DURMS
Durham Undergraduate Research in Music & Science

The Influence Between Traits of Autism Spectrum Disorder and Emotion Perception in Speech and Music

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ABSTRACT

This study examined emotion perception in speech and music for people with a high number compared to a low number of Autistic Spectrum Disorder (ASD) traits. Research has shown that people with ASD cannot perceive emotion in speech as accurately as those with Typical Development (TD), however both groups have similar or equal abilities at perceiving emotion in music. Research thus far has not acknowledged the spectrum of emotion intensities in speech and music, and the current study tests emotion perception in increasing levels of emotion in speech and music. The main results supported the hypothesis that although people with a high number compared to a low number of ASD traits were on average less accurate in perceiving emotion in speech compared to in music, people with a high number of ASD traits performed better in exaggerated levels of emotion in speech than lower levels. These results are promising, and it would be beneficial to replicate the experiment involving participants with official diagnoses of ASD, as this could help our understanding of ASD, and suggest that people with ASD can perceive emotion in exaggerated levels of speech more accurately than thought, which may help treatment for people with ASD.

1. INTRODUCTION AND LITERATURE REVIEW

This study explores emotion perception in speech and music for individuals with Autism Spectrum Disorders (ASD) compared to individuals without ASD, also known as "Typical Development" (TD). I will also investigate a novel research question within a field of related research, exploring how individuals with high levels of traits of ASD rate emotion levels in speech and music compared to individuals with low levels of ASD traits. The study contains ideas which, as far as can be seen, have not been used before and could hopefully show a different way of understanding the abilities in emotion perception for individuals with ASD.

ASD has developed from a little-known condition, first identified by Leo Kanner in 1943 and Hans Asperger in 1944 (Happé 1999), however stories of people with unusual behaviour and a lack of common sense as a possible portrayal of ASD were relayed through folk tales for years before this (Happé 1999, 7). When first identified, ASD traits were based on behavioural aspects such as loneliness and being obsessive about keeping routine (Happé 1999, 15), but actually, when studying ASD there are three levels; biological, cognitive, and behavioural (Happé 1999, 2). Now, ASD is recognised as a condition with varying levels of severity, or a "spectrum", and traits vary with each individual (Baron-Cohen, Knickmeyer and Belmonte 2005; Baron-Cohen and Lombardo et al. 2011). The most recent (2013) edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5), which is the result of over ten years of work by experts in the field of mental health (American Psychiatric Association, n. d.), states that traits typically include a lack of social-emotional reciprocity, lack of non-verbal communication (such as eye contact and facial expressions), the need for repetitive activities and movements, and difficulties in making friends and imagining stories or games (Reynolds and Kamphaus 2013, 1). In this study, "autism" will be referred to as "Autism Spectrum Disorder", or "ASD", and people diagnosed with ASD as "individuals or people with ASD". People not diagnosed with ASD will be referred to as "individuals or people with TD (Typical Development)". This is due to some of the most recent studies on individuals with ASD referring to them in this same way (Kalandadze and Norbury et al. 2016; Brown and Cox et al. 2017; Bird, Cornell and Gaigg 2016).

1.1 Defining Speech and Music.

First, "speech" and "music" must be defined, especially as there can be a wide spectrum of different types of speech and music. English Oxford Living Dictionaries defines "speech" as "the expression of or the ability to express thoughts and feelings by articulate sounds" (Oxford Dictionaries, n. d.), and "music" as "vocal or instrumental sounds (or both) combined in such a way as to produce beauty of form, harmony, and expression of emotion" (Oxford Dictionaries, n. d.). However, could it be said that both of these definitions can overlap and be true for both speech and music? Speech can be extremely expressive and emotive, and music can express thoughts and feelings, indicating much crossover between the two. The English Oxford Living Dictionaries does not have a definition for "vocal music", but Encyclopaedia Britannica defines it as "any of the genres for solo voice and voices in combination, with or without instrumental accompaniment" (Porter 2019). It seems that there is difficulty in defining rigid terms for what "speech" and "music" are, especially when regarding vocal music, and this is in part what will be investigated later on in my experiment.

1.2 Parallels Between Speech and Music

There are many similarities and differences between speech and music. Rousseau believed languages are all "natural" (Rousseau 1998, 293), and that speech was invented for humans to communicate their needs (Rousseau 1998, 293). Zatorre, Belin and Penhune say there are similar aspects such as their "generative nature", meaning they are developed gradually from smaller parts (tones) into larger elements

(words and melodies) which we can understand, and are then joined together to make whole songs or sentences (Zatorre, Belin, and Penhune 2002, 37). So, even though similarities such as both involving sound production and both needing the ability to very accurately control vocal production are present (Jackendoff 2009, 196), the levels of pitch and melody are different between speech and music, and different areas of the brain control intonation of language and music pitch (Peretz and Coltheart 2003).

1.3 ASD and its Traits

People with ASD often have impaired skills in social interaction (Happé 1999), and compared to those with TD they have a lesser ability at naming their own emotions, as well as a decreased understanding of other people's minds (Ezangwill 2013). Compared to those with TD, people with ASD also often have a lower ability in understanding emotional cues in speech, many of which are communicated through speech prosody (Bhatara 2010), and an impaired ability to perceive emotion through speech prosody (Augustyn and Klin et al. 2005). Defined by Robert Mannell, speech prosody is the melody and rhythm in speech which help us to understand the meaning of speech, and prosody also often accounts for vocal pitch, volume of speech, and rhythm (Mannell 2007). However, there is no significant difference on a physiological level between individuals with ASD and TD when responding to music (Allen and Heaton 2010), and comparing children with ASD and TD, they do not differ in their ability to place musical excerpts into categories with happy and sad faces (Heaton, Hermelin and Pring 1999).

