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Autism, Attachment, and Alexithymia: Investigating Emoji Comprehension

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ABSTRACT

Emoji are often misinterpreted. This study investigated whether individual differences known to impact facial emotion recognition would also affect emoji recognition. Participants completed an online emoji classification task, and then completed questionnaires assessing their autistic traits, attachment style, and alexithymia score. Results showed that Autism Quotient (AQ) scores influenced classification accuracy, but only when considered in conjunction with alexithymia and attachment anxiety. Accuracy was poorer when AQ scores and alexithymia scores were both high, whereas high attachment anxiety boosted emotion recognition in participants with high AQ scores. Results highlight the importance of studying individual differences factors concomitantly, allowing for more accurate identification of individuals who may be at risk of emotional miscommunication online, and are therefore suitable targets for support or intervention. Furthermore, findings will be informative for designers of digital tools that are used to convey emotion.

When face-to-face, communication is facilitated by non-verbal cues, such as facial expressions. Ekman and Friesen (1971) argued that there are six universal emotions – happiness, anger, sadness, surprise, fear, and disgust – with associated, typical facial expressions. Emojis were created to mimic these cues during online communication (Kaye et al., 2017; Lee et al., 2016; Lu et al., 2016). Thus, emojis serve a social purpose; to add meaning to and reduce the "cluelessness" of computer-mediated communication (CMC, Rutter & Stephenson, 1979; Thompson & Filik, 2016). Between 92 and 95% of the online community use emojis daily (Alismail & Zhang, 2020; Kaye et al., 2017), yet there are large inter-individual differences in the comprehension of their meaning (e.g., Miller et al., 2016; Tigwell & Flatla, 2016). Although emojis (or emoticons) representing facial expressions are the most widely used (Riordan, 2017), they are also the most misunderstood, in part due to the subjective interpretation of their meaning from both the sender and receiver, as well as the interaction with the context in which they are used (Hand et al., in press; Howman & Filik, 2020). Multiple individual differences can affect facial expression recognition (Alismail & Zhang, 2020; Li et al., 2018; Weiß et al., 2020), and it is reasonable to assume these may impact emoji understanding as well. The aim of the current paper was to examine how various factors which are relevant to facial recognition and emotion processing, specifically, autistic traits, alexithymia, and attachment style, might influence successful recognition of emojis representing facial emotional states.

1.1. Autism spectrum disorder

Autism spectrum disorder (ASD) is a neurodevelopmental disorder present in approximately 1 in 100 children worldwide (Zeidan et al., 2022). However, prevalence estimates vary depending on factors such as biological sex, sociodemographic status, and race/ethnicity (Zeidan et al., 2022); for instance, a cohort study of over seven million pupils in England found a prevalence of 1.76% (Roman-Urrestarazu et al., 2021). ASD is characterized by a triad of atypicalities involving social interaction, social communication/language, and social imagination or rigidity of thought patterns/repetitive stereotyped behaviours (e.g., Wing & Gould, 1979). One of the most commonly reported difficulties in ASD is recognizing facial expressions (Balconi & Carrera, 2007; Celani et al., 1999; Eack et al., 2015); hypothesized to be a manifestation of social-communication difficulties (Balconi & Carrera, 2007; Behrmann et al., 2006; Hauck et al., 1998), and reduced social attention (Fletcher-Watson & Bird, 2020).

Specifically, some autistic individuals may have difficulty identifying emotions (e.g., Baron-Cohen et al., 1993; Behrmann et al., 2006; Ellis & Leafhead, 1996; Loth et al., 2018). Wellman (1990) and Perner (1991) distinguished between "simple" versus "complex" emotions. It was argued that simple emotions were those wherein beliefs and intentional states are non-essential. Baron-Cohen et al. (1993) qualify this by highlighting that if someone is happy because of a real-world event or situation, then this is a relatively simple emotion. If the same emotion were triggered by a

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belief (i.e., someone is happy because they *think* that X), because this is belief-based, it is arguable that this is now a more complex emotion. Baron-Cohen et al. (1993) selected happiness and sadness as typical simple emotions, and surprise as a (complex) cognitive emotion. It was found that autistic individuals showed differential identification patterns to controls for complex emotions. Similar results have been found for the identification of fear and disgust (Behrmann et al., 2006; Ellis & Leafhead, 1996; Loth et al., 2018). Thus, emotion recognition – a complex process requiring integration of multiple cues – could be challenging (Hobson et al., 1988). Consequently, the abilities of autistic populations to identify and understand facial expressions (and emoji) might be impacted by their divergent cognitive profiles.

Importantly, a limited number of studies investigating facial expression recognition in ASD acknowledge the significance of the Alexithymia Hypothesis of ASD (Bird & Cook, 2013). While emotion recognition difficulties are common in ASD, not all individuals struggle (Loth et al., 2018), suggesting the disorder may not be causal of them. Characterized by difficulties in identifying emotional arousal and feelings (Nemiah et al., 1976), alexithymia is present in approximately 50% of autistic individuals (Bird & Cook, 2013), as opposed to 10% of the general population (Salminen et al., 1999). Several studies indicate that the association between ASD and poor facial expression recognition is mediated by co-occurring alexithymia (Bothe et al., 2019; Cook et al., 2013; Kätsyri et al., 2008). It is therefore vital to consider the concomitant effect of alexithymia when investigating the recognition of emojis representing facial emotion expressions in relation to ASD.

Some initial evidence that autistic traits might influence emoji comprehension comes from a recent study by Hand et al. (2022; Study 1). They examined performance on an emoji recognition task in which participants were first presented with an emoji, then asked to select which of the six universal emotions they believed it represented. In Hand et al.'s study, participants were either diagnosed with ASD or were otherwise neurotypical (NT). Results showed that participants across groups were consistent in their classification of happy, angry, and disgusted emoji, but showed diversity in their classification of sad, fearful, and surprised emoji. However, their study was somewhat limited by its sample size ($N = 88$; $n_{ASD} = 31$, $n_{NT} = 57$) and did not assess sub-group diversity in relation to other relevant traits, such as alexithymia.

1.2. Attachment

Emotion understanding emerges during the "sensitive period" of development (under the age of two years; Bowlby, 1958; Ogren & Johnson, 2021); and is involved in the development of the attachment system (Ekman, 1992). Attachment theory (Bowlby, 1958) posits that the attachment between an individual and their primary caregiver allows the individual to survive. Anthony et al. (1992) suggested that the internal working model formed from this initial attachment is used to facilitate facial expression recognition, with the primary caregiver used as a reference point. Thus, emotional learning is underpinned by the emotional expressiveness of the immediate family (Bell, 2001; Brown & Dunn, 1996; Cooke et al., 2016; Eisenberg et al., 1998; Harris, 1999; Scharfe, 2000; Tomkins, 1991); and it has been suggested that attachment is associated with the understanding of facial expressions (Li, 2013).

