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Recognition of facial expressions in autism: effects of face masks and alexithymia

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Abstract

It is often assumed that the recognition of facial expressions is impaired in autism. However, recent evidence suggests that reports of expression recognition difficulties in autistic participants may be attributable to co-occurring alexithymia – a trait associated with difficulties interpreting interoceptive and emotional states – not autism *per se*. Due to problems fixating on the eye-region, autistic individuals may be more reliant on information from the mouth region when judging facial expressions. As such, it may be easier to detect expression recognition deficits attributable to autism, not alexithymia, when participants are forced to base expression judgements on the eye-region alone. To test this possibility, we compared the ability of autistic participants (with and without high levels of alexithymia) and non-autistic controls to categorize facial expressions i) when the whole face was visible, and ii) when the lower portion of the face was covered with a surgical mask. High-alexithymic autistic participants showed clear evidence of expression recognition difficulties: they correctly categorised fewer expressions than non-autistic controls. In contrast, low-alexithymic autistic participants were unimpaired relative to non-autistic controls. The same pattern of results was seen when judging masked and unmasked expression stimuli. In sum, we find no evidence for an expression recognition deficit attributable to autism, in the absence of high levels of co-occurring alexithymia, either when participants judge whole-face stimuli or just the eye-region. These findings underscore the influence of co-occurring alexithymia on expression recognition in autism.

Key words:

Autism, Alexithymia, Expression recognition, Eye-region, Face masks

Introduction

Autism spectrum disorder (hereafter autism) is a neurodevelopmental condition associated with differences in social communication, together with focused patterns of behaviours and intensive interests (APA, 2013). There is considerable interest in the ability of autistic individuals to interpret facial expressions (for reviews, see: Harms, Martin, & Wallace, 2010; Uljarevic & Hamilton, 2013). Facial expressions are a key form of non-verbal communication that can be used to infer someone's emotional state and likely intentions (Adolphs, 2002; Frith, 2009). As such, the accurate recognition of expressions is important for the development of mentalizing and wider mechanisms of social cognition. Where observed, poor expression recognition may hinder social interaction and the development of complex mentalizing abilities (Frith & Frith, 2006).

Many studies have sought to compare the expression recognition of autistic participants with samples of matched non-autistic controls drawn from the general population (for reviews, see: Harms et al., 2010; Uljarevic & Hamilton, 2013). However, the findings described are inconsistent. Some results suggest that autistic individuals exhibit broadly typical expression recognition (Adolphs, Sears, & Piven, 2001; Brewer, Biotti, Bird, & Cook, 2017; Castelli, 2005; Neumann, Spezio, Piven, & Adolphs, 2006), while others suggest that expression recognition may be impaired (Ashwin, Chapman, Colle, & Baron-Cohen, 2006; Humphreys, Minshew, Leonard, & Behrmann, 2007; Loth et al., 2018).

In principle, there are several possible reasons for these inconsistent findings, including differences in participant age and methodology (Harms et al., 2010). Similarly, differences in the diagnostic criteria employed mean that participants' verbal and social abilities may vary between studies. However, one suggestion that has received considerable attention is the possibility that subgroups exist within the autistic population that possess different cognitive and perceptual profiles (Happé & Ronald, 2008; Happé, Ronald, & Plomin, 2006). In particular, there is growing interest in the possibility that autistic individuals with and without co-occurring alexithymia differ in their expression recognition ability (Cook, Brewer, Shah, & Bird, 2013; Keating, Fraser, Sowden, & Cook, 2022; Oakley, Brewer, Bird, & Catmur, 2016; Ola & Gullon-Scott, 2020).

Alexithymia is a trait associated with difficulties interpreting interoceptive (e.g., hunger, thirst, warmth) and emotional (e.g., happiness, anger, disgust) states (Brewer, Cook, & Bird, 2016; Brewer, Happé, Cook, & Bird, 2015). For example, individuals with high levels of alexithymia sometimes confuse feeling angry and feeling hot (Brewer et al., 2016). Although the defining feature of alexithymia is an inability to describe one's own affective and interoceptive states,

individuals with high levels of alexithymia also exhibit impaired recognition and description of others' facial affect (Grynberg et al., 2012; Parker, Taylor, & Bagby, 1993).