1.4 Literature Relating More Closely to the Current Study

To date there has not been a study identical to the current study, however there are studies which are related and relevant. Ezangwill states that individuals with ASD find it more difficult than people with TD to understand and imagine emotion, yet there is no evidence for this being the case with music (Ezangwill 2013, 2), leading us to the hypothesis that music has a unique ability to trigger "normal emotion cognition in autistic listeners", maybe with listeners responding to music's rhythm (Ezangwill 2013, 2). Even though slow rhythms are associated with sad music, and fast rhythms with happy music, for example, music generally expresses emotion through its melody, and it seems more likely that people with ASD perceive emotion from the music's key and melody rather than its rhythm. Heaton, Hermelin and Pring suggested that children with ASD can identify major modes as happy and minor modes as sad (Heaton, Hermelin and Pring 1999), further highlighting the theory that musical mode is one of the main cues which helps people with ASD, and people in general, to perceive emotions expressed by music. Furthermore, a study by Quintin et al. compared individuals with ASD and TD and their ability to recognise musical emotions and match them to facial expressions. Individuals with ASD were able to recognise the emotion in music, but were less accurate in matching these to their corresponding facial expressions (Quintin and Bhatara et al. 2011, 1245). This could be due to people with ASD often having difficulty interpreting emotion in facial expressions (Eack, Mazefsky, and Minshew 2017; Poliac, Poliac, and Wagemans 2012). Heaton, Hermelin and Pring investigated whether children with ASD can perceive affect in music. Children with ASD and a control group were compared, and participants had to match music excerpts with happy and sad faces, with results showing that children with ASD and the control group did not differ in their ability to place musical excerpts into categories of happy or sad faces (Heaton, Hermelin and Pring 1999). This suggests that children with ASD were able to pick up emotional connotations in major and minor modes whilst not displaying a deficit in processing these musical stimuli (Heaton, Hermelin and Pring 1999).

There have also been studies about ASD and emotion perception in speech. Lindström and Lepistö-Paisley et al. investigated the processing of emotional prosodic change in word stimuli for children with TD and ASD (Lindström and Lepistö-Paisley et al. 2016, 47). The study tested "sad", "scornful" and "commanding", and a female speaker uttered words for the audio stimuli (Lindström and Lepistö-Paisley et al. 2016, 48). The results demonstrated an impaired level of discriminating prosodic changes between the different emotion examples, showing that children with ASD have a deficit in processing words and changes in speech prosody (Lindström and Lepistö-Paisley et al. 2016, 50). In 2010, Van Santen et al. used a computer to generate nonsense words with varying speech prosody in the words, comparing children with ASD and TD (Van Santen et al. 2010, 217). Participants were required to either repeat the nonsense words with the same stresses on syllables, or when a picture of an animal was described incorrectly, to correct the mistake with a stress on the corrected word. The hypothesis was clearly confirmed in the results, as individuals with ASD performed more poorly than those with TD (Van Santen et al. 2010, 222), re-affirming that people with ASD are impaired in their understanding and use of speech prosody compared to people with TD.

1.5 Implications and the Current Study

Whilst these studies are useful to understand background in this area, there are differences in the current study, the main one being the use of a spectrum of emotions rather than just one level of emotion intensity. These will range from monotone speech, speech with a slight, normal and exaggerated level of emotion, to sung music with a slight, normal and exaggerated level of emotion. This is because emotion is subjective, and there is a gap in literature and studies to date as I have not yet found a study which does this. A spectrum of emotion intensities gives the opportunity to see if there is a level that people with ASD can accurately perceive emotion. Secondly, I will not recruit participants specifically with ASD diagnoses as there were not the means in place for this. Instead, the Autism Spectrum Quotient (AQ) will be used, which has been used in previous literature such as Garza-Villarreal, Heaton and Vuust (2012), "Do Musicians with Perfect Pitch Have More Autism Traits than Musicians without Perfect Pitch? An Empirical Study". Developed by the psychologist Simon Baron-Cohen along with colleagues at the Autism Research Centre in Cambridge, the AQ was made

to measure traits of ASD in adults (https://aspietests.org/aq/index.php, n. d.) which are present in the general population. The AQ is not a diagnostic tool, and someone can score very highly but not have ASD, or vice versa. In the current study, I will compare individuals with a high number to a low number of ASD traits.

If there is a point that people with ASD and TD can perceive emotion to a similar ability, it would be my hypothesis that this would happen in the exaggerated speech example or one of the sung music examples, due to previously examined studies suggesting that children with ASD and TD have the same ability at perceiving and interpreting emotion in music. If this was the case, it would be important for research as previously it has been generally accepted that people with ASD have a deficit in perceiving emotion in speech and speech prosody, but not music.

2. METHOD

2.1 Design

This study used repeated measures, and audio examples were in a randomised order for each participant to avoid predictability when rating emotion. The experiment was in an experimental design, as the mood stimuli were manipulated, and there were three independent variables: the emotion expressed by the female singer, the intensity of emotion, and the mode of delivery. Dependent variables were the levels of emotion participants perceived after audio examples, and since this could have been influenced by outside factors, participants were asked before the study began whether they felt happy, sad, angry, fearful, or neutral, and if applicable, why, to try and explain any potentially biased results towards one particular emotion. Participants were asked if they had had a formal diagnosis of ASD to help explain any correlations between emotion perception of audio and AQ ratings.

2.2 Participants

There were 39 participants, mostly recruited via Facebook where the link to the experiment was shared. Participants completed the experiment at a time and location of their choice, but were encouraged to do so in a quiet place where they would not be disturbed, wearing headphones to minimise sound disruption from their surroundings. The study was anonymous and did not require participants' personal information unless they wished to give their email address to find out the results of the study. There were 25 females and 14 males, and ages ranged from 18 to 70, with the mean age of participants being 37.4 years. Participants were required to complete the Goldsmiths Musical Sophistication Index (GOLD-MSI) test to determine who was a "musician" or a "non-musician". The lowest score on the test was 7, the highest 44, and the mean was 28.5 (out of a maximum of 49 points and a minimum of 7). Although it did not matter particularly whether participants were musicians or non-musicians, this was included to account for any possible bias in the results where musicians could have felt more emotion to the sung excerpts. Participants were asked whether their first language was English, as if it was not the participant's understanding of the language might not have been the same, and two participants did not have English as their first language. Most participants (21) said they felt neutral before completing the experiment, 14 said they felt happy, two sad, one angry and one fearful. One participant said they had a formal ASD diagnosis, and the mean AQ score (out of a maximum of 50 points and a minimum of 0 points) was 18.4, with the highest score being 39 and the lowest 4. For AQ scores, there were five categories: 0-10 points indicates a low score with no tendency at all towards ASD traits, 11-21 points is the average result, 22-25 points shows ASD tendencies slightly above the average population, 26-31 points shows a borderline indication of ASD (also possibly Asperger's or mild autism), and 32-50 points indicates a strong chance of Asperger's or autism (Asperger's Test 2013). Eight participants were in the low score category, 18 in the average category, six slightly above average, six borderline ASD, and one strong likelihood of ASD.

