JoDD
Journal on Developmental Disabilities
Volume 27, Number 1, 2022
On-Line First

The Processing of Emotions in Faces and Music by Adolescents on the Autism Spectrum with Lower and Higher Verbal Cognitive Ability: A Pilot Study

Le traitement des émotions du visage et dans la musique par des adolescents sur le spectre de l'autisme ayant des habiletés cognitives verbales plus basses et plus élevées : un projet pilote

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Keywords

adolescents
autism spectrum disorder
emotion processing
facial expressions,
music-evoked emotions,
verbal cognitive ability
music education

Abstract

Verbal cognitive ability is known to correlate with emotion processing in faces and music in typically developing individuals. However, the relation between these variables among autistic people is not clear and has been investigated mainly in those who have proficient verbal cognitive ability. For this reason, we compared the recognition and perceived intensity of emotions in faces and music of 25 adolescents (12–16 years old) on the autism spectrum with lower (n = 12) or higher (n = 13) verbal cognitive ability. Participants were assessed with the verbal index of a cognitive test (WISC-V), an online hearing test, and two computer tasks that assessed emotion recognition using 4-second face and music stimuli. Participants were asked: (1) to identify the emotion conveyed in facial expressions and musical excerpts; and (2) to rate the intensity of that emotion. Participants were very accurate at identifying emotions (happiness, sadness, fear) in faces and music, irrespective of verbal cognitive ability. In fact, accuracy scores were near ceiling, which precluded a statistical comparison of emotion identification in faces and music. We discuss factors that likely influenced these results such as the level of task difficulty and the participants' ages. In terms of intensity ratings in faces, sadness was perceived as less intense than happiness and fear. In music, intensity ratings of happiness, sadness and fear were similar within and between the groups with low or high verbal cognitive ability. Verbal cognitive *ability was negatively associated with perceived emotional intensity in faces but not in music, which may indicate that language ability modulates the experience of facial emotional processing. On the basis of these findings, we suggest that adolescents across the autism spectrum might benefit from music education as a strength-based approach for teaching emotion processing skills.*

Résumé

Il est connu que les habiletés cognitives verbales sont corrélées avec le traitement des émotions du visage et à travers la musique chez les personnes ayant un développement typique. Toutefois, la relation entre ces variables chez les personnes autistes n'est pas claire et a principalement été étudiée auprès de ceux ayant un niveau élevé d'habiletés cognitives verbales. Pour cette raison, nous avons comparé la reconnaissance des émotions et la perception de leur intensité exprimées par des visages et à travers la musique chez 25 adolescents (12 à 16 ans) sur le spectre de l'autisme dont les habiletés cognitives verbales étaient faibles (n=12) ou élevées (n=13). Les participants ont été évalués à l'aide de l'indice verbal d'un test cognitif (WISC-V), d'un test auditif en ligne et de deux tâches à l'ordinateur qui évaluent la reconnaissance des émotions utilisant des visages ou de la musique en tant que stimuli présentés pendant 4 secondes. Les participants devaient : (1) identifier l'émotion exprimée par les visages et les extraits musicaux ; et (2) évaluer l'intensité de cette émotion. Les participants ont eu de la facilité à identifier les émotions (joie, tristesse, peur) exprimées par des visages et à travers la musique, indépendamment de leurs habiletés cognitives verbales. En fait, leur performance a atteint un quasi-plafonnement, ce qui a empêché une comparaison statistique de l'identification des émotions exprimées par des visages et à travers la musique. Les facteurs susceptibles d'avoir influencé ces résultats sont discutés, tels que le niveau de difficulté des tâches et l'âge des participants. En termes d'évaluation de l'intensité des émotions exprimées par des visages, la tristesse a été perçue de façon moins intense que la joie et la peur. En ce qui concerne la musique, l'évaluation de l'intensité de la joie, de la tristesse et de la peur s'est avérée similaire entre les groupes aux habiletés cognitives verbales faibles et élevées, de même qu'au sein de ces groupes. Les habiletés cognitives verbales se sont avérées négativement associées avec l'intensité des émotions exprimées par des visages, mais pas à travers la musique, ce qui pourrait indiquer que les habiletés langagières modulent les expériences de traitement des émotions exprimées au sein du visage. Nos résultats suggèrent que les adolescents sur le spectre de l'autisme pourraient bénéficier de l'enseignement de la musique en tant qu'approche axée sur leurs forces pour développer leurs compétences de traitement des émotions.

Mots-clés : adolescents, trouble du spectre de l'autisme, traitement des émotions, expressions faciales, émotions suscitées par la musique, habiletés cognitives verbales, éducation musicale

Introduction

A pervasive impairment in social interaction and communication is a core feature of autism spectrum disorder (autism[1]) (American Psychiatric Association, 2013). This area of challenge is

[1] "autism spectrum", "autistic", and "autism" are used interchangeably in this paper to reflect preferred language of many members of the autism community (Canadian Autism Spectrum Disorder Alliance [CASDA], 2020).

thought to be associated with the processing of emotions (Baron-Cohen, 1988) since the recognition and understanding of emotional information is necessary for adaptive interpersonal communication and developing social bonds (Ekman, 1992).