Importantly, high levels of alexithymia are much more common in the autistic population than in the general population (Bird & Cook, 2013; Kinnaird, Stewart, & Tchanturia, 2019). Only ~5% of the general population describe high levels of alexithymia (Kinnaird et al., 2019). In contrast, high levels of alexithymia may be seen in ~50% of autistic individuals (Kinnaird et al., 2019). Indeed, in a large sample of female autistic individuals, more than 70% met the cut-off for high levels of alexithymia (Ola & Gullon-Scott, 2020).

According to the *alexithymia hypothesis*, expression recognition difficulties in autistic participants are attributable to co-occurring alexithymia, not autism *per se* (Bird & Cook, 2013; Cook et al., 2013). In other words, only those autistic individuals with high levels of co-occurring alexithymia are thought to exhibit poor expression recognition. This account potentially explains the inconsistent reports of impaired expression recognition in autism. Autistic samples that contain high numbers of high-alexithymic autistic participants may exhibit below-average expression recognition at the group level. Conversely, autistic samples that contain relatively low numbers of high-alexithymic autistic participants, may exhibit similar performance to samples drawn from the general population.

Evidence in support of the alexithymia hypothesis in mounting. Relative to autistic individuals with low-levels of alexithymia, autistic individuals with high levels of alexithymia have more difficulties categorising static (Milosavljevic et al., 2016) and dynamic (Ola & Gullon-Scott, 2020) displays of facial affect. Similarly, in pooled samples that contain non-autistic participants with and without high levels of alexithymia, and autistic participants with and without high levels of alexithymia, alexithymia severity is highly predictive of participants' ability to classify static (Cook et al., 2013; Oakley et al., 2016) and dynamic (Keating et al., 2022) expression stimuli.

The present study

There is now considerable evidence that levels of co-occurring alexithymia affect expression recognition in samples of autistic participants (Cook et al., 2013; Keating et al., 2022; Milosavljevic et al., 2016; Oakley et al., 2016; Ola & Gullon-Scott, 2020). In light of these findings, a key question is whether there is any association between autism and expression recognition ability once the influence of alexithymia is accounted for – whether there is an independent effect of autism *per se* (Keating et al., 2022). In the present study, we sought to address the possibility that the respective contributions of autism and alexithymia depend on

the type of stimuli being judged, and as a result a unique contribution of autism may have been overlooked in the existing literature.

When viewing faces, autistic individuals are thought to fixate less on the eye-region than non-autistic individuals, but exhibit typical or heightened interest in the mouth region (Dalton et al., 2005; Spezio, Adolphs, Hurley, & Piven, 2007). It has been suggested that autistic individuals may find the eye-region socially threatening and thus exhibit a different pattern of fixation behaviour from non-autistic individuals (Tanaka & Sung, 2016). These findings raise the possibility that autistic individuals may be more reliant on information from the mouth region when judging facial expressions. For example, they may develop particular expertise that aids the detection, encoding, and interpretation of mouth cues, but fail to develop equivalent expertise for eye-region cues. If correct, autistic participants may be at a particular disadvantage when forced to base expression judgements on the eye-region alone (i.e., where the rest of the face is occluded). Thus, it may be easier to detect expression recognition deficits attributable to autism – and not alexithymia – when participants must focus on the eye-region.

Consistent with this suggestion, several studies have found that autistic participants tend to achieve lower scores on the Reading the Mind in the Eyes Test (RMET; Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001) than non-autistic controls (Baron-Cohen et al., 2001; Golan, Baron-Cohen, Hill, & Rutherford, 2007; Kirchner, Hatri, Heekeren, & Dziobek, 2011; Wilson et al., 2014). In this task, participants view cropped expressive eye-region stimuli and must identify the most appropriate verbal label (e.g., Serious, Ashamed, Alarmed or Bewildered; Reflective, Aghast, Irritated, or Impatient). The verbal and mentalizing demands of the RMET may be higher than most expression recognition tasks used in this field (Peñuelas-Calvo, Sareen, Sevilla-Llewellyn-Jones, & Fernández-Berrocal, 2019). Nevertheless, these findings accord with the view that autistic participants have a problem detecting and interpreting expression cues from the eye-region.

