception which has been found to be atypical among autistic individuals, particularly for vocal stimuli [10], [11].

Considerably fewer studies have investigated whether autistic and NT individuals differ in their processing of emotions in music. The tentative conclusion is that there are no group differences [12], suggesting music may be processed differently to speech. A recent meta-analysis found that difficulties in emotion processing in music among autistic individuals may apply to fear and sadness, but not happiness [13]. However, this should be interpreted with caution given the small number of studies with musical stimuli included in the meta-analysis [13]. Preserved music-emotion processing and impaired speech-emotion processing among autistic individuals is not surprising, given the double dissociation in processing the two domains among autistic individuals. For example, autistic individuals seem to have equal, if not superior, processing of musical contour and intervals, and pitch memory [14][15]. Indeed, the apparent music processing ability among autistic individuals has led some to suggest music-based interventions for autism [16]. If music emotion perception is associated with basic auditory perception, as with speech emotion perception, then it follows that autistic individuals may show a preserved ability to decode emotions in music.

It should be noted that most of the music-related studies reviewed above used stimuli generated from musical instruments, not including sung vocals. Drawing parallels to differences in human vs. non-human faces, it is unclear if findings from music emotion processing generated from musical instruments would generalise to that of human-produced sung vocals, the latter of which may be more socially meaningful. Moreover, most studies on emotion perception among autistic individuals have relied on unimodal stimuli (e.g., static photographs, audio-only clips, etc.), which are arguably less ecologically valid than the use of audio-visual (AV) stimuli. Of the handful of studies that examined AV emotion processing among autistic and NT individuals, no groups differences in accuracy were reported [17], [18], though autistic individuals showed less gain from multimodal relative to unimodal stimuli than NT individuals [18].

When considering the effect of autism or autistic traits on emotion processing, it is vital to account for alexithymia, a condition related to difficulty describing and identifying emotions, especially since alexithymia is highly prevalent among autistic individuals [19]. Indeed, some argue that it is alexithymia, rather than autism per se, that drives the group differences in emotion perception seen in previous studies [20]. Thus, alexithymia needs to be accounted for, to determine whether autism or autistic traits may have any influence on emotion processing above and beyond alexithymia.

The current study addresses the gaps identified in the literature: using AV stimuli, we examined emotion perception in speech and song with adults with varying levels of autistic traits, while controlling for their alexithymia. Based on previous studies, we hypothesised a negative effect of autistic traits on speech emotion perception. We made no clear predictions about the effect of autistic traits on song emotion perception: if performance on the song condition is based on music auditory perception, then no effect of autistic traits is expected; however, if performance is based on the social nature of the song stimuli, then a negative effect of autistic traits is expected.

2. Methods

2.1. Participants

Participants consisted of 55 young adults (M_{age} = 24.00, SD_{age} = 4.04, Range = 18-30; Female *n* = 34, Male *n* = 20, Non-binary *n* = 1), all of whom self-reported to have normal or corrected-to-normal vision and hearing. Most were native British English speakers (*n* = 49) and of the few who were not, they rated their English proficiency to be above-average (i.e., rating themselves at least a 6 on a 7-point scale).

Approximately half of the participants self-reported to have a formal diagnosis of autism (*n* = 27), though this was not verified due to the anonymity of the online experiment. Somewhat confirming their diagnosis, the autistic participants had a significantly higher autistic traits score (as measured using the Autism Spectrum Quotient, or AQ – see Tasks & Stimuli subsection) than the neurotypical participants ($t(53)$ = 6.56, $p < .001$). Some participants (*n* = 15) reported having experience with musical training: their mean cumulative experience ranged from 0.5 to 35 years (M = 9.37, SD = 8.61) and some participants (*n* = 9) reported having experience with drama and acting, with their cumulative experience ranging between 1 and 14 years (M = 5.89, SD = 5.18).

Participants were recruited from the Psychology research participant pool or from Prolific. All participants provided their written informed consent prior to their participation, and they were given course credit or monetary compensation as reimbursement for their time. The study protocol was reviewed and approved by the University Research Ethics Committee at the University of Reading.

2.2. Tasks and stimuli

2.2.1. *Autism Spectrum Quotient (AQ)*

Autistic traits were measured using The Autism Spectrum Quotient (AQ) [21], a screening test designed to determine the degree to which adults have traits associated with autism such as social skills, attention to detail, and communication. The AQ consists of 50-items, for which participants are required to indicate how much they agree or disagree on a 4-point scale. Higher AQ scores reflect higher levels of autistic traits.