Studies that explore emotion processing and emotion recognition (ER), in particular of autistic people, have used highly social stimuli such as faces, predominantly. Despite some contradictory findings (e.g., Jones et al., 2011), the majority of studies show ER impairments on tasks using still or dynamic face stimuli (Enticott et al., 2014; Harms et al., 2010; Uljarevic & Hamilton, 2013). A meta-analysis of 43 studies examining facial ER by children and adults on the autism spectrum found a general impairment across emotions (happiness, sadness, fear, anger, surprise, and disgust) with a moderate negative effect size of $Zr = -.36$ (Lozier et al., 2014). Other studies have found difficulties in the recognition of specific emotions rather than a generalized deficit, with negative emotions being most affected (Ashwin et al., 2007; Ashwin et al., 2006; Boraston et al., 2007; Howard et al., 2000; Humphreys et al., 2007), particularly when presented at subtle intensities (Smith et al., 2010; Song & Hakoda, 2018; Whitaker et al., 2017).

In contrast, music may be an alternative domain for studying ER of people on the autism spectrum in light of its intrinsic emotional properties (Juslin & Sloboda, 2001) and the musical strengths commonly associated with autism (see Heaton, 2009 and Quintin, 2019 for a review). In contrast, with apparent difficulties in ER from faces, autistic children, adolescents and adults readily recognize the emotional qualities of music (e.g., Allen et al., 2009; Allen et al., 2013; Heaton et al., 1999; Quintin et al., 2011; Stephenson et al., 2016; see, however, Bhatara et al., 2010). For example, they can accurately link emotions from music with visual representations (e.g., match fearful music with a picture of a boy seeing a spider; Heaton et al., 2008), and rate the emotional intensity of happy, sad, fearful, and peaceful music excerpts similarly to same-aged peers when controlling for verbal cognitive ability (Quintin et al., 2011).

The use of social stimuli like faces may not be an ideal method for assessing ER as findings may reflect interpersonal difficulties (e.g., atypical eye gaze) (Frazier et al., 2017) associated with autism rather than true differences in ER itself. Although music can be a social experience, listeners can enjoy instrumental music without directly engaging in interpersonal communication with the composer (Heaton et al., 1999; Quintin et al., 2011). In other words, people can extract meaningful social content from a musical piece, such as listening to its melody and tempo for emotional information, without having to engage in a socially salient experience such as analyzing content in a person's eyes. In contrast, facial emotion recognition tasks rely on prerequisite social skills to obtain accurate social information such as efficient face processing, which is a skill that develops differently for many autistic people (Frazier et al., 2017; Grossmann, 2017). Given that the social elements of music are more latent or less explicit than the social features of faces, emotion recognition in music may not be impacted by the social difficulties that characterize autism, which may explain why autistic children and adolescents are able to interpret emotions from music similarly to neurotypical children, but not from faces. Thus, the first goal of this study was to elucidate the nature of ER abilities among adolescents on the autism spectrum, by directly comparing ER accuracy and ratings of emotional intensity of "socially-salient" (faces) and "socially-latent" (music) stimuli. We hypothesized that the participants would display greater ER accuracy and provide more intense ratings of basic emotions (i.e., happiness, sadness, fear) in music than faces.

Furthermore, few studies on ER and autism include participants with low cognitive ability (e.g., Heaton et al., 2008; Jones et al., 2011; Whitaker et al., 2017), which limits the generalizability of findings to people across the spectrum. Specifically, verbal cognitive ability has been associated with facial ER among people on the autism spectrum (Trevisan & Birmingham, 2016). With respect to music, studies demonstrate that autistic people do not differ in emotion recognition accuracy of music-evoked emotions compared to people with Down syndrome (Heaton et al., 2008) and typically developing persons, after controlling for verbal cognitive ability (Quintin et al., 2011). Given that we know adult-like accuracy for recognition of basic emotions in music is usually attained in pre-adolescence in typical development (e.g., Dalla Bella et al., 2001), our second goal was to examine how verbal cognitive ability impacts ER among autistic adolescents. Specifically, we explored whether adolescents on the autism spectrum who have lower versus higher verbal cognitive ability differ in ER accuracy and ratings of emotional intensity in faces and music.