In the present study we compared the ability of 66 autistic participants (46 with and 20 without high levels of co-occurring alexithymia) and 66 matched non-autistic controls to categorize facial expressions in an eyes-only condition and in a whole-face condition. In the eyes-only condition, expression stimuli were presented with a surgical mask occluding the mouth region. This allowed us to occlude expression signals from the mouth and nose region of our stimuli, whilst retaining a naturalistic appearance. In the whole-face condition, participants judged the same expression stimuli, but without any occlusion.

Several studies of the alexithymia hypothesis have previously employed non-autistic control groups that were matched for alexithymia (Cook et al., 2013; Keating et al., 2022; Oakley et al., 2016). These control groups include individuals who are recruited because they describe high levels of alexithymia, but who have not been diagnosed with a psychiatric condition prior to the study. In this design, the alexithymia hypothesis predicts that the autistic and non-autistic groups will exhibit similar levels of expression recognition. Our approach was different: we sought to compare the expression recognition of autistic individuals (with and without co-occurring alexithymia) against a representative control group drawn from the general population.

According to the alexithymia hypothesis, some studies find evidence of expression recognition deficits in autism, while others do not, because of differences in the levels of co-occurring alexithymia present in autistic samples (Bird & Cook, 2013). Crucially, the inconsistent results that the alexithymia hypothesis seeks to explain are typically obtained using samples of non-autistic controls drawn from the general population (i.e., the levels of alexithymia within these samples were not manipulated). Thus, a key assumption of the alexithymia hypothesis is that high-alexithymic autistic participants – but not low-alexithymic autistic participants – exhibit impaired expression categorisation relative to representative samples of non-autistic participants drawn from the general population. By comparing the performance of high-alexithymic autistic participants and low-alexithymic autistic participants with a sample drawn from the general population we sought to test this critical assumption.

Method

Participants

Data collection took place between May 2021 and November 2021. During this period, we recruited as many autistic participants as possible via www.ukautismresearch.org. Once we knew the size and profile of the autistic sample, we recruited a matched sample of non-autistic controls via www.prolific.co. To be eligible, all participants (autistic and non-autistic) had to be aged between 18 and 60, speak English as a first language, and have normal or corrected-to-normal visual acuity. All participants were required to be a current UK resident and to have resided in the UK for the previous 12 months.

Sixty-six participants with a clinical diagnosis of autism (M_{age} = 33.09 years; SD_{age} = 11.14 years) were recruited for the study. Of the 23 individuals who described their sex as male, 18 described their gender identity as male, 4 identified as non-binary, and 1 identified as female. Of the 43 individuals who described their sex as female, 33 described their gender identity as female, 9 identified as non-binary, and 1 identified as male. All autistic

participants had received an autism diagnosis (e.g., Autism Spectrum Disorder, Asperger's Syndrome) from a clinical professional (General Practitioner, Neurologist, Psychiatrist, or Clinical Psychologist) based in the UK. All participants in the autistic group also reached cut-off (a score of 32) on the Autism Spectrum Quotient (AQ; Baron-Cohen et al., 2001). The mean AQ score of the autistic group was 41.23 (*SD* = 4.59).

Sixty-six non-autistic individuals (M_{age} = 32.89 years; SD_{age} = 9.54 years) were recruited to serve as controls. Of the 66 participants in the non-autistic group, 23 described their sex and gender identity as male and 43 described their sex and gender identity as female. All non-autistic participants scored below cut-off (a score of 31 or less) on the AQ. The mean AQ score of the non-autistic group was 17.21 (*SD* = 7.21).

The autistic and non-autistic participants did not differ significantly in terms of participants' age [$t(130) = .109$, $p = .913$] or sex [$X^2_{(1)} = .000$, $p = 1.000$]. However, the groups did differ in terms of participants' gender identity [$X^2_{(2)} = 14.433$, $p < .001$]. As expected, the autistic (*M* = 41.23, *SD* = 4.59) and non-autistic (*M* = 17.21, *SD* = 7.21) groups differed in their AQ scores [$t(130) = 22.82$, $p < .001$].