2.3 Materials and Stimuli

Participants completed the Gold-MSI test, a tool for measuring individual variations in musical sophistication (Goldsmiths University of London, n. d.), and the Autism Spectrum Quotient (AQ), a measure of ASD traits in adults, developed by Simon Baron-Cohen and his colleagues at the Autism Research Centre in Cambridge (The Autism Spectrum Quotient (AQ), n. d.). Its first major trial resulted in the average score of 16.4 in the control group, and 80% of adults who had a diagnosis of an Autism Spectrum Disorder scored 32 or more (The Autism Spectrum Quotient (AQ), n. d.). However, the AQ is not a diagnostic tool, and some people who score 32 or more and have features of ASD do not have problems in their lives (The Autism Spectrum Quotient (AQ), n. d.). Instead, the tool measures ASD traits in adults which everyone in the general population exhibit; some just present more than others. After this stage, there were 25 audio questions consisting of the phrase "I went to the shops and bought some apples", chosen due to its neutral nature which would be highly unlikely to evoke strong emotions in the participants. One was spoken monotone, and for each emotion being tested (happy, sad, anger, and fear) there were three spoken and three sung conditions. The first spoken and sung conditions presented the emotion to a slight degree, the second to a normal degree, and the third to an exaggerated degree, and participants listened to each excerpt once. Melodies in the sung excerpts were improvised by the female singer so there would not be any familiarity with well-known melodies being used which could have evoked emotions in participants. Overall, the happy sung excerpts were in a major key, with sad, fear, and anger all sounding minor, and generally as the emotion intensity of examples increased, the speed of the excerpts also increased, except in "sad" stimuli.

2.4 Procedure

Before the experiment, participants completed a consent form, stated their age, gender, whether English was their first

language or not, whether they felt happy, sad, angry, fearful, or neutral, whether they had had a formal diagnosis of ASD, and completed the GOLD-MSI test and AQ. Audio examples consisted of the neutral sentence being spoken in four different emotions; happy, sad, anger and fear, with three different levels of emotional intensity for both spoken and sung examples. Participants rated examples on a scale of 1-7 based on how strongly they perceived the emotion in the audio to be out of all four emotions being tested, where one was not at all, and seven was extremely high. Participants rated emotions for all four emotions being tested, not just the emotion the audio was conveying, and there was no time limit so that participants would not rush and give inaccurate results.

3. RESULTS

To reach the results, the data was interpreted in various different ways, but before exploring this it is important to clarify some words which I will use to describe the results. When I refer to a "correct" emotion, I am referring to the emotion which the stimuli were meant to express, for example in the "slightly happy, spoken" example, the "correct" emotion is happy, and the "incorrect" emotions are sad, anger and fear. When I refer to "other emotional ratings", or "OERs", I am describing the means of the other three emotions which the stimulus was not meant to represent, or the "incorrect" emotions.

First, mean ratings were examined across all participants. There were no significant differences in results for people who did not have English as their first language, or for people who stated that they felt any particular emotion at the beginning of the experiment. For "happy" stimuli, ratings in happiness rose along with the rising intensity of emotions for spoken and sung stimuli, however for "sad", "anger", and "fear" stimuli, although correct emotions rose in spoken conditions, in sung conditions "normal" stimuli was rated lower than "slight" and "exaggerated" stimuli. All emotion examples across "happy", "sad" and "anger" had the correct emotion rated the highest, however in "fear, slight, spoken" and all three sung conditions for "fear", participants mistook fear for sadness, shown in Figure 1.

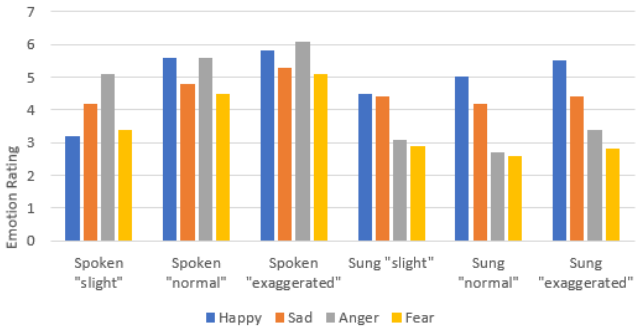

Figure 1. Mean emotional response ratings to happy, sad, angry and fearful stimuli across all participants

OERs were calculated to show how ambiguous or difficult the participant found perceiving the emotion in excerpts. For happy and fear stimuli in "slight" conditions, OERs were lower for sung compared to spoken conditions, suggesting participants were on average more easily able to pick up on subtle emotion cues in music compared to in speech, as shown in Figure 2.

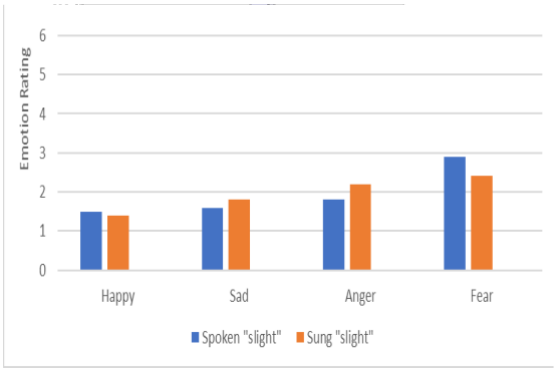

Figure 2. OERs across mean ratings in "slight" conditions for all participants

3.1 Individual AQ Score Categories

Participants were next divided into the five AQ categories mentioned previously, based on their score. These results clearly show that difficulties perceiving correct emotions did not begin until participants had an AQ score of 22 or greater, with the 22-25 group displaying traits of ASD slightly above the population average. In groups scoring low results on the AQ, scores for correct emotions generally rose with the rising intensities of emotions, and on average the spoken examples were rated higher than the sung examples. As with the "high" AQ group analysed previously, the group scoring 22-25 points on the AQ also confused "anger" with happiness and "fear" with happiness, sadness, and anger. OERs for these incorrectly perceived emotions were also on average higher than the emotion which the stimuli was supposed to be expressing, meaning that participants were much more unsure as to what emotion they were perceiving. However, for "happy" and "sad" stimuli, OERs on average were lower for sung rather than spoken stimuli. The group scoring 26-31 on the AQ, suggesting a borderline indication of ASD and a possibility of Asperger's or mild autism, also confused "anger" and "fear" emotions, but to a lesser degree than the group scoring 22-25. Additionally, OERs were lower in "sad" sung stimuli than the spoken, but the same for "happy" spoken and sung stimuli for the 26-31 group.