Materials and Methods

A total of 25 adolescents on the autism spectrum (23 males, two females) between the ages of 12 and 16 years participated in this study. The participants were native French speakers and were recruited from special education classes for students with neurodevelopmental disorders in a high school in Quebec, Canada. Autistic children were selected using a special education code (explained in Fombonne et al., 2006 and Lazoff et al., 2010) and diagnosis was verified by teacher ratings on the Social Responsiveness Scale, Second Edition (SRS-2, Constantino & Gruber, 2012). The SRS-2 includes a total of 65 items providing an overall social engagement score, and subscale scores for social awareness, social cognition, social communication, social motivation, and restricted interests and repetitive behaviour. The scores are converted to T-scores to assess whether social behaviour is within the normal range for the general population (below $T = 60$), or whether there is a mild (T = 60–65), moderate (T = 66–75), or severe (T = 76 or higher) presence of autistic traits. Our sample initially included a total of 31 participants, of whom two were extreme outliers in their performance accuracy on the two ER tasks and four scored below a T-score of 55 on the SRS-2 (cutoff T-score of 60 for autism); these six individuals were excluded from the study. Of the remaining 25 participants, four participants had an SRS-2 T-score between 55 and 59. All the analyses were re-run with and without the four participants, which revealed a similar pattern of results. Therefore, we included the four participants in the results reported here, given that their school placement was based on expert clinical assessment.

Verbal Comprehension Index (VCI) scores were used to divide the participants into low (standard scores ≤ 80; $n = 12$) and high (standard scores > 80; $n = 13$) verbal cognitive ability groups, based on their performance on this index of the French version of the Weschler Intelligence Scale for Children, fifth edition (WISC-V; Wechsler, 2014). The WISC-V was also used to measure cognitive functioning and provide a full-scale IQ (FSIQ) for 18 of the participants (this was not possible for seven participants due to schedule constraints). The groups significantly differed on VCI and FSIQ, but not on age or SRS-2 total T-scores. All the participants passed an online hearing test (https://www.legroupeforget.com). A summary of participant characteristics is presented in Table 1.

Parental consent, child assent, and teacher consent was obtained for each participant. Small gifts were offered to the participants as a token of appreciation (stickers for students and gift cards for a coffee for teachers). Ethical approval to conduct this study was granted from McGill University's Research Ethics Board.

Table 1

A Summary of Participants' Characteristics

	Low VCI Group *n* = 12		High VCI Group *n* = 13		Total Sample *N* = 25	
	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range
Age (years)	14 (1)	12-16	14 (1)	12-16	14 (1)	12-16
VCI**	67 (7)	50-76	93 (10)	84-111	80 (16)	50-111
FSIQ* (*n* = 18)	74 (12)	56-99	92 (14)	76-121	83 (16)	56-121
SRS-2 Total	71 (14)	55-104	67 (10)	55-90	69 (12)	55-104

Note. Low and High VCI Groups differed at ** $p < .001$ and *$p < .05$. Abbreviations: SD, standard deviation; VCI, Verbal Comprehension Index (standard scores); FSIQ, full-scale IQ (standard scores); and SRS-2, Social Responsiveness Scale-2 (*T*-scores).

Emotion Recognition (ER) Tasks

The Facial ER task measured emotion recognition in faces and used stimuli chosen from the STOIC database (Roy et al., 2007). This database comprises 80 standardized dynamic faces that were validated with 35 adult participants (mean age of 25 years; the validation process and results are found in Roy et al., 2007). The dynamic faces are presented in 256 x 256-pixel movie clips, which are 500 ms in length and show five different male and female actors (20–45 years of age) expressing emotions of fear, happiness, anger, disgust, sadness, surprise, and pain. Actors were shown on a grayscale background, with a mid-gray elliptical mask hiding all external facial features. Of the 80 movie clips in the STOIC database, 18 were included in the Facial ER task that depicted emotions of happiness, sadness, or fear at 100% intensity (6 clips per emotion; 9 female and 9 male faces). Only movie clips depicting happiness, sadness, and fear were selected as they can be evoked in music. We thought it necessary to extend the duration of each movie clip in order to accommodate the neurodiverse profiles of children in our study in light of evidence of reduced processing speed among autistic people, particularly those with more prominent social communication differences (Haigh et al., 2018) and/or reduced verbal cognitive abilities (Hedvall et al., 2013), and reduced facial emotion recognition when stimuli are presented at faster rates (e.g., Tardif et al., 2007). Therefore the 18 selected dynamic clips were lengthened to 4-seconds using AVS Video Editor 6.0.

The Musical ER task used a modified version of the instrumental musical stimuli that had previously been used with autistic adolescents with average or above average cognitive abilty (Quintin et al, 2011) and validated with typically developing adults (Eerola and Vuoskoski, 2011; Quintin et al., 2011). The musical stimuli used by Quintin et al. (2011) and Eerola and Vuoskoski (2011) were taken mainly from the classical and popular repertoire (i.e., they were not created in a lab). Eighteen musical tracks evoking happiness, sadness, or fear emotions were randomly selected from the larger pool (6 tracks per emotion) and shortened to 4-second segments (originally 30–50-seconds long) that intensely evoked the targeted emotion to equate the exposure time with that of the face stimuli. Previous work shows intact emotion recognition of short musical tracks in autistic (Gebauer et al., 2014) and typically developing populations

(Paquette et al., 2013; Sachs et al., 2018). The shortened music stimuli were normalized using Sound Forge Pro (i.e., volume of -18 db, sample rate of 44,100 Hz, attack and release times of 200 ms). The shortened clips were then validated by 10 participants (18–26 years old; 6 females and 4 males) who were undergraduate students that were recruited from a separate study of musical ER among typically developing adults. The 18 music clips received an average percentage agreement of 95% (range = 70% to 100%).