To ensure that the autistic and non-autistic participants were approximately matched for non-verbal intelligence, all participants completed a measure of abstract visuospatial reasoning. Forty items were selected from The Matrix Reasoning Item Bank (MaRs-IB; Chierchia et al., 2019). Participants were given 30 seconds to complete each puzzle by selecting the correct answer from 4 options. Participants responded using keyboard number keys (1-4), were given a 5-second warning before the end of each trial, and received no feedback. All participants attempted all forty items. Participants had to complete 3 practice trials correctly before beginning the test. The scores of the autistic participants (*M* = 25.59, *SD* = 5.63, range: 14 to 37) and the non-autistic controls (*M* = 24.36, *SD* = 5.66, range: 12 to 36) did not differ significantly [$t(130) = 1.249$, $p = .214$].

The presence of alexithymia was assessed in all participants using the Twenty-item Toronto Alexithymia Scale (TAS-20; Bagby, Parker, & Taylor, 1994; Taylor, Bagby, & Parker, 2003). The TAS-20 scores of the autistic participants (*M* = 65.50, *SD* = 12.75, range: 36 to 88) were significantly higher than those of the non-autistic controls (*M* = 43.18, *SD* = 11.61, range: 24 to 70) [$t(130) = 10.517$, $p < .001$]. Of the 66 autistic participants, 46 (69.7%) reached the cut-off (≥ 61) for high levels of alexithymia. Of the 66 non-autistic participants, 6 (9.1%) reached this cut-off. Based on participants' TAS-20 score, we split the autistic group into two

subgroups: low-alexithymic autistic individuals and high-alexithymic autistic individuals. The details of the two subgroups are shown in Table 1.

Table-1

The non-autistic and low-alexithymic autistic participants did not differ significantly in terms of age [$t(84) = .560$, $p = .577$], sex [$X^2_{(1)} = .177$, $p = .674$], or visuospatial reasoning ability [$t(84) = .860$, $p = .392$]. However, the groups did differ in terms of gender identity [$X^2_{(2)} = 17.53$, $p < .001$]. Participants further differed significantly in terms of AQ [$t(84) = 13.44$, $p < .001$] and TAS scores [$t(84) = 2.467$, $p = .016$], with low-alexithymic autistic participants scoring higher on both measures.

The non-autistic group did not differ significantly from the high-alexithymic autistic group in terms of age [$t(110) = .446$, $p = .656$], sex [$X^2_{(1)} = .061$, $p = .805$], or visuospatial reasoning ability [$t(110) = 1.116$, $p = .266$]. Once again, however, the groups did differ in terms of gender identity [$X^2_{(2)} = 12.401$, $p = .002$]. As expected, the groups also differed significantly in terms of AQ [$t(110) = 20.217$, $p < .001$] and TAS scores [$t(110) = 14.958$, $p < .001$], with the high-alexithymic autistic group scoring higher on both measures.

Experimental task

The experiment was conducted online using Gorilla Experiment Builder (Anwyl-Irvine, Massonnié, Flitton, Kirkham, & Evershed, 2020). Face stimuli were obtained from the Radboud Faces Database (Langner et al., 2010). Masked versions were created by superimposing surgical-type masks over the nose and mouth using Adobe Photoshop (Figure 1a). Participants viewed ten identities (five women, five men), each posing seven facial expressions: neutral, happy, sad, angry, fearful, disgusted, and surprised. Each expression stimulus was presented twice: once wearing a face mask and once without a mask. In total, participants completed 140 trials (10 identities × 7 expressions × 2 mask conditions) in a random order. Images appeared 4.8cm × 7cm on participants' displays. Trials began with a fixation cross (1000ms) followed by a face image presented for 500ms (Figure 1b). The stimulus image was replaced by a mask constructed of high-contrast greyscale ovals (500ms), followed by a response screen on which participants selected one of seven response options (neutral, happy, sad, angry, fearful, disgusted, surprised). There was no time limit on participants' responses. The experimental task is available as Open Materials at gorilla.sc (https://app.gorilla.sc/openmaterials/276504).