Importantly, attachment plays a predictive role in future facial expression recognition ability (Brown & Dunn, 1996; Dunn et al., 1991; Harris, 1999). While there are many recognized attachment types, the present study considered the extent to which participants had "anxious" or "avoidant" attachment type traits. In contrast to securely attached individuals, who have a consistent relationship with their primary caregiver; anxiously attached individuals have inconsistent relationships with their primary caregiver. Avoidant attachment type is characterized by an individual experiencing rejection from their primary caregiver, thus appearing detached from them (Ainsworth et al., 1978; Hazan & Shaver, 1987).

Those classified as securely attached generally most accurately comprehend emotions (Cooke et al., 2016), presumably due to the open communication between parent and child. There is a negative association between insecure-avoidant attachment and facial expression recognition (Li, 2013), which is ostensibly because of a lack of emotional expressiveness from the primary caregiver (Cooke et al., 2016). Particularly, individuals with an insecure-avoidant attachment type experience difficulty with understanding negative emotions (Cooper et al., 2009), as the child learns, through rejection by their caregiver, to mask their own negative emotions (Brumariu, 2015). However, certain studies indicate that anxious attachment facilitates understanding of negative facial expressions (Cooper et al., 2009), due to hypervigilance. Thus, the direction of the relationship between attachment type and facial expression recognition varies depending on the emotion displayed.

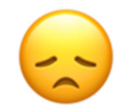
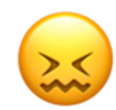
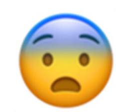
The literature investigating the relationship between adult attachment and facial expression recognition is inconsistent (Afshadi et al., 2017; Steele et al., 2001). While some evidence suggests that attachment type remains constant throughout development (Hazan & Shaver, 1987), it cannot be assumed that this relationship holds with specific cognitive functions, such as facial expression recognition. Furthermore, the authors are aware of no studies to date that investigated the impact of attachment type on emoji recognition. Thus, the present study aims to establish whether emoji comprehension ability is associated with attachment type traits.

1.3. The present research

The aim of the present research was to explore the influence of individual differences on the successful identification of emojis representing facial emotional expressions. This was achieved by examining performance on an emoji recognition task implementing Ekman and Friesen (1971) six universal emotions: happiness, anger, sadness, surprise, fear, and disgust. Participants were first presented with an emoji, then asked to select which of the six universal emotions they believed it represented. They then completed questionnaires assessing ASD traits, alexithymia, and attachment style.

It was hypothesized that in general, emojis representing "simple" emotions (happiness, sadness, and anger) would be recognized more easily by participants due to their saliency (Craig et al., 2014; Hansen & Hansen, 1988). In relation to individual differences, we predicted that there would be a negative association between ASD traits and emoji classification, particularly for emojis representing more "complex" emotions (e.g., surprise, fear, and disgust; (Baron-Cohen et al., 1993; Perner, 1991; Wellman, 1990). Following the Alexithymia Hypothesis (Bird & Cook, 2013), we predicted that participants with higher scores reflecting alexithymia traits would perform particularly poorly in emoji classification. Finally, it was hypothesized that there would be a relationship between performance on the emoji recognition task and participants' scores on measures of attachment anxiety and avoidance. If emoji recognition is similar to facial emotion recognition, we may expect a negative association between scores for insecure-avoidant attachment and emoji recognition (following Li, 2013), but a positive association between anxious attachment and emoji recognition (following Cooper et al., 2009), especially for negative emotions.

Table 1. Emoji used

Target emotion	Android	iOS
Happiness		
Sadness		
Disgust		
Fear		
Anger		
Surprise		

2. Materials and methods

2.1. Participants

The final sample (three participants were excluded due to incomplete responses) consisted of 645 participants (424 female, 220 male, 1 non-binary, $M_{age} = 30.23$ years, $SD = 13.43$, range = 18–78). Participants were recruited through anonymous links distributed via social media platforms, and through the School of Psychology Research Participation Scheme (RPS). Seventy-nine participants were awarded 0.25 RPS credits for their participation. All other participants were invited to enter a prize draw to win one of two £10 Amazon vouchers.

2.2. Materials and design

2.2.1. Emoji classification task

The emoji classification task involved participants being shown an emoji that represented one of the six universal emotions (happiness, sadness, disgust, fear, anger, surprise; Ekman & Friesen, 1971). Participants were required to select one of six emotion words displayed below the emoji, that they believed best described the emotion being shown. All emojis were taken from Unicode Version 13.1 (http://unicode.org/emoji/charts/full-emoji-list.html), with both Android and iOS emojis being included (Table 1). Thus, in total, 12 emojis were used (one per emotion per platform; i.e., six iOS, six Android), and every participant completed all trials. Emojis (72×72 pixels) were shown individually per page, in the centre of the screen. Both the order in which emotional labels were presented underneath the emojis, and the order the emojis themselves were displayed was randomized to minimize order effects.

Individual differences were then assessed using the short-form Autism Spectrum Quotient (AQ-10; Allison et al., 2012), Toronto Alexithymia Scale (TAS-20; Bagby et al., 1994), and Experience in Close Relationships short form scale (ECR-12; Lafontaine et al., 2016).

2.2.2. AQ-10

The AQ-10 (Allison et al., 2012) consists of 10 items; an example item would be, "I find it difficult to work out other people's intentions." Participants rated each item on a four-point scale from "Definitely Agree" to "Definitely Disagree." A higher score on the AQ-10 indicates a stronger demonstration of ASD-stereotyped traits, with a score of six or above being considered for diagnostic referral in clinical settings. Analysis of our participants' data revealed a Cronbach's alpha of 0.520 (0.546 standardized) [however, the associated ANOVA revealed cohesive between-item responses – $F(9,5841) = 280.48$, $p < .001$]. Our Cronbach's alpha is in line with previous research utilizing the AQ-10, such as Rhind et al. (2014) with 0.56 and Bertrams (2021) with 0.59.

2.2.3. TAS-20

The TAS-20 (Bagby et al., 1994) consists of 20 items such as, "I don't know what's going on inside me." Participants rated each item on a five-point scale from "Strongly

Disagree" to "Strongly Agree." A higher score represents a greater likelihood of alexithymia-type profiles. Analysis of our participants' data revealed a Cronbach's alpha of 0.858 (0.852 standardized), indicating reliability.