2.2.2. *Toronto Alexithymia Scale (TAS)*

Alexithymia was measured using the Toronto Alexithymia Scale (TAS) [22]. This 20-item self-report instrument measures difficulty identifying and describing emotions by asking participants to how much they endorse each item on a 5-point scale. Higher TAS scores suggest more alexithymic traits.

2.2.3. *Emotion recognition task*

Stimuli from the emotion recognition task were taken from the Reading Everyday Emotion Database (REED) [23]. The REED consisted of AV recordings of native British English adults with varying levels of acting experience ('encoders') expressing emotions using their 'everyday' recording devices (e.g., webcam, mobile phone). A subset of 160 recordings from the REED was used in the task: 2 domains (speech/song) × 10 emotions (1 neutral; 6 basic—angry, happy, sad, disgusted, fearful, surprised; and 3 complex— embarrassed, sarcastic, and stressed) × 8 encoders. All the stimuli have the same verbal content: "Happy birthday to you" that is either spoken or sung to the first line of the Happy Birthday song. The recordings were recognised above chance in a previous validation study.

On every trial, participants were presented with a fixation cross for 500ms, then the recording, after which they were asked to select what emotion they thought was being portrayed from a choice of six labels (the target, 4 foils, and an 'Other' option, which should be chosen should neither of the 5 labels adequately describe the depicted emotion). Participants could not replay the recording, and they had to respond within 8s; otherwise, an incorrect response was recorded, and the next trial began automatically. Participants were given the opportunity to take a break after every 20 clips. Participants completed four practice trials prior to the start of the task.

To ensure participants were paying attention, catch trials were inserted throughout the task, consisting of a greyscale clip with no audio or a clip with an auditory beep. Participants were instructed to select 'Other' for those catch trials.

2.3. Procedure

Participants completed the tasks online, hosted on Gorilla [24]. After providing their informed consent and checking that the volume was at a comfortable level, participants completed a short demographic questionnaire, followed by the AQ and TAS questionnaires. Finally, participants completed the emotion recognition task. The entire study took approximately 30 minutes to complete.

2.4. Data analysis

Analysis was conducted on accuracy and reaction time on the emotion recognition task, separately.

Accuracy data was modelled using a binomial mixed effects model, with the binary variable Correct (Correct/Incorrect) as the dependent variable. We entered Domain (Speech/Song), Emotion (all 10 emotions), autistic traits (AQ), and all the possible interactions between them. To account for the possible effects of alexithymia, we included their TAS score as a predictor too. As random effects, we entered by-item random intercepts, by-subject random intercepts, and by-subject random slopes for Domain and Emotion.

Reaction time (RT) data on correct trials was modelled using a linear mixed effects model with the dependent variable Reaction Time in milliseconds. The same fixed effects as the Accuracy model were entered. As random effects, only by-subject and by-item random intercepts were entered due to convergence issues.

In both models, all categorical variables were effect coded and all continuous variables were mean centred. We analysed both models using the *lme4* package [25]. Statistical significance of each predictor was determined using the *Anova()* function from the *car* package [26]. Subsequent pairwise comparisons were conducted using the *emmeans* package with Tukey correction [27]. Model reduction for nonsignificant predictors was not done as the predictors were related to our a priori predictions.

3. Results

3.1. Accuracy

Output of the accuracy model is displayed in Table 1.

Table 1. *Output of the accuracy model.*

Predictors	χ^2	df	*p*
Intercept	0.02	1	.883
Domain	1.44	1	.230
Emotion	26.34	9	.002
AQ	0.11	1	.738
TAS	0.43	1	.513
Domain × AQ	0.70	1	.403
Domain × Emotion	10.96	9	.278
Emotion × AQ	9.42	9	.399
Domain × Emotion × AQ	15.34	9	.082

There was a main effect of Emotion, such that, as shown in Figure 1, some of the basic emotions (Happy, Neutral) were recognised more accurately than some of the complex emotions (Embarrassed, Stressed; Happy vs. Embarrassed: $z = 3.97$, $p = .003$; Happy vs. Stressed: $z = 3.45$, $p = .020$; Neutral vs. Embarrassed: $z = 3.59$, $p = .012$).