Only one participant scored 32-50 in the AQ, indicating a strong likelihood of Asperger's or autism. This individual's results are not conclusive, but look promising for the experiment's hypothesis. Unlike any other participant groups analysed, this individual gave incorrect emotion ratings across all four emotions. Emotion ratings are shown in Figure 3 for

"fear" stimuli, as this is where there were the most incorrectly rated emotions.

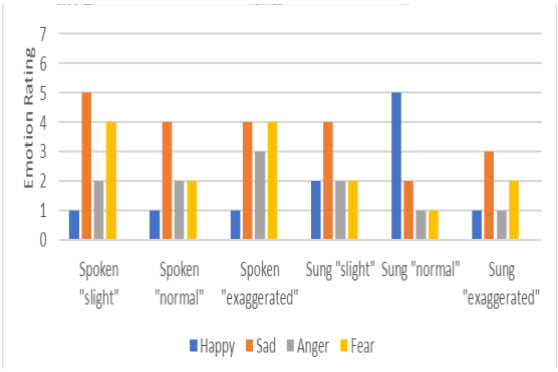

Figure 3. "Fear" ratings for the Participant in the 32-50 group

For "happy" stimuli, only the "normal" emotion intensity was correctly perceived, with "slight" rated as 1.0 for all four emotions. "Exaggerated" scored 1.0 for happy, and an OER of 3.7, clearly demonstrating the difficult which the participant had in perceiving the emotion. For sung "happy" stimuli, emotion ratings were correct and increased with the emotion intensity. For "sad" stimuli, the participant confused the "exaggerated" spoken example with anger, and the "normal" sung example with happiness. Like other participants, the individual incorrectly labelled sung "anger" stimuli with fear, sadness and happiness, and all "fear" stimuli were perceived incorrectly. The participant only rated sung "slight" emotion for the correct emotion as higher than for the spoken condition in the "happy" stimuli, with a difference of 3.0 points, but for "happy" and "sad" stimuli, the participant rated "exaggerated" levels of emotion higher for sung stimuli compared to spoken stimuli, with a mean of 3.5. This suggests that for "happy" and "sad" stimuli, the participant perceived a higher level of emotion in the sung stimuli, compared to spoken stimuli. Mean OERs between spoken and sung stimuli for each emotion are shown in Figure 4.

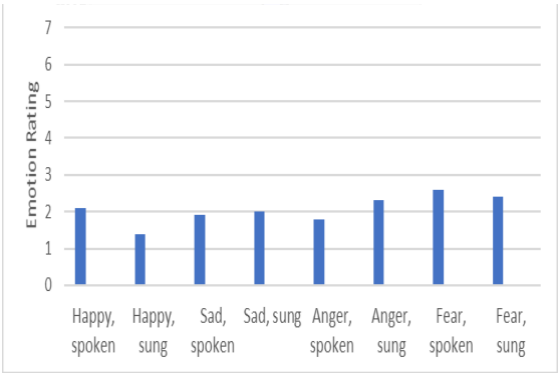

Figure 4. Mean OERs for the participants in the 32-50 group

3.2 Combined AQ Score Categories

Finally, two larger groups based on participants' AQ scores were made. Since the main differences in results are seen with the group scoring 22-25, and this is where participants begin to display ASD tendencies above average, I compared a "low ASD traits" ("LAT") group scoring 0-21 in the AQ to a "high ASD traits" ("HAT") group scoring 22-50 in the AQ. Although a similar method for analysing results as a median split, analysing the results with HAT and LAT groups produced more pronounced results, and using HAT and LAT groups did not include participants who had a normal score on the AQ, whereas the median split did. For the LAT group, emotion ratings for spoken conditions across all four emotions consistently increased with increasing emotion intensities, however this did not always happen for sung conditions, as shown in Figure 5.

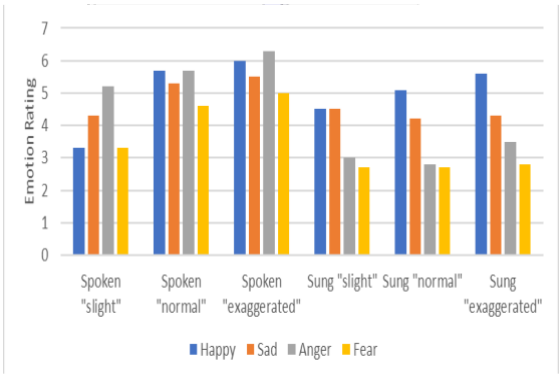

Figure 5. Mean emotion ratings for the LAT group

For the HAT group, emotion ratings in examples of the correct emotions for "happy" and "sad" stimuli did not consistently increase with increasing emotion intensity for spoken conditions, however they did for sung conditions, and the mean emotion ratings for this group are shown in Figure 6.