2.2.4. ECR-12

The ECR-12 (Lafontaine et al., 2016) was used to ascertain participants' Anxiety and Avoidance scores. As the questionnaire primarily assesses romantic relationships, participants were instructed to answer the questions in terms of their closest relationship if they were not in a romantic relationship. Example items include, "I need a lot of reassurance that I am loved by my partner" (anxiety) and "I try to avoid getting too close to my partner" (avoidance). Participants responded via a seven-point scale from "Strongly Disagree" to "Strongly Agree" to two six-item subscales, measuring avoidant and anxious attachment respectively. Higher scores on either of the subscales indicates a higher attachment anxiety/avoidance. The ECR-12 is composed of two six-item sub-scales. Each sub-scale generates a score with which to uniquely evaluate a participant's "anxiety" and their "avoidance." Participants could score low in both dimensions, which would represent an overall, holistic "security"; they could score highly in one dimension but not in another (representing selective insecurity), or they could score highly in both dimensions, indicating relative holistic insecurity. Our participants generated scores on both dimensions, and these scores were used in our analyses. We did not group participants nominally as demonstrating one attachment type or another. Participant scores on the Anxiety dimension ranged from 6 to 42 ($M_{\text{Anx}} = 25.1$, $SD_{\text{Anx}} = 9.6$); visual inspection of the Anxiety data suggested a normal distribution, with a portion of low-anxiety (i.e., anxiety-secure) participants equivalent to that showing high anxiety scores. Participant scores on the Avoidance dimension ranged from 6 to 40 ($M_{\text{Anx}} = 15.8$, $SD_{\text{Anx}} = 7.0$); visual inspection of the Avoidance data suggested skew towards the low end of the sub-scale, suggesting that most participants were low-avoidance (avoidance-secure). Taken together, among our sample, we have representation of people scoring low in one or both dimensions (thus, secure individuals).

Since we did not recruit only participants who were in a close romantic relationship, nor did we ask our participants to affirm this status, we conducted Confirmatory Factor Analysis (CFA) on our ECR-12 data. The Kaiser-Meyer-Olkin measure of sampling adequacy (KMO) was .883 and Bartlett's Test of Sphericity was significant [$\chi^2(66) = 4108$, $p < .001$]. Visual inspection of the initial scree plot suggested that two dimensions would adequately explain the data. CFA using Principal Axis Factoring (PAF) and Direct Oblimin rotation revealed a two-component structure that was in-line with Lafontaine et al. (2016) ECR-12 instrument. This two-component structure explained a cumulative 58% of variance with a Rotated Sums of Squared Loadings of 3.36. Inspection of the structure matrix confirmed that the items used in the current study, and their associated responses, mapped perfectly against LaFontaine et al.'s ECR-12 measure. Analysis of our participants' data revealed a Cronbach's alpha of 0.815 (0.815 standardized). Together, these results suggest both validity and reliability.

2.3. Procedure

The study was conducted following the ethical guidelines of the School of Psychology at the University of Nottingham (ethics committee ref: 738) and the Declaration of Helsinki (2000). The survey was hosted by Qualtrics. Participants clicked on the survey link and completed the survey using either a desktop or mobile device. Participants were first presented with an information sheet and Research Participation Privacy Notice, after which they were asked to indicate their consent to take part in the study, before providing their demographic details.

All participants first completed the emoji classification task. The instruction screen was displayed, after which each emoji (plus six emotion-descriptor words) remained on screen until participants clicked an arrow to move to the next trial. Upon completion of the emoji classification task, participants were routed to the first of the three questionnaires (the order of which were randomized to mitigate order effects). Instructions remained at the top of the screen while the questionnaires were completed. Completion of all three questionnaires led participants to the final screen, containing debriefing information and the opportunity to provide contact details if they wished to be entered into the prize draw. The whole task took approximately 15 minutes to complete.

2.4. Data analysis

Raw survey data was exported and checked for completeness. The 645 individuals described in the Participants section represent only those who provided complete data for both the emoji classification task and all survey items. Emoji classification scores were coded 1 (correct) or 0 (incorrect) per trial. AQ, TAS, and ECR-12 scores were calculated as per the scoring instructions associated with those instruments, including reverse-scoring where required. Participants' scale scores to represent the dimensions of AQ, TAS, and ECR Anxiety and ECR Avoidance were centred prior to modelling (*z*-score method). Again, scores per dimension were used in analyses – we did not nominally group participants into only anxious or avoidant attachment types, nor alexithymia "types," nor AQ groups.

To determine the individual and combined effects of emoji type, AQ, TAS, attachment anxiety (ANX) and attachment avoidance (AVO) on classification accuracy, we generated a series of linear mixed effects models in R (R Development Core Team; http://www.r-project.org). Across participants and trials, there were 7,740 data points available for analysis. We used the "lme4" package (Bates et al., 2015); we followed a generalized linear mixed-effects approach using the "glmer" command and added the argument "family = binomial," given the nature of our classification data. Optimal random effect structures were identified using forward model selection (see Barr et al., 2013;

Matuschek et al., 2017). The random effect structure for these models included only random intercepts by participants and items (more-complicated error terms resulted in non-convergence in full and reduced models). Fixed effects were tested using likelihood-ratio tests comparing full and reduced models. Post-hoc tests were conducted using the "emmeans" package (v1.4.8, 26/06/20; Lenth et al., 2020), and significance thresholds adjusted using the Bonferroni method. An observed power analysis conducted using the PowerSim function of the "simr" package in R (Green & MacLeod, 2016) determined that given our sample size and number of observations, our analyses were 100% fully powered.

3. Results

Descriptive statistics for data collection instruments are shown in Table 2. Table 3 provides a summary of the fixed effects and interactions that were tested for overall classification accuracy.

All five-factor and four-factor interaction models failed to converge. All three-way interactions were non-significant [all χ^2s < 9.31, all *p*s $> .097$]. The interaction between emoji type and participants' ECR Anxiety scores on classification accuracy was non-significant [$\chi^2(5) = 9.81$, $p = .081$]. The interaction between emoji type and participants' ECR Avoidance scores on classification accuracy was non-significant [$\chi^2(5) = 10.39$, $p = .065$].

However, the interaction between participants' AQ scores and TAS scores on classification accuracy was significant [$\chi^2(1) = 5.16$, $p = .023$; see Figure 1].

Follow-up comparisons (simple slopes) revealed that when AQ was lower (i.e., −1 SD), the slope of TAS was not significantly different from 0 [$z = 0.39$, $p = .70$], when AQ was mean-centred, the slope of TAS was not significantly different from 0 [$z = -1.07$, $p = .28$]. However, when AQ was higher (i.e., +1 SD), the slope of TAS was significantly different from 0 [Est. $= -0.21$, $SE = 0.10$, $z = -2.14$, $p = .03$]. Johnson-Neyman interval analysis revealed that the slope of TAS was not significantly different from zero for AQ scores between 0 and 4. Thus, TAS scores did not impact on classification accuracy for participants with lower AQ scores but increases in TAS were associated with poorer emoji classification for higher AQ participants.

Furthermore, the interaction between participants' AQ and ECR Anxiety scores on classification accuracy was significant [χ^2 $(1) = 5.79$, $p = .016$; see Figure 2].