Experimental Procedure

The participants completed the experiment in a quiet room at their high school. Both Facial and Musical ER tasks were presented using E-Prime 2.0 with a PC laptop and over ear headphones for the Musical ER task. A two-tiered response using mouse clicks was required for each stimulus item within each ER task: 1) Emotion identification: The participants were first instructed to identify the emotion in the face or music (i.e., “Which emotion best describes the face/music?”); 2) Intensity rating: Next, the participants were instructed to rate the intensity of their selected emotion. Although we refer to the second tier of the ER tasks as measuring the *perceived intensity* of emotions, the question asked to the participants was open-ended and exploratory in nature (i.e., “how happy?”, “how sad?”, or “how fearful”), and thus, could have been interpreted as perceived arousal. The participants provided their responses using a modified version of the Self-Assessment Manikin (SAM) (Bradley & Lang, 1994). The SAM minimizes the need for verbal identification and ratings of emotion, to accommodate the participants with lower verbal cognitive ability, and are effectively used to measure ER with autistic persons (e.g., Stephenson et al., 2016; Trimmer et al., 2017). Similarly, schematic face drawings are useful for facilitating the identification of musically expressed emotions in typically developing and autistic children (Heaton et al., 1999; Stachó et al., 2013).

In the emotion identification phase, three SAMs showing mannequins with facial expressions of happiness, sadness, and fear were presented along with corresponding emotion labels. In the intensity rating phase, five SAMs showing gradual increases in intensity of facial expressions of the selected emotion (happiness, sadness, or fear) were presented. Prior to beginning the ER tasks, the participants completed a practice session with the SAMs to ensure understanding, and corrective feedback was provided if needed. The stimuli within each task and the order of task completion were both randomized. Follow-up data analyses revealed no differences in emotion identification and intensity ratings of emotions between the participants who completed the Facial ER task first compared to the participants who began with the Musical ER task. The ER tasks took approximately five minutes to complete and, depending on scheduling, were administered either before or after the hearing test and cognitive measure. Taken together, the participants completed the experimental procedure in approximately 60 to 75 minutes.

Planned Data Analyses

All analyses were conducted with SPSS statistics (version 23). For inferential statistics, two-tailed tests were performed at the 95% confidence interval (p-value of .05) and a Bonferonni correction was applied to adjust for multiple comparisons where appropriate.

Emotion Identification

To examine performance on the emotion identification phase of the ER tasks, accuracy scores reflecting the average number of correct responses in percentage within each ER task across and within each emotion condition (happy, sad, and fearful trials) were produced. Although our intention was to directly compare ER accuracy in faces and music, visual inspection of histograms, box-plots, and qq-plots, and an analysis of skewness values revealed near ceiling performances across participants overall and within emotion conditions of the Facial and Musical ER tasks, which precluded a statistical comparison between Facial and Musical ER. Medians and interquartile ranges (IQRs) were instead used to qualitatively describe performance accuracy on the ER tasks to interpret this highly skewed distribution (Miles & Banyard, 2007). To examine the potential effect of verbal cognitive ability on emotion identification, the distribution of accuracy scores were visually re-examined with participants divided into the low (n = 12) and high (n = 13) VCI groups, which yielded near ceiling performances across groups overall and for happy and sad trials of the Facial and Musical ER tasks. This impacted our ability to capture potential differences in ER related to participants' verbal cognitive ability with inferential statistics. Nevertheless, descriptive statistics including medians and IQRs are presented to qualitatively describe ER among the two groups of participants with lower and higher verbal cognitive ability. Given slightly greater variability in performance accuracy for fearful trials compared to happy and sad trials among participants in the low VCI group, VCI standard scores and accuracy scores for fearful trials within the Facial and Musical ER tasks were graphed on scatterplots and a non-parametric test, Spearman's rank-order correlation coefficients, was used to clarify whether or not verbal cognitive ability influenced emotion identification.

Intensity Ratings

Average intensity ratings for each emotion condition (happiness, sadness, and fear) were calculated to analyze performance on the second phase of the Facial and Musical ER tasks. The average intensity ratings ranged from 1 (lowest perceived emotional intensity) to 5 (greatest perceived emotional intensity) and combined correct and incorrect trials from the emotion identification phase. A symmetrical distribution of scores was revealed following visual inspection of histograms, box plots, and q-q plots, and an examination of skewness and kurtosis values. To compare ratings of emotional intensity, taking into account verbal cognitive ability, a 2 x 2 x 3 mixed design analysis of variance (ANOVA) model was used with task (Facial and Musical ER) and emotion (happiness, sadness, and fear) as the within-subjects variables and VCI groups (low versus high) as the between-subjects factor. Assumptions for this parametric test were met; Levene's tests for homogeneity of variances, Shapiro-Wilk test of normality, and Mauchly's test of sphericity were non-significant (i.e., all $ps > .05$). Post-hoc exploration contrasts with Bonferonni correction for multiple comparisons and significant interaction effects were explored using simple means analyses or independent samples t-tests.