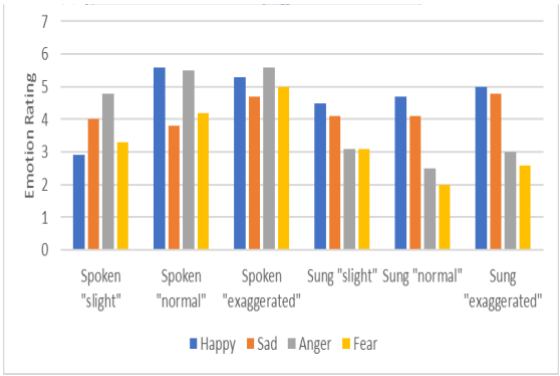

Figure 6. Mean emotion ratings for the LAT group

For "happy" and "sad" stimuli, where "slight" stimuli for sung conditions were rated higher than spoken conditions, this was at a mean of 0.85, a score higher than the LAT group who scored a mean of 0.70. Mean ratings for "anger" and "fear" stimuli in the HAT group showed many inaccuracies in emotion perception, with 25% of the inaccuracies rated as "happy", a positive emotion despite the emotion perceived being negative. However, in the LAT group there were only four inaccurate emotion mean ratings for this group, compared to 12 in the HAT group, and for the LAT group all

inaccuracies were in "fear" stimuli, with the incorrect emotion of "sadness" being perceived for each of the cases. For combined means between "slight" and "normal" spoken stimuli across all four emotions, the LAT group rated the correct emotion on average 0.3 points higher than the HAT group. "Slight" sung conditions in comparison were only rated 0.2 higher on average for the correct emotion score in the LAT group than the HAT group. When comparing "exaggerated" spoken conditions to combined scores for "slight" and "normal" sung conditions, the LAT group on average only rated the "exaggerated" spoken stimuli 0.9 points higher than "slight" and "normal" combined, however the HAT group rated the "exaggerated" spoken condition one point higher than "slight" and "normal", suggesting that those scoring higher on the AQ found it easier to identify emotion cues in spoken conditions when emotions were exaggerated.

Therefore, when comparing AQ groups into a higher and lower group, on average the LAT group was more accurate at labelling the correct emotion, and the intensity of this rating rose with the stimuli's intensity, in speech rather than in music. The HAT group had the opposite results. Both groups showed some inaccurate emotion ratings in "anger" and "fear" excerpts, but whilst the LAT group still rated the emotion as a negative one, the HAT group was more likely to confuse it with a positive one. When comparing "slight" and "exaggerated" stimuli, the HAT group rated "slight" emotion intensities higher in sung than spoken conditions, and the LAT group on average rated emotions as higher in "slight" and "normal" stimuli than the HAT group. These results demonstrate that: 1) participants scoring higher on the AQ, therefore displaying more traits of ASD, were more accurate at perceiving emotion in music than in speech; 2) participants scoring higher on the AQ were better at picking up on emotion cues in "slight" sung stimuli than spoken stimuli; 3) participants scoring higher on the AQ found it easier to pick up emotion cues in speech in the "exaggerated" condition, compared to "slight" and "normal" conditions.

3.3 T-Tests

T-tests were run in R-Studio to see if differences in emotion ratings between spoken and sung stimuli for the HAT and LAT AQ groups were statistically significant, comparing emotion ratings for sung and spoken examples with "slight" and "exaggerated" emotion levels. Only three of the examples indicated statistical significance: "happy, spoken, exaggerated", "anger, sung, slightly", and "anger, sung, normal". This low incidence of statistical significance was not surprising and is probably due to the study comparing people with a high score compared to a low score on the AQ, rather than people with an ASD diagnosis.

3.4 Correlations

Finally, a Pearson correlation in R-studio was run to examine the relationship between emotion ratings and AQ scores. Looking at means of correct emotion ratings across all spoken and sung stimuli, it can be seen in Figure 7 that there is a negative correlation between increasing AQ score and intensity of the emotion perceived.

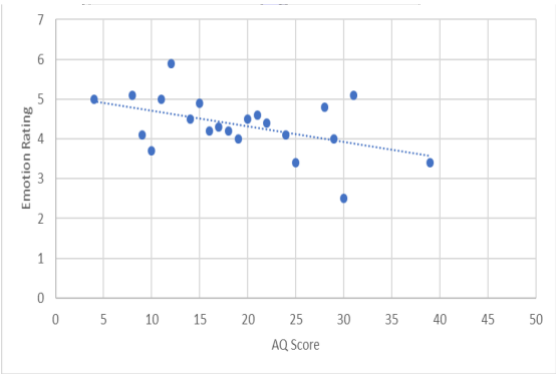

Figure 7. Correlation between AQ scores and emotion ratings for all stimuli (r=-0.48)

Looking at spoken and sung stimuli separately, the results show a stronger negative correlation between AQ score and intensity of the correct emotion rating in spoken stimuli (Figure 8) than sung stimuli (Figure 9).

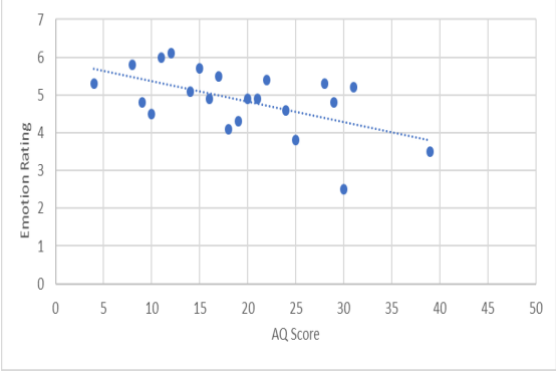

Figure 8. Correlation between AQ scores and emotion ratings for spoken stimuli (r=-0.56)

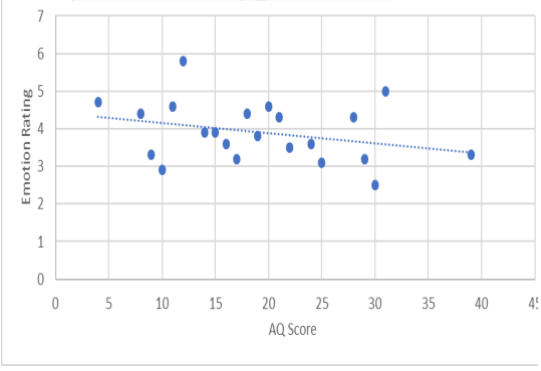

Figure 9. Correlation between AQ scores and emotion ratings for sung stimuli (r=-0.30)

4. DISCUSSION

The results supported the hypothesis that individuals in the higher category of the AQ scores would rate the spoken "slight" and "normal" conditions less accurately than those in the lower category of the AQ scores, and that individuals scoring higher in the AQ found it easier to pick up on emotion cues in "exaggerated" spoke conditions compared to "slight" and "normal" spoken conditions. I also found that the HAT group was more likely to confuse "anger" or "fear" stimuli with "happy" rather than another negative emotion, unlike the LAT group which was more likely to confuse "anger" with "fear" and vice versa, or "anger" with "sad".