Follow-up comparisons revealed that when AQ was lower (i.e., −1 SD), the slope of ECR Anxiety was not significantly different from 0 [$z = 0.40$, $p = .69$]. However, when AQ was mean-centred, the slope of ECR Anxiety was significantly different from 0 [Est. $= 0.17$, $SE = 0.07$, $z = 2.33$, $p = .02$]. Additionally, when AQ was higher (i.e., +1 SD), the slope of ECR Anxiety was significantly different from 0 [Est. $= 0.30$, $SE = 0.09$, $z = 3.31$, $p < .01$]. Johnson–Neyman interval analysis revealed that the slope of ECR Anxiety was not significantly different from zero for AQ scores between 0 and 2. Thus, increases in ECR Anxiety were associated with better classification performance for average and higher AQ participants, but not for lower AQ participants.

All other two-way interactions were non-significant [all χ^2s < 3.50, all *p*s $> .624$].

The fixed effect of emoji type on classification accuracy was significant [$\chi^2(5) = 46.84$, $p < .001$]. The proportions of correct classifications by emoji types are visualized in Figure 3.

Follow-up comparisons revealed that disgust emojis were less-identifiable than all other emoji types (all *p*s $< .001$), except fear emojis – which were equally-identifiable ($p > .999$); similarly, fear emojis were less-identifiable than all other emoji types (all *p*s $< .001$) except disgust emojis. Angry emojis were better-recognized than disgust and fear emojis (both *p*s $< .001$), but less-identifiable than happy ($p < .001$), sad ($p = .001$), and surprised emojis ($p = .008$). Happy emojis were more-identifiable than disgust, anger, and fear emojis (all *p*s $< .001$), but were as-identifiable as sad ($p = .218$) and surprised emojis ($p = .054$). Sad emojis were more-identifiable than disgust ($p < .001$), anger ($p = .001$), and fear emojis ($p < .001$), and as-identifiable as happy ($p = .218$) and surprised emojis ($p > .999$). Surprised emojis were better-identified than disgust ($p < .001$), anger

Table 2. Descriptive statistics.

Measure	Min.	Max.	Mean	SD	95% Confidence interval Lower bound	95% Confidence interval Upper bound
AQ-10	0	10	3.03	1.86	2.88	3.17
TAS	20	81	48.75	12.54	47.78	49.72
ECR-12 anxiety	6	42	25.06	9.58	24.32	25.80
ECR-12 avoidance	6	40	15.78	6.97	15.24	16.32

Note. AQ-10 – possible maximum score of 10; TAS – possible maximum score of 100; ECR-12 Anxiety/Avoidance – possible maximum scores of 42.

Table 3. Summary of fixed effects and interactions – overall classification accuracy

Effect/Interaction	χ^2	*df*	*p*	*sig.*
Emoji Type × AQ × TAS	3.39	5	.640	
Emoji Type × AQ × ANX	2.91	5	.714	
Emoji Type × AQ × AVO	2.15	5	.828	
Emoji Type × TAS × ANX	4.17	5	.526	
Emoji Type × TAS × AVO	5.36	5	.373	
Emoji Type × ANX × AVO	9.30	5	.098	
AQ × TAS × ANX	<1			
AQ × TAS × AVO	<1			
AQ × ANX × AVO	<1			
TAS × ANX × AVO	<1			
Emoji Type × AQ	3.49	5	.624	
Emoji Type × TAS	3.45	5	.631	
Emoji Type × ANX	9.81	5	.081	
Emoji Type × AVO	10.39	5	.065	
AQ × TAS	**5.16**	**1**	**.023**	*
AQ × ANX	**5.79**	**1**	**.016**	*
AQ × AVO	1.91	1	.167	
TAS × ANX	<1			
TAS × AVO	<1			
ANX × AVO	<1			
Emoji type	**46.84**	**5**	**<.001**	***
AQ	1.04	1	.308	
TAS	2.72	1	.099	
ANX	**13.01**	**1**	**<.001**	***
AVO	2.87	1	.090	

Note. The five-way and all four-way interactions failed to converge. Effects that were statistically significant are highlighted in bold. *Denotes significant at the 0.05 level; ***denotes significant at the 0.001 level.

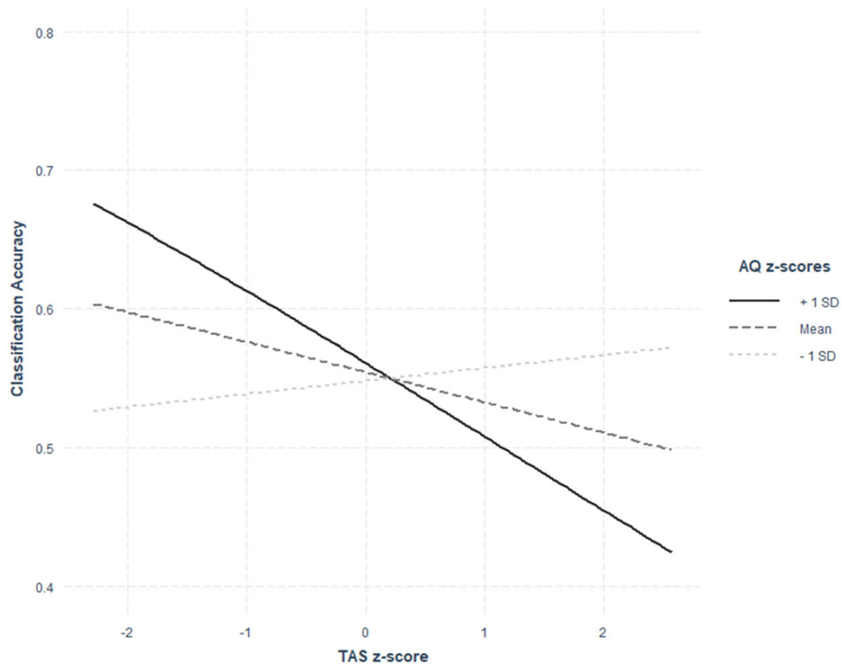


Figure 1. AQ × TAS interaction.

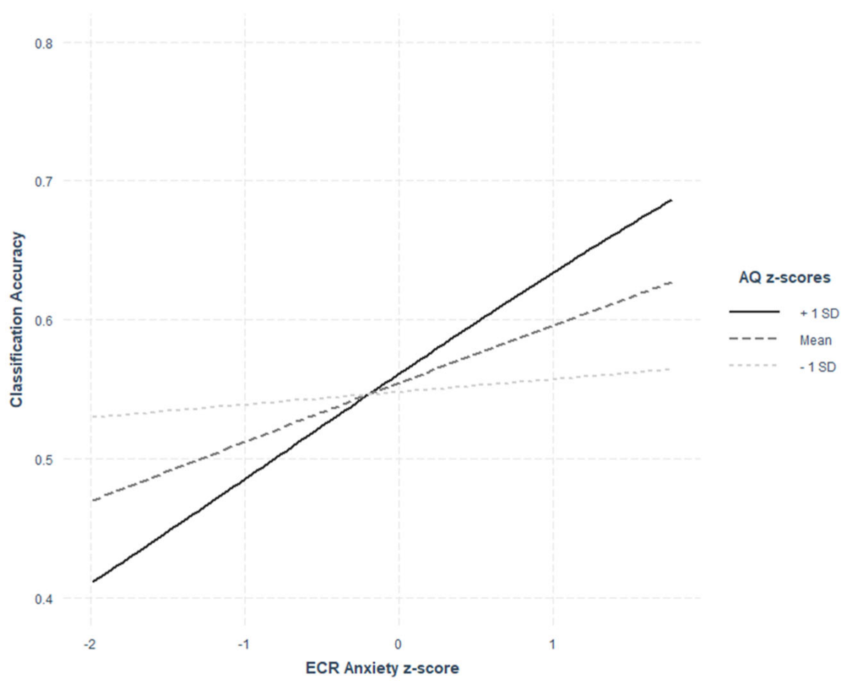


Figure 2. AQ × ECR anxiety interaction – simple slopes.