Results

Emotion Identification

Performance accuracy scores on the emotion identification phase of the Musical and Facial ER tasks are depicted in Table 2. The participants were very successful on the ER tasks with most performing at or near ceiling across emotion conditions on the Facial ER (*median* = 94%, *IQR* = 89%–100%) and Musical ER (*median* = 94%, *IQR* = 86%–100%) tasks, including the participants in the low VCI group (Facial ER task: *median* = 94%, *IQR* = 89%–99%; Musical ER task: *median* = 94%, *IQR* = 85%–100%). An average accuracy score of 100% was obtained by 23 participants on happy trials (*median* = 100%, *IQR* = 100%–100%), 16 participants on sad trials (*median* = 100% , *IQR* = 83%–100%), and by 13 participants on fearful trials (*median* = 100%, *IQR* = 83%–100%) of the Facial ER task. Performance remained qualitatively similar on the Musical ER tasks with an average accuracy score of 100% obtained by 19 participants on happy trials (*median* = 100%, *IQR* = 92%–100%), 16 participants on sad trials (*median* = 100%, *IQR* = 83%–100%), and 14 participants on fearful trials (*median* = 100%, *IQR* = 83%–100%). Given a ceiling effect on both the ER tasks, we were unable to assess for ER differences in faces and music via inferential statistics. Nevertheless, the results described here are meaningful as they suggest that the participants were able to complete the tasks and very accurately identify basic emotions in music and faces irrespective of their level of verbal cognitive ability.

Among the participants in the low and high VCI groups, similar performance accuracy was observed across emotion conditions on the Facial ER (low: *median* = 94%, *IQR* = 89%–99% high: *median* = 94%, *IQR* = 89%–100%) and Musical ER (low: *median* = 94%, *IQR* = 85%–100%; high: *median* = 94%, IQR = 86%–100%) tasks. Within emotion conditions, low and high VCI groups were observed to perform similarly on happy trials of the Facial ER task (low & high: medians = 100%, IQRs = 100%–100%) and Musical ER task (*low*: median = 100%; *IQR* = 87%–100%; high: *median* = 100%, *IQR* = 92%–100%), and on sad trials of the Facial ER task (low: *median* = 100%, *IQR* = 83%–100%; high: *median* = 100%, *IQR* = 75%–100%) and Musical ER task (low: *median* = 100%, *IQR* = 83%–100%; high: *median* = 100%, *IQR* = 67%–100%). Although participants in the low VCI group appeared to have slightly more variability in their performance on the fearful trials compared to the happy and sad trials within the Facial ER task (*median* = 83%, *IQR* = 67%–100%) and Musical ER task (*median* = 83%, *IQR* = 83%–100%), visual inspection of scatterplots and Spearman's rank-order correlations across participants revealed monotonic relationships between VCI and accuracy scores for fearful trials with tasks combined (r_s = .28, p = .173) and within the Facial ER (r_s = .13, p = .544) and Musical ER (r_s = .26, p = .22) tasks, which confirmed that verbal cognitive ability was not correlated with the ability to identify fearful stimuli in our tasks.

Table 2

Facial and Musical Emotion Recognition (ER) Task Acurracy Neared Ceiling for the Total Sample and for the Low and High VCI (Verbal Comprehension Index) Groups

	Facial ER task		Musical ER task		Across ER tasks	
Low VCI Group	Median	IQR	Median	IQR	Median	IQR
Happiness	100	100-100	100	87-100	100	94-100
Sadness	100	83-100	100	83-100	100	83-100
Fear	83	67-100	83	83-100	83	83-92
Overall	94	89-99	94	85-100	94	92-94
High VCI Group	Median	IQR	Median	IQR	Median	IQR
Happiness	100	100-100	100	92-100	100	92-100
Sadness	100	75-100	100	67-100	83	79-100
Fear	100	83-100	100	83-100	92	92-100
Overall	94	89-100	94	86-100	94	89-99
Total Sample	Median	IQR	Median	IQR	Median	IQR
Happiness	100	100-100	100	92-100	100	92-100
Sadness	100	83-100	100	83-100	92	83-100
Fear	100	83-100	100	83-100	92	83-100
Overall	94	89-100	94	86-100	94	89-97

Note. Accuracy scores (%) are given under the subheading "Median"; interquartile ranges (%) are given under the subheading "IQR". The IQR describes the middle 50% of values when ordered from lowest to highest; it represents the difference between the 75^{th} and 25^{th} percentiles of the dataset.

Intensity Rating

Average intensity ratings on the Facial and Musical ER tasks are presented in Table 3 and results of the mixed design ANOVA are shown in Table 4. Significant effects are reported below.