4.1 What the Current Study Means for ASD Research

This experiment is important in the field of ASD and emotion perception research, as the main limitation of previous studies is that they have not accounted for the wide spectrum of emotions in speech and music, instead claiming that people with ASD cannot perceive emotion as accurately in speech than those with TD, but they can in music, disregarding the possibility that this could be disproven in exaggerated levels of emotion in speech. The current study counters this research, suggesting that people with ASD may be able to perceive exaggerated levels of emotion in speech, maybe not as intensely as those with TD, but more accurately than they can in slight or normal levels of emotion in speech. If this study was replicated comparing individuals with ASD diagnoses and TD, and if the results supported the current study, our understanding of how people with ASD perceive emotion could be improved, ranging from new techniques to help people with ASD understand how to perceive emotion in speech, how to help people with TD communicate better with people with ASD, and incorporating this into music therapy for people with ASD.

4.2 Relationship of Findings to Previous Research

The current study supports some of what was discussed in the Literature Review. Heaton, Hermelin and Pring's 1999 study compared children with ASD and TD, and their ability to categorise musical excerpts into happy or sad faces, showing that both groups had the same ability (Heaton, Hermelin and Pring 1999). This is supported by the current study's results, which showed less of a discrepancy between the HAT and LAT groups in their ratings of the correct emotions in sung than spoken stimuli. Ezangwill hypothesised that it could be music's rhythm which affects its emotion perception, due to slower rhythms generally being used in sad music, and fast rhythms in happy music (Ezangwill 2013). The current study somewhat supports these ideas, as "happy" and "sad" stimuli for spoken and sung conditions were rated the most accurately. However, in "anger" and "fear" stimuli where the sung conditions were in a minor key, this previous research would suggest that the HAT group would pick up on emotion cues in the "anger" and "fear" stimuli from their minor keys, and would rate the examples in either of these examples to be angry, fearful, or sad. The HAT group frequently confused "anger" and "fear" as "happy", whereas the LAT group did not make this mistake, refuting these previous studies. Regarding rhythm, "happy" and "fear" sung stimuli tended to increase slightly in speed with the rising intensity of emotions, and vice versa for "sad" and "anger" stimuli. Since "fear" sung stimuli was more often confused by HAT groups as "happy" rather than "anger", it could be that the HAT group were in fact picking up on the rhythm of the excerpts and thought that a faster rhythm indicated "happy" emotion cues.

The confusion for the HAT group perceiving "anger" or "fear" as "happy" was interesting and not hypothesised. It indicated that people with a high number of ASD traits may have more difficulty differentiating "anger" or "fear" as negative rather than positive emotions, since the HAT group was more likely to rate these examples as "happy". This has been supported by Brennand, Schepman, and Rodway, who tested children with ASD and their accuracy identifying happiness, sadness, anger and fear in spoken vocal excerpts (Brennand, Schepman and Rodway 2011, 1567). Compared to a TD control group, children with ASD on average performed slightly worse at identifying the correct emotion in the excerpts, and unlike the TD group, differed significantly in confusing anger as "happy", fear as "anger" and sad as "happy" (Brennand, Schepman and Rodway 2011, 1571). This is consistent with the current study's findings with sung examples of "anger" and "fear".

Unlike previous studies in the Literature Review, the main results were not statistically significant. It is likely that this was due to the study not specifically testing people with an ASD diagnosis compared to those who did not.

4.3 Challenges and Limitations

The current study's main limitation was the use of participants irrespective of whether or not they had an ASD diagnosis, rather than having a group diagnosed with ASD and a TD group with no ASD diagnoses. If this study was replicated, this limitation would be addressed. Although the current study was not long (it was estimated to last about 15 minutes), the tasks were repetitive and very similar. A future study could offer a small financial reward to all participants as an incentive. Due to the study being completed online, participants could have carried out the experiment in any location with a computer and internet access, and may not have followed the instructions at the beginning of the experiment. To prevent this, it would be beneficial to have participants come to a room where the experiment could be completed individually or by groups at the same time with the researcher present to ensure that it is done properly.

A challenge encountered in the study was recording the stimuli. "Happy" and "sad" stimuli did not pose problems, but the female singer had difficulty with the sung examples for "anger" and "fear" due to earworms from previous excerpts. To solve this, I gave the female singer time to practise how she would sing the examples until we were both happy with the result, pauses between recordings for excerpts, and positive or negative imagery to imagine. A further challenge was interpreting the results, due to the large amount of data to

be analysed, in addition to the GOLD-MSI and AQ results. In a future study, I would implement a scoring mechanism on the online data software when creating the experiment which would automatically generate a score for participants.

REFERENCES

Allen, R. and Heaton, P. 2010. "Autism, Music, and the Therapeutic Potential of Music in Alexithymia". *Music Perception: An Interdisciplinary Journal*, Vol. 24, no. 4: 251-261.

Ashwin, C., Chapman, E., Colle, L., and Baron-Cohen, S. 2006. "Impaired recognition of negative basic emotions in autism: A test of the amygdala theory". *Social Neuroscience*, Vol. 1, Issue 3: 349-63.

Aspergerstest.net. 2013."Interpreting AQ Test (Autism Spectrum Quotient) Results". Accessed 25th November, 2018. https://aspergerstest.net/interpreting-aq-test-results/.

Augustyn, A., Klin, A., Paul, R. and Volkmar, F. R. 2005. "Perception and production of prosody by speakers with autism spectrum disorders". *Journal of Autism and Developmental Disorders*, Vol. 35, issue 2: 205-20.

Autism Research Centre. n.d. "Autism Spectrum Quotient"Accessed 20th November, 2018. https://www.autismresearchcentre.com/project_7_asquotient

Baron-Cohen, S., Knickmeyer, R. and Belmonte, M. 2005. "Sex Differences in the Brain: Implications for Explaining Autism". *Science* Vol. 310, Issue 5749: 819-23.