($p = .008$), and fear ($p < .001$), but were as-identifiable as happy ($p = .054$) and sad emojis ($p > .999$).

Additionally, the individual fixed effect of ECR Anxiety scores on classification accuracy was significant [$\chi^2(1) = 13.01$, $p < .001$]. The estimate associated with this effect was 0.193, indicating that as participants' ECR Anxiety increased, as did the likelihood that they would make correct identifications in the emoji classification task.

All other individual fixed effects were non-significant [all χ^2s < 2.88, all ps $> .090$].

3.1. "Simple" vs. "complex" emojis

Based on previous research (e.g., Baron-Cohen et al., 1993; Behrmann et al., 2006; Ellis & Leafhead., 1996; Loth et al., 2018), we considered different effect patterns across emojis representing simple (i.e., angry, happy, sad) or complex emotions (i.e., disgust, fear, surprise). We split our dataset: two × 3,870 observations, then modelled our data as before. Both "simple" and "complex" emoji analyses returned models with random intercepts by participants and items – other models failed to converge. Our sub-analyses based on emoji representing simple

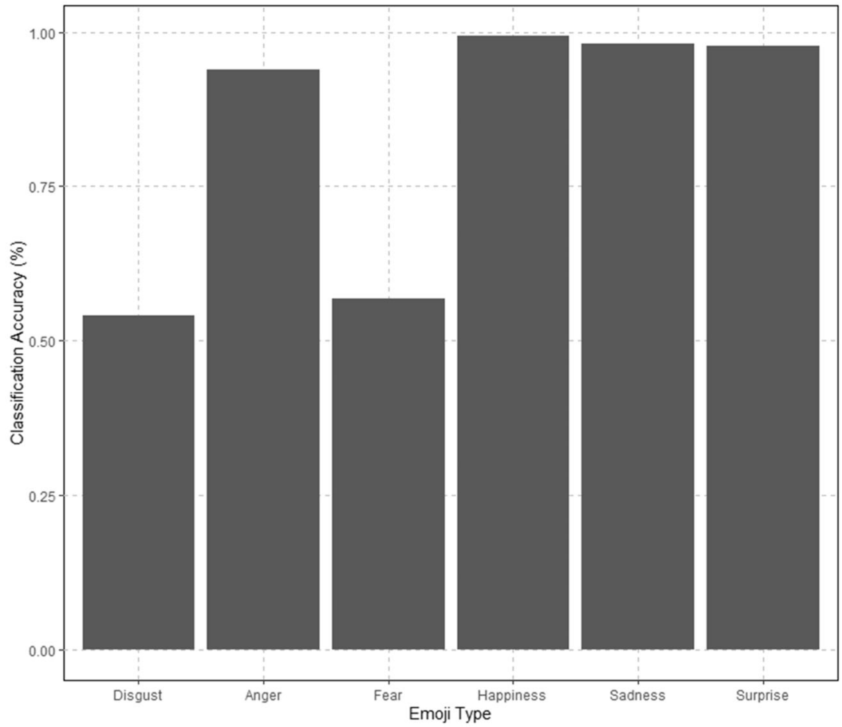


Figure 3. Proportion of correct classifications by emoji type.

Table 4. Simple and complex emoji sub-analyses

	Simple		Complex	
Effect	χ^2	*p*	χ^2	*p*
AQ × TAS × ANX × AVO	<1		1.62	.203
AQ × TAS × ANX	1.85	.174	<1	
AQ × TAS × AVO	3.10	.213	5.00	.082
AQ × ANX × AVO	1.98	.159	<1	
TAS × ANX × AVO	**3.92**	**.048**	<1	
AQ × TAS	2.11	.147	**4.08**	**.043**
AQ × ANX	<1		**6.85**	**.009**
AQ × AVO	<1		1.56	.212
TAS × ANX	<1		1.13	.287
TAS × AVO	<1		<1	
ANX × AVO	<1		<1	
AQ	1.84	.175	<1	
TAS	<1		3.29	.070
ANX	**12.26**	**<.001**	**7.73**	**.005**
AVO	<1		2.63	.105

Note. Effects that were statistically significant are highlighted in bold. AQ: autism quotient score; TAS: alexithymia score; ANX: ECR Anxiety score; AVO: ECR Avoidance score.

or complex emotions were estimated to have 81% power (95% confidence interval: 78–83%).

Interactions and individual fixed effects are summarized in Table 4.

3.2. "Simple" emoji

There was a three-way interaction between alexithymia scores, ECR Anxiety score, and ECR avoidance scores on classification accuracy. In short, Anxiety scores became more influential when avoidance and alexithymia scores were higher; when avoidance and alexithymia scores were both lower, anxiety scores were not associated with classification accuracy. More formally, the pattern of this interaction was that when ECR Avoidance was lower (i.e., −1 SD) and TAS was lower (i.e., −1 SD), the effect of ECR Anxiety was non-significant ($z = 1.02$, $p = 0.31$). When ECR Avoidance was lower and TAS was mean-centred, the effect of ECR Anxiety was significant (Est. = 0.49, $SE = 0.15$, $z = 3.33$, $p < 0.01$). When ECR Avoidance was lower and TAS was higher (i.e., +1 SD), the effect of ECR Anxiety was significant (Est. = 0.81, $SE = 0.00$, $z = 1276.01$, $p < 0.01$). When ECR Avoidance was mean-centred and TAS was lower, ECR Anxiety was significant (Est. = 0.45, $SE = 0.16$, $z = 2.73$, $p = 0.01$). When ECR Avoidance and TAS were mean-centred, ECR Anxiety was significant (Est. = 0.53, $SE = 0.12$, $z = 4.34$, $p < 0.01$). When ECR Avoidance was mean-centred and TAS was higher, the effect of ECR Anxiety was significant (Est. = 0.60, $SE = 0.17$, $z = 3.64$, $p < 0.01$). When ECR Avoidance was higher and TAS was lower, ECR Anxiety was significant (Est. = 0.72, $SE = 0.31$, $z = 2.30$, $p = 0.02$). When ECR Avoidance was higher and TAS was mean-centred, ECR Anxiety was significant (Est. = 0.56, $SE = 0.19$, $z = 2.99$, $p < 0.01$). When both ECR Avoidance and TAS were higher, ECR Anxiety was significant (Est. = 0.40, $SE = 0.20$, $z = 1.99$, $p = 0.05$).