Table 3

Variability in Average Intensity Ratings of Emotions for the Total Sample and for Low and High VCI (Verbal Comprehension Index) Groups

	Facial ER task		Musical ER task		Across ER tasks	
Low VCI Group	*M* (SD)	Range	*M* (SD)	Range	*M* (SD)	Range
Happiness	4.2 (.50)	3.3-5.0	3.5 (.67)	2.5-4.9	3.8 (.49)	2.5-5.0
Sadness	3.3 (.48)	2.7-4.5	3.5 (.46)	2.3-4.1	3.4 (.38)	2.3-4.5
Fear	4.1 (.46)	3.3-5.0	4.1 (.62)	2.8-4.8	4.1 (.45)	2.8-5.0
Overall	3.8 (.39)	3.4-4.8	3.7 (.45)	3.1-4.4	3.8 (.35)	3.1-4.8
High VCI Group	*M* (SD)	Range	*M* (SD)	Range	*M* (SD)	Range
Happiness	3.4 (.55)	2.3-4.2	3.5 (.48)	2.8-4.5	3.5 (.43)	2.3-4.5
Sadness	2.7 (.48)	1.8-3.4	3.6 (.47)	3.0-4.2	3.2 (.28)	1.8-4.2
Fear	3.4 (.34)	2.9-4.2	3.6 (.64)	2.7-4.6	3.5 (.39)	2.7-4.6
Overall	3.2 (.26)	2.7-3.6	3.6 (.47)	3.0-4.3	3.4 (.28)	2.7-4.3
Total Sample	*M* (SD)	Range	*M* (SD)	Range	*M* (SD)	Range
Happiness	3.8 (.64)	2.3-5.0	3.5 (.57)	2.5-4.9	3.6 (.50)	2.3-5.0
Sadness	3.0 (.55)	1.8-4.5	3.5 (.46)	2.3-4.2	3.3 (.35)	1.8-4.5
Fear	3.7 (.52)	2.9-5.0	3.8 (.67)	2.7-4.8	3.8 (.51)	2.7-5.0
Overall	3.5 (.47)	2.7-4.8	3.6 (.45)	3.0-4.4	3.6 (.37)	2.7-4.8

Note. M = Mean, and SD = standard deviation. Average intensity ratings combine correct and incorrect trials from the emotion identification phase (score out of 5).

Table 4

Significant Interaction Effects Indicate that Emotions are Rated Differently in Facial and Musical Emotion Recognition (ER) Task by the Low and High VCI (Verbal Comprehension Index) Groups

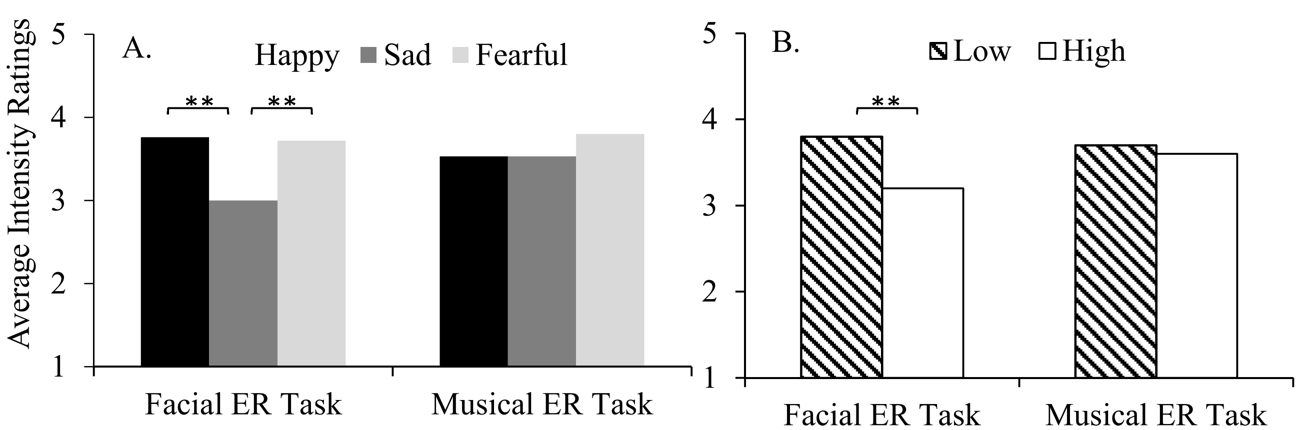
Effects	*F*	*df*	*p* value	partial η^2
Task (Facial and Musical ER)	1.50	1, 23	.233	.061
Emotion (Happiness, Sadness, Fear)	17.05	2, 46	.000	.426
VCI (Low and High)	10.00	1, 23	.004	.303
Task x Emotion	13.72	2, 46	.000	.374
Task x VCI	7.66	1, 23	.011	.250
Emotion x VCI	2.06	2, 46	.140	.082
Task x Emotion x VCI	2.26	2, 46	.116	.089

Main effects. A significant main effect of emotion was found. Pairwise comparisons with Bonferroni correction showed that across ER tasks, the participants rated sad stimuli less intensely than happy (p = .001) and fearful stimuli (p < .001), and happy and fearful stimuli were as equally intense (p = .776). The main effect of VCI was also significant, such that the participants with lower VCI scores rated emotions more intensely than the participants with higher VCI scores overall (i.e., across task and emotion conditions). This relationship was corroborated by a moderate negative Pearson correlation between VCI and average intensity ratings (r = -.45, p = .023).