Baron-Cohen, S., Lombardo, M., Auyeng, B., Ashwin, E., Chakrabarti, B., and Knickmeyer, R. 2011. "Why Are Autism Spectrum Conditions More Prevalent in Males?". *PloS Biology*, Vol. 9, Issue 6;

Baron-Cohen, S. and Wheelwright, S. 2003. "The Friendship Questionnaire: An Investigation of Adults with Asperger Syndrome or High-Functioning Autism, and Normal Sex Differences". *Journal of Autism and Developmental Disorders*, Vol. 33, Issue 5: 509-17.

Bhatara, A. 2010. "Perception of emotion in musical performance in adolescents with autism spectrum disorders". *Autism Research*, Vol. 3, Issue 5: 214-25.

Bird, G., Cornell, A. Gaigg, S. 2016. "The psychophysiological mechanisms of alexithymia in autism spectrum disorder". *Sage Journals*, Vol. 22, Issue 2: 227-31.

Brennand, R., Schepman, A., and Rodway, P. 2011. "Vocal emotion perception in pseudo-sentences by secondary-school children with Autism Spectrum Disorder". *Research in Autism Spectrum Disorders*, Vol. 5, Issue 4: 1567-1573.

Brown, S. 2017. "A Joint Prosodic Origin of Language and Music". *Frontiers in Psychology*.

Brown, T., Cox, D., Gaffney, G., Moncrief, M., Reeve, R., Ross, V. and Schmitt, R. 2017. "Measuring the attitudes of novice drivers with autism spectrum disorder as an indication of apprehensive driving: Going beyond basic abilities". *Sage Journals*, Vol. 22, issue 1: 62-9.

Carlson, R., Friberg, A., Fryden, L., Granstrom, B. and Sundberg, J. 1989. "Speech and music performance: Parallels and contrasts". *Contemporary Music Review*, Vol. 4, Issue 1: 391-404.

Darwin, C. 2010. *The Descent of Man and Selection in Relation to Sex*, Vol. 1, published online by Cambridge University Press 2010, originally published in 1871.

American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders (DSM-5)*, https://www.psychiatry.org/psychiatrists/practice/dsm, n. d., accessed 13th November 2018.

Eack, Mazefsky, and Minshew. 2014. "Misinterpretation of Facial Expressions of Emotion in Verbal Adults with Autism Spectrum Disorder". *Autism*, Vol. 19, Issue 3: 308-15.

English Oxford Living Dictionaries. n. d. "Music". Accessed 10th February, 2019. https://en.oxforddictionaries.com/definition/music.

English Oxford Living Dictionaries. n.d. "Speech". Accessed 10th February, 2019. https://en.oxforddictionaries.com/definition/speech.

Ezangwill, N. 2013. "Music, Autism and Emotion". *Frontiers in Psychology*, Vol. 4.

Fenk-Oczlon, G. and Fenk A. 2009. "Some parallels between language and music from a cognitive and evolutionary perspective". *Musicae Scientiae*, Vol. 13, Issue 2: 201-226.

Gervais, H., Belin, P., Boddaert, N., Leboyer, M., Coez, A., Sfaello, I., Barthélémy, C., Brunelle, F., Samson, Y., and Zilbovicius, M. 2004. "Abnormal Cortical Voice Processing in Autism". *Nature Neuroscience*, Vol. 7: 801-802.

Gold, C., Wigram, T., and Elefant, C. 2006. "Music therapy for autistic spectrum disorder". *Cochrane Database Syst Rev.*

Happé, F. 1999. *Autism: An introduction to psychological theory*. Psychology Press, Taylor & Francis Group.

Heaton, P., Hermeling, B. and Pring, L. 1999 "Can children with autistic spectrum disorders perceive affect in music? An experimental investigation". *Psychological medicine*, Vol. 29, Issue 6: 1405-10.

Itzchak, E. B., and Zachor, D. A. 2011. "Who benefits from early intervention in autism spectrum disorders?". *Research in Autism Spectrum Disorders*, Vol. 5, Issue 1: 345-50.

Jackendoff, R. 2009. "Parallels and Nonparallels between Language and Music". *Music Perception: An Interdisciplinary Journal*, Vol. 26, No. 3: 195-204.

Juslin, P. N. and Laukka, P. 2003. "Communication of Emotions in Vocal Expression and Music Performance: Different Channels, Same Code?". *Psychological Bulletin*, Vol. 129, Issue 5: 770-814.

Kalandadze, T., Norbury, C., Naerland, T. and Naess, K. 2016. "Figurative language comprehension in individuals with autism spectrum disorder: A meta-analytic review" *Sage Journals*, Vol. 22, Issue 2: 99-117.

Kern, P. and Humpal, M. (ed.). 2012. *Early Childhood Music Therapy and Autism Spectrum Disorders: Developing Potential in Young Children and their Families*. London: Jessica Kingsley Publishers.

Koegel, L. K., Koegel, R. L., Ashbaugh, K., and Bradshaw, J. 2014. "The importance of early identification and intervention for children with or at risk for autism spectrum disorders". *International Journal of Speech-Language Pathology*, Vol. 16, Issue 1: 50-56.

Lindstrom, R., Lepisto-Paisley, T., Vanhala, R., Alén, R., and Kujala, T. 2016. "Impaired Neural Discrimination of Emotional Speech Prosody in Children with Autism Spectrum Disorder and Language impairment". *Neuroscience Letters*, Vol. 15, Issue 628: 47-51.

Liss, M., Mailloux, J., and Erchull, M. 2008. "The relationships between sensory processing sensitivity, alexithymia, autism, depression, and anxiety". *Personality and Individual Differences*, Vol. 45, Issue 3: 255-259.

Mannell, R. 2007. *Phonetics and Phonology: Introduction to Prosody Theories and Models*, http://clas.mq.edu.au/speech/phonetics/phonology/intonation/prosody.html. Macquarie University.

Oldfield, A. 2006. *Interactive Music Therapy – A Positive Approach: Music Therapy at a Child Development Centre*. London: Jessica Kingsley Publishers.

Peretz, I. and Coltheart, M. 2003. "Modularity of Music Processing" *Nature Neuroscience*, Vol. 6, Issue 7: 688-91.

Poljac E., Poljac E., and Wagemans J. 2012. "Reduced accuracy and sensitivity in the perception of emotional facial expressions in individuals with high autism spectrum traits". *Sage Journals*, Vol. 17, Issue 6: 668-680.