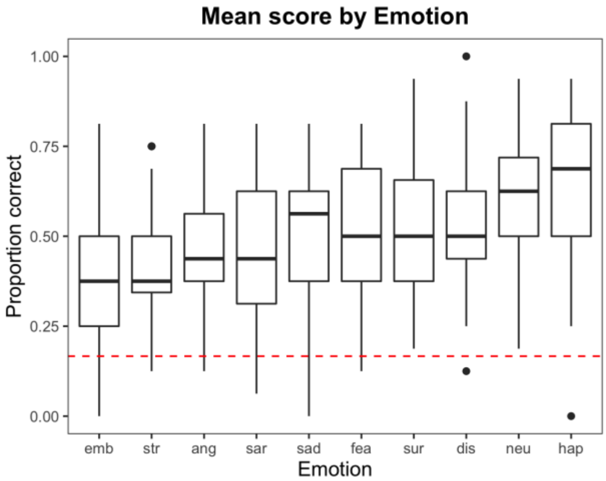

Figure 1: *Boxplots depicting accuracy by emotion. Dashed line represents chance level (1/6).*

We also explored the marginal three-way interaction between Domain, Emotion, and AQ, and we found that Surprised Song condition had a marginally significant negative AQ slope, but Disgusted Song condition had a marginally positive AQ slope (Disgusted: $z = 1.93$, $p = .054$; Surprised: $z = 1.95$, $p = .051$). Pairwise comparisons across domains only revealed a significant difference in the Disgusted conditions ($z = 2.243$, $p = .025$) but not in the Surprised conditions ($z = 1.56$, $p = .118$, see Figure 2).

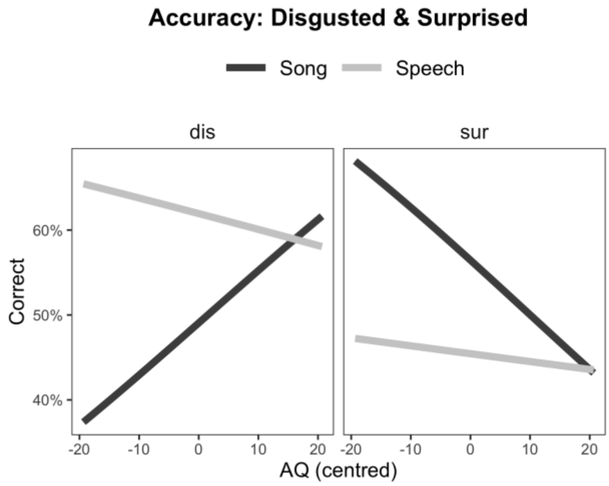

Figure 2: *Predicted percent correct for Disgusted (left) and Surprised (right) Speech (light grey) and Song (dark grey) as a function of autistic traits (AQ).*

3.2. Reaction time

Table 2 displays the output of the RT model. There was a marginal effect of TAS such that, surprisingly, higher TAS scores led to faster RT ($B = -13.99$, SE = 7.41).

Table 2. *Output of the RT model.*

Predictors	χ^2	df	*p*
Intercept	1273.52	1	<.001
Domain	0.15	1	.697
Emotion	33.04	9	<.001
AQ	1.93	1	.165
TAS	3.56	1	.059
Domain × AQ	2.72	1	.099
Domain × Emotion	14.04	9	.121
Emotion × AQ	20.75	9	.014
Domain × Emotion × AQ	8.76	9	.460

There was a main effect of Emotion, but this was qualified by an Emotion × AQ interaction. Follow-up comparisons revealed that the effect of AQ was only significant for Sarcastic ($z = 2.38$, $p = .017$) and Surprised ($z = 2.66$, $p = .008$) such that higher AQ was associated with longer RT for those two emotions (see Figure 3).

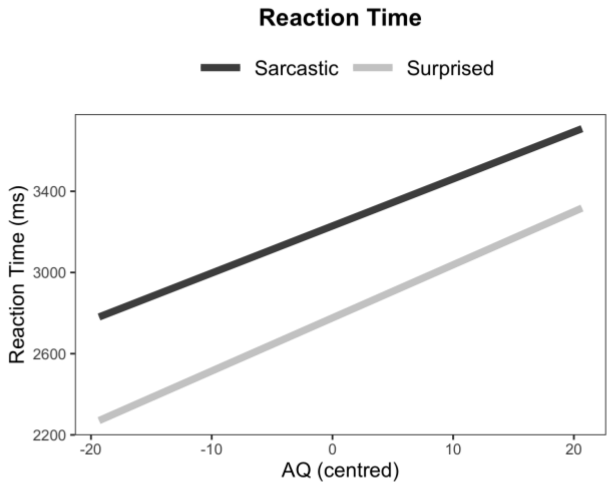

Figure 3: *Predicted RT (in ms) for Sarcastic (dark grey) and Surprised (light grey) as a function of autistic traits (AQ).*

4. Discussion

This study used AV stimuli to examine whether emotion perception in speech and song may differ as a function of autistic traits (AQ), while controlling for alexithymia. We predicted that there would be a negative AQ relationship for speech but made no clear predictions for emotion perception in song. On both accuracy and reaction time (RT), we found no general effect of AQ. A closer inspection revealed some weak evidence that the effect of AQ on accuracy might be modulated by Domain and Emotion. Results also suggested that AQ effect on RT was modulated by Emotion.