Interaction effects. There was a significant two-way interaction between task and emotion (see Figure 1A). Simple main effect analyses revealed that emotions were rated differently on the Facial ER task ($F(2, 48) = 27.58$, $p < .001$, partial $\eta^2 = .535$), but not on the Musical ER task ($F(2, 48) = 3.20$, $p = .062$, partial $\eta^2 = .118$, Greenhouse-Geisser correction). Pairwise comparisons with Bonferroni correction revealed that sad faces were rated as less intense than happy (p < .001) and fearful (p < .001) faces, while there were no differences between emotions for intensity ratings of musical clips. The two-way interaction between task and VCI was also significant (Figure 1B). Post-hoc independent t-tests revealed that the participants with lower VCI scores rated emotions more intensely than the participants with higher VCI scores for faces ($t(23) = 5.06$, $p < .001$) but not for music ($t(23) = 0.75$, $p = .464$). This was supported by a significant negative moderate Pearson correlation between VCI and average intensity ratings for faces (r = -.57, p = .007) but not for music (r -.22, p = .344).

Figure 1

Interaction Effects Between Task and Emotions and Between Task and Verbal Comprehension Index



Note. **A**. An interaction effect between task and emotions revealed that sadness was less intensely rated than happiness and fear in faces (**p < .001), but not in music. **B**. An interaction effect between task and VCI (Verbal Comprehension Index) demonstrated that the participants with lower VCI scores rated emotions more intensely than the participants with higher VCI scores in faces but not in music (**p < .001).

Discussion

Emotion Identification

The present study examined emotion perception from faces and music among adolescents on the autism spectrum who had a wide range of verbal cognitive ability. The aims of this study were to directly compare ER accuracy in faces and music and explore whether or not any differences in ER were influenced by verbal cognitive ability. Although we had hypothesized that adolescents would display greater ER accuracy on the Musical ER task than on the Facial ER task, we were unable to test this hypothesis with inferential statistics due to ceiling effects on both tasks and across adolescents with lower and higher verbal cognitive ability. That is, autistic adolescents in our study were very successful at identifying emotions of happiness, sadness, and fear in facial and musical stimuli, with the majority of adolescents obtaining at least 94% accuracy on the task overall, including adolescents with lower verbal cognitive ability. This near ceiling performance likely indicates that the task was too easy for the adolescents and thus, could not elucidate whether potential differences exist between the groups in emotion identification accuracy from faces versus music. Further, it was also difficult to explore or control for the potential impact of verbal cognitive ability on performance accuracy. Only one non-parametric correlation was conducted between verbal cognitive ability and fearful trials of the ER tasks due to variability in accuracy scores for fearful trials, which revealed no relationship between the identification of fear in faces and music and verbal cognitive ability. Nevertheless, our findings are meaningful as they coincide with existing research showing that autistic people with average-to-above average intelligence can accurately recognize basic emotions in highly intense facial expressions and in music (e.g., Jones et al., 2011; Quintin et al., 2011; Stephenson et al., 2016). Further, our findings provide preliminary evidence to suggest that adolescents with lower verbal cognitive ability can accurately recognize these basic emotions.

There are several potential explanations for the ceiling effects on our ER tasks. First, the use of highly intense and dynamic presentation of stimuli in the Facial ER task may have made the task less difficult, as autistic people may perceive dynamic facial expressions as more intense than static facial expressions (Uono et al., 2014). It is thus possible that deficits in processing basic ER from faces is less detectable than in studies using “full blown” stimuli (i.e., “100% expression” stimuli). Second, limiting our investigation to the recognition of three basic emotions (happiness, sadness, and fear) in faces and music may have contributed to our findings. While musical clips evoking happiness, sadness, and fear emotions have been validated (Heaton et al., 1999; Heaton et al., 2008; Quintin et al., 2011), other basic emotions like anger, surprise, or disgust are inherently difficult to portray in music.

The age range of the participants likely contributed to our findings. Some studies indicate a strong association between age, ER ability and autism such that older autistic children are more proficient at recognizing facial expressions of emotions than younger autistic children (Kuusikoo et al., 2009; Smith et al., 2010). While children on the autism spectrum have been shown to have difficulty with facial ER (Enticott et al., 2014; Harms et al., 2010; Lozier et al., 2014; Uljarevic & Hamilton, 2013), this difficulty may subside by early adolescence, especially for the recognition of highly expressed emotions. Future research may consider comparing the identification of musical versus facial expressions of emotions by younger children with a wide range of verbal cognitive ability, using stimuli presented at more moderate intensities and that elicit other basic emotions. Moreover, the ER tasks in the current study exposed each face and music stimulus on a computer screen for four seconds. Future studies that aim to compare ER in typically developing and special populations could manipulate the exposure time of various types of stimuli in order to explore if exposure time is related to ER abilities in different modalities.