Porter, W. n.d. "Vocal Music". *Encyclopaedia Britannica*. Accessed 10th February 2019. https://www.britannica.com/art/vocal-music.

Quintin, E. M., Bhatara, A., Poissant, H., Fombonne, E., and Levitin, D. 2011. "Emotion Perception in Music in High-Functioning Adolescents with Autism Spectrum Disorders". *Journal of Autism and Developmental Disorders*, Vol. 41, Issue 9: 1240-55.

Reynolds, C. R. and Kamphaus, R. W. 2013. "Autism Spectrum Disorder". *Diagnostic and Statistical Manual of Mental Disorders*, (*DSM-5 Diagnostic Criteria)*, Fifth Edition. American Psychiatric Association.

Rousseau, J. J. *Essay on the Origin of Languages and Writings Related to Music*. 1998. The Collected Writings of Rousseau, Vol. 7. Translated and edited by John T. Scott. University Press of New England, Hanover.

The Autism Spectrum Quotient (AQ). n.d. Accessed 10th February 2019.https://aspietests.org/aq/index.php.

Toolman, P. G., and Coleman, S. Y. 1994. "Music therapy – a description of process: Engagement and avoidance in five people with learning disabilities". *Journal of Intellectual Disability Research*, Vol. 38, Issue 1: 17-24.

Van Santen, J. P., Prud'hommeaux, E. T., Black, L. M., and Mitchell, M. 2010. "Computational Prosodic Markers for Autism". *Autism*, Vol. 14, Issue 3: 215-36.

Wang, A., Lee, S., Sigman, M., and Dapretto, M. 2015. "Neural Basis of Irony Comprehension in Children with Autism: The Role of Prosody and Context". *Brain*, Vol. 129, Issue 4: 932-43.

Wennerstrom, A. 2001. *The Music of Everyday Speech – Prosody and Discourse Analysis*. Oxford University Press, Oxford.

Wimpory, D., Chadwick, P., and Nash, S. 1995. "Brief Report: Musical interaction therapy for children with autism: An evaluative case study with two-year follow-up". *Journal of Autism and Developmental Disorders*, Vol. 25, Issue 5: 541-552.

Zatorre, R. J., Belin, P., Penhune, V. B. 2002. "Structure and function of auditory cortex: music and speech". *Trends in Cognitive Sciences*, Vol. 6, Issue 1: 37-46.

APPENDIX

Autism Quotient Questions:

All questions are answered as either "definitely agree", "slightly agree", "slightly disagree", or "definitely disagree".

1) I prefer to do things with others rather than on my own.
2) I prefer to do things the same way over and over again.
3) If I try to imagine something, I find it very easy to create a picture in my mind.
4) I frequently get so strongly absorbed in one thing that I lost sight of other things.
5) I often notice small sounds when others do not.
6) I usually notice car number plates or similar strings of information.
7) Other people frequently tell me that what I've said is impolite, even though I think it is polite.
8) When I'm reading a story, I can easily imagine what the characters might look like.
9) I am fascinated by dates.
10) In a social group, I can easily keep track of several different people's conversations.
11) I find social situations easy.
12) I tend to notice details that others do not.
13) I would rather go to a library than a party.
14) I find making up stories easy.
15) I find myself drawn more strongly to people than to things.
16) I tend to have very strong interests which I get upset about if I can't pursue.
17) I enjoy social chit-chat.

18) When I talk, it isn't always easy for others to get a word in edgeways.
19) I am fascinated by numbers.
20) When I'm reading a story, I find it difficult to work out the characters' intentions.
21) I don't particularly enjoy reading fiction.
22) I find it hard to make new friends.
23) I notice patterns in things all the time.
24) I would rather go to the theatre than a museum.
25) It does not upset me if my daily routine is disturbed.
26) I frequently find that I don't know how to keep a conversation going.
27) I find it easy to "read between the lines" when someone is talking to me.
28) I usually concentrate more on the whole picture, rather than the small details.
29) I am not very good at remembering phone numbers.
30) I don't usually notice small changes in a situation, or a person's appearance.
31) I know how to tell if someone listening to me is getting bored.
32) I find it easy to do more than one thing at once.
33) When I talk on the phone, I'm not sure when it's my turn to speak.
34) I enjoy doing things spontaneously.
35) I am often the last to understand the point of a joke.
36) I find it easy to work out what someone is thinking or feeling just by looking at their face.
37) If there is an interruption, I can switch back to what I was doing very quickly.
38) I am good at social chit-chat.
39) People often tell me that I keep going on and on about the same thing.
40) When I was young, I used to enjoy playing games involving pretending with other children.
41) I like to collect information about categories of things (e.g. types of car, types of bird, types of train, types of plant, etc.).
42) I find it difficult to imagine what it would be like to be someone else.
43) I like to plan any activities I participate in carefully.
44) I enjoy social occasions.
45) I find it difficult to work out people's intentions.
46) New situations make me anxious.
47) I enjoy meeting new people.
48) I am a good diplomat.
49) I am not very good at remembering people's date of birth.
50) I find it very easy to play games with children that involve pretending.

GOLD-MSI Questions:

I have never been complimented for my talents as a musical performer, 1) completely disagree, 2) strongly disagree, 3) disagree, 4) neither agree nor disagree, 5) agree, 6) strongly agree, 7) completely agree.

I would NOT consider myself a musician, 1) completely disagree, 2) strongly disagree, 3) disagree, 4) neither agree nor disagree, 5) agree, 6) strongly agree, 7) completely agree.

I engaged in regular, daily practice of a musical instrument (including voice) for 0 / 1 / 2 / 3 / 4-5 / 6-9 / 10 or more years.

At the peak of my interest, I practiced 0 / 0.5 / 1 / 1.5 / 2 / 3-4 / 5 or more hours per day on my primary instrument.

I have had formal training in music theory for 0 / 0.5 / 1 / 2 / 3 / 4-6 / 7 or more years.

I have had 0 / 0.5 / 1 / 2 / 3-5 / 6-9 / 10 or more years of formal training on a musical instrument (including voice) during my lifetime.

I can play 0 / 1 / 2 / 3 / 4 / 5 / 6 or more musical instruments.