Unpacking the marginal interaction between AQ, Domain and Emotion for accuracy revealed that individuals with high AQ showed comparable performance for Speech and Song for Disgusted and Surprised, whereas individuals with low AQ showed differential performance: better for Speech than for Song for Disgusted, and the reverse for Surprised (see Figure 2). It is not immediately clear why this is the case, but we caution against drawing too strong a conclusion from this interaction given that the interaction and the subsequent post-hoc comparisons were only marginally significant.

In terms of the AQ × Emotion interaction for RT, we found that higher AQ was associated with longer RT for Sarcastic and Surprised. These findings are particularly interesting in relation to generally poorer accuracy performance for Surprised among individuals with high AQ. Taken together, these results suggest that Surprised, and to an extent, Sarcastic, may be challenging for individuals with higher levels of autistic traits, consistent with previous studies [28], [29]. These emotions to an extent rely on Theory of Mind, or the ability to understand one's mental states to infer their feelings or thoughts, which is thought to be atypical among autistic individuals [30]. For example, to recognise that someone is surprised, one must infer that they are unaware of or did not expect the situation that is unfolding.

We did not observe a general effect of AQ on emotion recognition of speech and song. On the latter, this is in line with the idea that music emotion processing among autistic individuals is spared [12]. This is to be expected if music emotion processing relies in part on one's basic auditory processing ability, which is found to be preserved among autistic individuals for musical stimuli [14], [15]. The lack of a negative effect of autistic traits on speech emotion recognition, on the other hand, is surprising, given previous studies reporting group differences when decoding affective speech prosody [6]. We propose that this may be due to methodological differences: previous studies have mostly relied on unimodal stimuli (e.g., audio-only speech affective prosody) whereas we used audio-visual stimuli. The AV benefit is well-documented, at least among neurotypicals [31]. Suppose that speech emotion perception is associated with autistic individuals' atypical basic auditory vocal perception, as suggested by previous studies [10], [11]. Then, our findings, together with the few AV studies on autism [17], [18], suggest that any emotion processing difficulties that autistic individuals or individuals with high autistic traits have may be ameliorated with the presence of (redundant) information from the visual modality. This remains speculative at this stage of course, and further studies are needed to confirm this (indeed, we plan to repeat the study with an audio-only condition using the same stimulus set).

Some limitations of the study are worth noting. The sample size is modest, and given the number of predictors in the model, a larger sample size may be necessary to have sufficient power to detect any effects. Moreover, we used a dimensional (autistic traits) approach rather than the typical case-control approach seen in previous autism studies, comparing individuals who have received an autism diagnosis with those who did not. Indeed, some have cautioned against conflating autistic traits obtained from self-report measures with autism [32]. When we repeated the analysis with self-reported autism diagnosis, that is, we compared those with vs. without autism (though note that we were unable to confirm their diagnosis), we found no effects or interactions involving diagnosis. Thus, the case-control approach similarly revealed no group differences in emotion processing of speech and song when audio-visual stimuli were used. Future studies should also consider how gender may influence the findings, given some evidence for gender differences in emotion processing [33]. This was not possible in the present study given the imbalance of gender distribution (just over a third of our sample identified as male, one non-binary individual, and the rest female). With more participants, we hope to investigate this further by including biological sex and gender in the analysis to examine how they may differ in emotion processing, and how this might relate to autism.

5. Conclusions

In conclusion, contrary to our prediction and previous studies, we did not find any evidence of differences in general emotion perception in speech and song as a function of autistic traits, though individuals with high autistic traits were slower at recognising emotions that require Theory of Mind. We speculate that the lack of a general effect of autistic traits relative to previous studies may be due to methodological differences: specifically, unlike previous studies that have mostly used unimodal stimuli, our use of audio-visual stimuli may have ameliorated any differences in emotion processing. Further work is needed to confirm this, which, if true, will have implications on whether the findings of emotion processing differences among autistic individuals in previous studies reflect a true atypical ability or an artefact of stimulus modality.

6. Acknowledgements

This work is supported by the European Union's Horizon 2020 research and innovation programme under the Marie

Skłodowska-Curie grant agreement No. 887283 awarded to JHO.

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