Ratings of Emotional Intensity

Similar to findings related to performance accuracy, intensity ratings did not differ between the Facial and Musical ER tasks in our study. However, it is possible that ER differences in faces versus music are emotion specific. We found that sadness was rated less intensely than happiness and fear in faces, but not in music. Our results are in line with studies showing difficulty identifying sadness (Ashwin et al., 2007; Boraston et al., 2007) and preserved processing of identification of happiness associated with autism (Farran et al., 2011; Song et al., 2012), but do not support studies showing impaired processing of fear (Ashwin et al., 2007; Humphreys et al., 2007; Howard et al., 2000). Less intense ratings of sadness than happiness and fear in faces, but not in music provides added support for intact processing of music-evoked emotions by autistic adolescents and may suggest that music is a unique and potentially preferred domain for studying emotion perception of autistic people. However, a limitation of the present study was the lack of a typically developing comparison group to verify that the sad facial expressions were not inherently less intense than the happy and fearful facial expressions for typically developing people as well. In addition, it is possible that intensity ratings in our study reflected perceived arousal as opposed to perceived intensity. However, little is known about whether or not perceived emotional intensity and arousal are mutually exclusive for autistic children. Future studies may consider including different types of questions in ER paradigms to see if they elicit different types of responses for autistic children (compared to a typically developing group). For example, our research group has developed an emotion recognition task that incorporates both a forced choice paradigm and a dimensional response option to assess potential differences in perceived valence and arousal (Sivathasan et al., 2019).

Finally, we found a negative association between verbal cognitive ability and intensity ratings, such that the participants with lower VCI scores rated emotions of happiness, sadness, and fear more intensely than the participants with higher VCI scores, in faces but not in music. Although verbal cognitive ability did not influence ER accuracy, our finding may indicate that language ability influences the “experience” of facial emotional information for adolescents on the autism spectrum. For example, adolescents with lower verbal cognitive ability may interpret their social world with greater sensitivity or arousal, which may affect their ability to effectively engage in interpersonal interactions. Sustained hyperarousal is shown to be positively associated with increased eye aversion and restricted and repetitive behaviours (Prince et al., 2017; Trevisan et al., 2017), both of which underlie social differences associated with autism. The few studies that have focused on the skill of autistic people with lower cognitive ability to recognize emotions have not examined the experience of these emotions as well (i.e., how these emotions make them feel or how intensely they perceive the emotions). Future research is warranted on this topic to inform the development of interventions aimed at enhancing the socioemotional skills of autistic people.

This study’s findings have important implications for the use of music as a learning tool for emotion perception skills of autistic people. Music appears to be a modality that effectively communicates basic emotions to adolescents across the spectrum and has the potential for extending use to those with greater social or cognitive impairments, or younger autistic children. There is growing evidence that children and adolescents on the autism spectrum show improvements in social communicative behaviours and emotional synchronicity following active participation in musical activities (LaGasse, 2017). Thus, continued investigation on the influence of music on autism symptomatology may provide more empirical support for the use of targeted music education programs that capitalize on strengths (musical interest and ability) to support socioemotional development.

Key Messages From This Article

People with Disabilities. We recognize that people on the autism spectrum, much like anyone else, have strengths and challenges in many domains of life, including the social domain. Music may be an effective and enjoyable medium for learning and practicing emotion recognition skills for children and adolescents on their own or with others (e.g., group music classes).

Professionals. Incorporating musical activities in educational curriculum may offer a strengths-based approach for enhancing the socioemotional functioning of children and adolescents across the spectrum.

Policymakers. Autistic children and adolescents with diverse cognitive profiles may be better accommodated when policies are put in place that capitalize on students' positive qualities and natural talents (e.g., musical interest and ability).

Messages clés de cet article

Personnes issues de la neurodiversité. Nous reconnaissons que les personnes sur le spectre de l'autisme, comme plusieurs, ont des forces et des défis dans plusieurs domaines de leur vie, incluant le domaine social. La musique pourrait être un moyen efficace et agréable pour permettre aux enfants et aux adolescents d'apprendre et de pratiquer la reconnaissance des émotions, soit par eux-mêmes ou avec les autres (p.ex., des cours de musique en groupe).

Professionnels. Intégrer des activités musicales dans le curriculum éducatif pourrait offrir une approche centrée sur les forces afin d'améliorer les fonctions socio-émotionnelle d'enfants et d'adolescents sur le spectre de l'autisme.

Décideurs. Les enfants et les adolescents autistes ayant des profils cognitifs divers pourraient bénéficier de politiques capitalisant sur leurs qualités positives et leurs talents naturels (p.ex., leurs intérêts et habiletés musicales).

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