The only other significant effect on "simple" emoji classification was that of ECR Anxiety. The estimate associated was 0.406, indicating that as participants' ECR Anxiety increased, as did the likelihood that they would make correct identifications of emoji representing simple emotions.

3.3. "Complex" emoji

Analyses of complex emoji were somewhat different. All four- and three-way interactions were non-significant. The

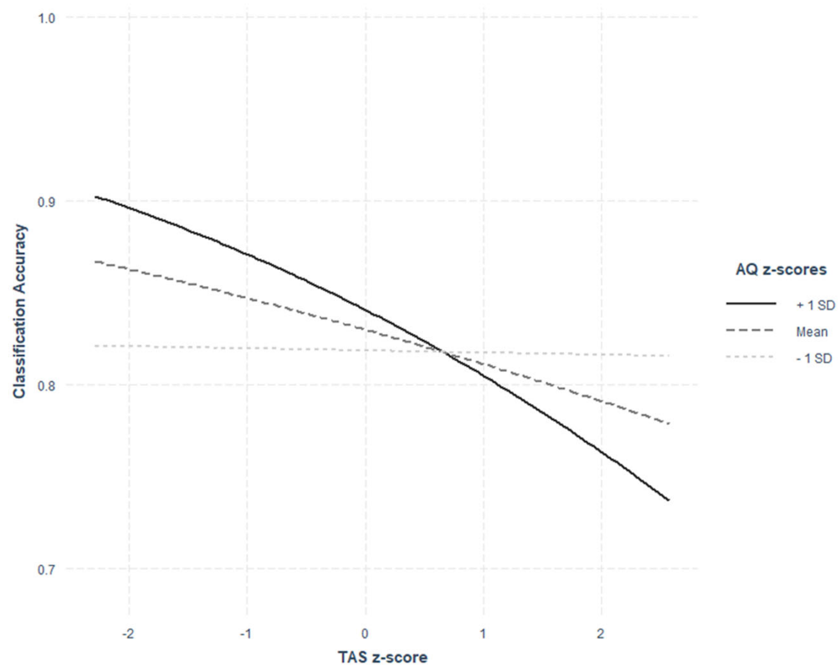


Figure 4. AQ × TAS interaction – 'complex' emoji.

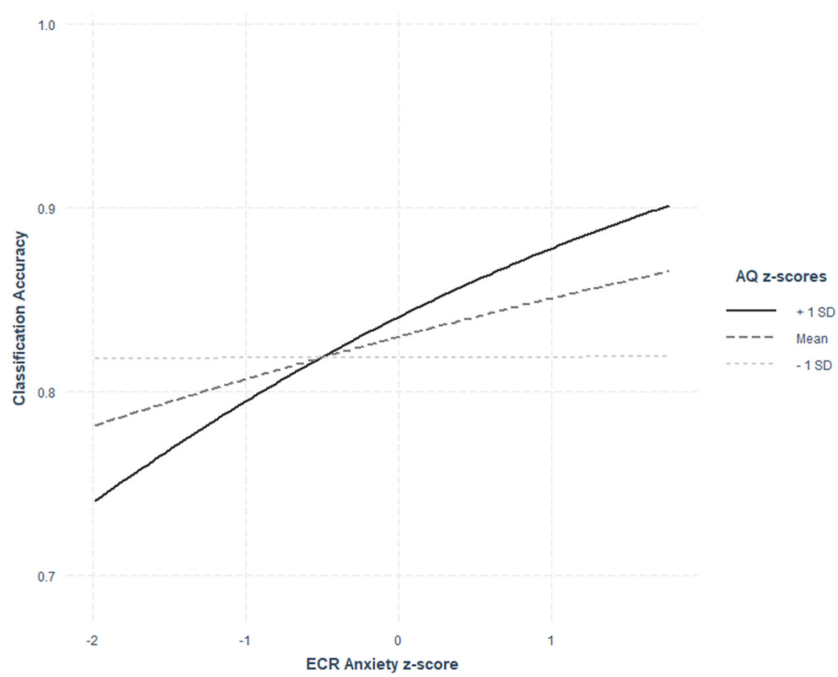


Figure 5. AQ × ECR anxiety interaction – 'complex' emoji.

interaction between participants' AQ scores and TAS scores on classification accuracy was significant (Figure 4).

Follow-up comparisons revealed that when AQ was lower (i.e., −1 SD), the slope of TAS was not significantly different from 0 [$z = -0.09$, $p = .93$]. When AQ was mean-centred, the slope of TAS was significantly different from 0 [Est. = −0.13, $SE = 0.06$, $z = -1.99$, $p = .05$]. When AQ was higher (i.e., +1 SD), the slope of TAS was significantly different from 0 [Est. = −0.25, $SE = 0.09$, $z = -2.81$, $p = .01$]. Johnson-Neyman interval analysis revealed that the slope of TAS was not significantly different from zero for AQ scores between 0 and 3. Thus, TAS scores did not impact on classification accuracy for participants with very low AQ scores; however, increases in TAS were associated with poorer "complex" emoji classification for medium-to-high AQ participants.

The interaction between participants' AQ scores and ECR Anxiety scores on classification accuracy was significant (Figure 5).

Follow-up comparisons revealed that when AQ was lower (i.e., −1 SD), the slope of ECR Anxiety was not significantly different from 0 [$z = 0.02$, $p = .98$]. However, when AQ was mean-centred, the slope of ECR Anxiety was significantly different from 0 [Est. = 0.16, $SE = 0.06$,

Table 5. Confusion matrix of responses (%) by emoji type.

	Disgust	Anger	Fear	Happiness	Sadness	Surprise
Disgust	54.03	15.50	15.81	0.00	13.57	1.09
Anger	5.27	94.03	0.00	0.00	0.70	0.00
Fear	4.34	0.16	56.74	0.08	7.60	31.09
Happiness	0.08	0.08	0.00	99.38	0.00	0.47
Sadness	0.78	0.00	0.70	0.00	98.29	0.23
Surprise	0.54	0.00	1.63	0.08	0.00	97.75

Note. Percentages rounded to 2DP.

$z = 2.74$, $p = .01$], and when AQ was higher (i.e., +1 SD), the slope of ECR Anxiety was significantly different from 0 [Est. = 0.31, $SE = 0.08$, $z = 3.79$, $p < .01$]. Johnson–Neyman interval analysis revealed that the slope of ECR Anxiety was not significantly different from zero for AQ scores between 0 and 3. Thus, increases in ECR Anxiety were associated with better classification performance for average and medium-to-high-scoring AQ participants, but not for low AQ participants.

The only other significant effect when "complex" emoji were considered was that of ECR Anxiety score. The estimate associated was 0.156, indicating that as participants' ECR Anxiety increased, as did the likelihood that they would make correct identifications of emoji representing complex emotions.

3.4. Error data

A summary of error data showing which other emoji types each emoji was most likely to be confused with can be seen in Table 5.

4. Discussion

The current study explored the interplay between participants' individual differences (autism spectrum traits, alexithymia traits, attachment styles) and their performance in an emoji classification task, based around emoji that represented Ekman and Friesen (1971) universal emotions. Below, we first discuss our findings in relation to emoji classification in general, followed by a discussion of the individual differences that were observed.

4.1. Overall classification accuracy

We predicted that in general, emojis representing "simple" emotions (happiness, sadness, and anger) would be classified more accurately than those representing more "complex" emotions (surprise, fear, and disgust) due to their saliency (Craig et al., 2014; Hansen & Hansen, 1988). Our results broadly supported this hypothesis, in that participants demonstrated very high accuracy scores for simple emotions. Emoji depicting happiness were readily identifiable, in line with previous research involving human facial emotions (e.g., Becker et al., 2011; Kardum et al., 2013; Székely et al., 2011;). While our "angry" emoji were better identified than both disgust and fear, interestingly, they were less well identified than happiness, sadness, or surprised emoji. How this pattern of results fits with findings such as the "Anger Superiority Effect," that is, the finding that angry or threatening faces are easier to detect in a crowd of distractor faces than happy or non-threatening ones (Hansen & Hansen, 1988) gives pause for thought. It may be that while anger is a highly salient emotion when confronted with a "real" person showing aggressive behaviour, it is inherently less threatening when communicated from a distance, via CMC.

For emoji representing "complex" emotions, accuracy scores were relatively low for fear and disgust. Previous facial expression research (Székely et al., 2011; Vicari et al., 2000) and emoji research (Brants et al., 2019) suggested that fear and disgust are the least-well recognized constructs; our results support these findings, as these two emoji were least-accurately classified. However, we found that the complex emotion of surprise was very accurately recognized. Surprise is often misperceived, especially among autistic individuals (e.g., Baron-Cohen et al., 1993; Loth et al., 2018); however, our "surprised" emoji was as accurately recognized as both our happy and sad emoji. It may be that the surprised emoji used in the current study was less-ambiguous/less-easily confused than human facial expressions of surprise (which might co-exist with fear, anger, happiness, depending on the context of the surprise), and/or that participants' own experience of this emoji in communication is non-ambiguous.

Consideration of participants' errors in the current study suggested that disgust emoji were interpreted as anger, fear, or sadness, whereas fear emoji were most often misclassified as surprise. These findings could reflect either the co-morbidity/simultaneous experience and/or expression of such emotions in reality. These findings could also reflect participants' own experiences (or lack thereof) of these emoji in their communication histories. Most emojis are related to positive emotions (Novak et al., 2015) and emojis are more frequently used in positive messages (Bai et al., 2019). Therefore, participants may be less familiar with fear/disgust emoji, leading to misconstrual. It is evident that individuals best understand their most-frequently used emoji (Alismail & Zhang, 2020), therefore it is logical that individuals would misconstrue the meaning of emoji such as disgust and fear if they do not use them as often.

4.2. Individual differences in emoji classification accuracy – ASD and alexithymia

In terms of individual differences, firstly, autism and alexithymia, we predicted that higher scores demonstrating ASD traits would be negatively associated with emoji classification, particularly for "complex" emojis (e.g., surprise, fear, and disgust), and that that participants with higher alexithymia traits would perform particularly poorly, following the Alexithymia Hypothesis (Bird & Cook, 2013). Results showed that the individual fixed effect of autism quotient (as indexed by AQ-10 scores) was non-significant, contrary to our expectation. On the surface, these findings would appear to be inconsistent with prior literature that has indicated that individuals with ASD experience difficulty with emotion recognition (e.g., Celani et al., 1999; Loth et al., 2018; Tanaka et al., 2012). Furthermore, the individual association between alexithymia scores (as indexed by TAS scores) and emoji classification was non-significant, again seemingly inconsistent with our prediction.

However, for complex emoji, analyses revealed an interactive pattern of effects between AQ and alexithymia scores on classification accuracy, such that only participants who scored highly in both AQ and TAS demonstrated higher error likelihood on the classification task. Specifically, TAS scores did not impact on classification accuracy for participants with low AQ scores, whereas for medium-to-high AQ participants increases in TAS were associated with poorer "complex" emoji classification. This interaction between autism quotient and alexithymia traits, whereby the weakest performance was shown by participants who scored highly in both traits, aligns with previous research which posits that alexithymia might underlie the stereotypical differences in emotion recognition in ASD populations (e.g., Cook et al., 2013; Grynberg et al., 2012; Ketelaars et al., 2016; Swart et al., 2009) and the Alexithymia Hypothesis (Bird & Cook, 2013). Thus, it appears that effects of alexithymia do not only apply to recognition of human facial emotions, words, and feelings, but also to emoji.

The TAS can be considered as three distinct sub-dimensions: difficulty identifying feelings (DIF), difficulty communicating feelings (DCF), and external thinking (ET). We elected to work with TAS total scores, calculated as per instrument scoring instructions. We considered the three sub-dimensions of the TAS versus AQ-10 scores. In short, all three sub-dimensions are significantly, positively correlated (each $r = .228$ to .377; all $ps < .001$). There was no difference in the strength of the relationship between AQ-10 and DIF and AQ-10 and DCF ($z = 1.14$, $p = .254$). There was a stronger relationship between AQ-10 and DIF and AQ-10 and ET (AQ-10 and DIF stronger; $z = 2.86$, $p = .004$). There was no difference in the strength of the relationship between AQ-10 and DIF and AQ-10 and ET ($z = 1.72$, $p = .085$). A rudimentary regression analysis suggested that all three sub-dimensions contributed significantly to estimations of AQ-10 (all betas between .096 and .282, all ts between 1.97 and 6.10, all $ps < .05$). Our rudimentary re-exploration of the data does not support any argument that one sub-dimension would be more important than another, in this case.

4.3. Individual differences in emoji classification accuracy – attachment style

In relation to attachment styles, we hypothesized that if emoji recognition is similar to facial emotion recognition, we may expect a negative association between scores for insecure-avoidant attachment and emoji recognition (following Li, 2013), but a positive association between anxious attachment and emoji recognition (following Cooper et al., 2009), especially for negative emotions. As predicted, results showed that the individual effect of attachment anxiety was significant, suggesting that higher attachment anxiety was associated with improved classification accuracy.

Furthermore, our analysis revealed that there was an interaction between AQ scores and ECR Anxiety scores, suggesting that for low AQ participants, attachment anxiety was non-impactful, whereas for average and higher AQ participants, attachment anxiety appeared to aid classification accuracy. It is possible that for higher AQ participants who also had high attachment anxiety, emotion recognition was boosted by hypervigilance (Cooper et al., 2009). It is important to stress that we do not make any claims about autistic adults and the "security" of their attachment styles, overall. Indeed, simple bivariate correlational analysis suggests that although there is a positive correlation between higher scores on the AQ-10 and greater ECR-12 anxiety [$r(645) = 0.190$, $p < .001$) and avoidance [$r(645) = 0.122$, $p = .001$], this is not a strong relationship; indeed, variability in AQ-10 scores only explained a fractional proportion of variance in ECR-12 scores.

For emojis representing simpler emotions there was a three-way interaction between alexithymia scores, attachment avoidance, and attachment anxiety. This interaction can be crudely summarized as co-morbidly higher scores on these dimensions resulting in weaker classification performance, whereas when participants score in the lowest ranges of these dimensions, their performance is typically unimpaired. The pattern of effects for emoji representing complex emotions generally reflected that of the overall analyses – co-morbid associations between higher AQ and higher alexithymia scores were associated with weaker classification accuracy, and higher attachment anxiety was "restorative" in terms of higher AQ participants' performance. Across both "simple" and "complex" emoji, higher attachment anxiety was associated with better classification accuracy.

4.4. Limitations

There are some limitations to the current study that need to be considered. In terms of the conceptual basis of the current task, this was based on classical research suggesting that there are six "universal" basic emotions – happiness, sadness, anger, fear, surprise, and disgust (e.g., Ekman & Friesen, 1971). However, it is important to note that not all researchers agree that internal emotional states can be straightforwardly mapped onto a set of standardized facial expressions, which are consistently recognized by all (see e.g., Feldman Barrett et al., 2019, for arguments against this approach; see also Heaven, 2020, for a recent discussion of this ongoing debate). This has important implications for developments in artificial intelligence which are designed to recognize emotional facial expressions in contexts such as airports, where operators may be aiming to detect suspicious behaviour.

However, it is also important to note that many emojis are designed to signify specific emotions – indeed, they are even given emotional labels by their creators (Unicode, https://unicode.org/emoji/charts/full-emoji-list.html). In this respect, emoji are not the same as natural facial expressions that are spontaneously produced in relation to a pleasant/noxious stimulus. Nevertheless, it is important to acknowledge that the sender is choosing an emoji to represent their inner emotional states, and thus it is still vital to consider whether senders are in any way "universal" in their choices. As well as considering individual differences in how emoji are interpreted, future research could additionally consider whether there are commonalities in the emojis that senders with different individual characteristics choose to use when asked to convey a specific emotion (see e.g., Thompson & Filik, 2016, who examined which paralinguistic devices people chose to use to convey sarcasm).

In relation to the task procedure, the presentation of emojis was not time-limited, in that they remained on the screen until the participant moved to the next trial. This inevitably allowed for increased time available for participants to process the stimuli, which, particularly in ASD, is associated with better recognition of emotions (Behrmann et al., 2006). Furthermore, in contrast to facial expressions, emojis represent a static representation of emotion. The static nature of emojis naturally means that the individual elements of the face will not change. As autistic individuals tend to focus on local elements of the face (Hobson et al., 1988; Loth et al., 2018), the fact that emojis are static is likely to facilitate recognition.

In the current study, we used the AQ-10 as an index of autistic traits, with the aim of reducing participant attrition during the online survey due to its relatively fast administration. Reliability scores were relatively low, with a Cronbach's alpha of 0.520 (0.546 standardized). However, this is in line with previous research utilizing the AQ-10, such as Rhind et al. (2014) with 0.56, and Bertrams (2021) with 0.59. Clearly it is beneficial for both researchers and clinicians to have access to a tool that can be rapidly administered and is both reliable and valid, particularly when increasing amounts of research is being conducted online, where participant attrition may be high. At the time of study conception, literature on the AQ-10 was supportive regarding its validity. For example, Booth et al. (2013) found little difference between the AQ-10 and AQ-50 in classification performance in adult participants. In addition, a more recent study conducted with a larger sample (Lundin et al., 2019) also concluded that the AQ-10 has adequate validity regarding its use as a measure of autistic traits. However, since then, other researchers (e.g., Taylor et al., 2020) have questioned its use. Therefore, the evidence regarding the use of the AQ-10 is somewhat mixed, which should be kept in mind when interpreting the current results.

We used the ECR-12 as an index of attachment styles. In order to be more inclusive, we instructed participants who were not in a romantic relationship to answer the questions in terms of their closest relationship. While we accept that this tool was initially validated for use in romantic relationships and acknowledge that our results may have been more robust had we only recruited participants who were currently in a romantic relationship, results from confirmatory factor analysis along with a high Cronbach's alpha suggest that the scale was nevertheless reliable and valid for the current sample.

Finally, although the present study investigated the ability of participants to classify specific emojis, there are other variables that may have impacted their performance. For example, the familiarity effect (Alismail & Zhang, 2020) is an important consideration, and the present study did not ask participants which emojis they used most frequently themselves. Moreover, there is a somewhat circular logic as, if participants do not know the meaning of an emoji, they will not use it within sentences, which will itself lead to increased ambiguity regarding its meaning. This effect should be recognized in, and controlled for, in subsequent studies.

5. Conclusions

In conclusion, the current research revealed several interesting and important findings in classification accuracy of emoji representing facial emotional expressions, in particular, in relation to individual differences in this process. Firstly, general findings would suggest parallels between emoji classification and facial recognition, in that simple emotions were generally more accurately classified than complex emotions (with the exception of surprise). In relation to individual differences, results offer support for the Alexithymia Hypothesis (Bird & Cook, 2013), highlighting that alexithymia is likely to mediate the relationship between ASD and emotion, and extending this to emoji classification. For attachment, scores in attachment anxiety appear to be particularly important, boosting classification accuracy in high AQ participants, possibly as a result of hypervigilance. Implications for practice are threefold. Crucially, our results highlight the importance of considering the effects of factors in interaction, rather than examining individual differences factors in isolation. Also, our findings allow for the more accurate identification of individuals who are most at risk of misinterpreting emotions/emoji in the context of written communication, facilitating better identification of individuals who may benefit from interventions designed to improve emotion recognition. In addition, the current results highlight important individual differences in interpretation amongst users of digital communication, which will be useful to designers of digital tools that are used to convey emotion (see, e.g., Fabri & Satterfield, 2019; Zolyomi & Snyder, 2021, for discussion of designing for users who score highly on dimensions of the autistic spectrum).

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Ethical approval

This research did not involve non-human participants. British Psychological Society (2014) principles were observed throughout the design and execution of this research; participants' responses were anonymous, participants were informed of their right to withdraw from the study at any time without reason yet without penalty, etc. All participants gave their full consent to participant, and as part of the consent process indicate that they were prepared to allow their data to be published (while being reassured that no single individual would be identifiable in any published report). The study was conducted following the ethical guidelines of the School of Psychology at the University of Nottingham (ethics committee ref: 738) and the Declaration of Helsinki (2000).

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Data availability statement

Data are stored on the Open Science Framework: https://osf.io/naqf9/?view_only=c9cafdbc4c3f412694855afafaa57331

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