Figure-1

Statistical procedures

In both studies, participants' emotion recognition performance was evaluated using ANOVA and *t*-tests (α = 0.05, two-tailed), performed using SPSS v.28. For the ANOVAs, we report partial eta squared (η_p^2) as a measure of effect size. For the paired samples *t*-tests, we report Cohen's *d*, calculated by dividing the mean pairwise difference by the standard deviation of the pairwise differences. For the independent samples *t*-tests, we report Cohen's *d*, calculated by dividing the difference between the group means by the pooled standard deviation. All comparisons were planned. Unless otherwise stated, comparisons survive Bonferroni correction.

For each *t*-test, we also provide the associated Bayes Factor (BF), calculated in JASP (JASP-Team, 2022) with default prior width. We interpret BFs of less than 3.0 as anecdotal evidence for the null hypothesis. BFs of greater than 3.0 are treated as substantial evidence for the null hypothesis (e.g., Jeffreys, 1961).

Results

For each participant, we computed separate measures of performance (% correct) for the unmasked and masked conditions. The mean performance of the autistic and non-autistic participants in the two viewing conditions is shown in Table 2 and Figure 2. The supporting data are available via the Open Science Framework (https://osf.io/axc4s/). The results described below are calculated using the entire control group (N = 66), including the 6 non-autistic participants who reached cut-off for high levels of alexithymia. We opted to retain these individuals to ensure that our sample of non-autistic controls remained representative of the general population (i.e., the levels of alexithymia within the control group were not manipulated). Similar patterns are obtained if these individuals are removed from the control group (see supplementary material).

Table-2 / Figure-2

Traditional group analysis

To begin with, the accuracy scores were analysed using ANOVA with Viewing Condition (unmasked, masked) as a within-subjects factor and Group (non-autistic, autistic) as a between-subjects factors. This first analysis reflects the traditional approach of combining low-alexithymic and high-alexithymic autistic individuals in a single 'autistic' group.

We observed a significant main effect of Group [$F(1,130) = 14.585$, $p < .001$, $\eta_p^2 = .101$], whereby the non-autistic controls were more accurate than the autistic participants, and a significant main effect of Viewing Condition [$F(1,130) = 747.764$, $p < .001$, $\eta_p^2 = .852$], whereby participants were more accurate in the unmasked condition. We observed no Group × Viewing Condition interaction [$F(1,130) = 1.692$, $p = .196$, $\eta_p^2 = .013$]. The accuracy scores of the autistic participants were significantly lower than those of the non-autistic participants in both the unmasked condition [$t(130) = 3.086$, $p < .001$, $d = .537$, $BF_{01} = .077$] and the masked condition [$t(130) = 3.743$, $p < .001$, $d = .652$, $BF_{01} = .011$].

Alexithymia subgroup analysis

Next, the accuracy scores were analysed using ANOVA with Viewing Condition (unmasked, masked) as a within-subjects factors and Group (non-autistic, high-alexithymic autistic, low-alexithymic autistic) as a between-subjects factors. This analysis examined the possibility that autistic individuals with and without high levels of alexithymia might differ in their expression recognition ability.

We observed a significant main effect of Group [$F(2, 129) = 14.294$, $p < .001$, $\eta_p^2 = .181$] and a significant main effect of Viewing Condition [$F(2, 129) = 585.149$, $p < .001$, $\eta_p^2 = .819$]. Once again, there was no Group × Viewing Condition interaction [$F(2, 129) = 1.949$, $p = .147$, $\eta_p^2 = .029$]. The non-autistic and low-alexithymic autistic groups did not differ in their categorisation accuracy in either the unmasked condition [$t(84) = .248$, $p = .804$ $d = .063$, $BF_{01} = 3.749$] or in the masked condition [$t(84) = .019$, $p = .985$ $d = .005$, $BF_{01} = 3.847$]. However, the accuracy scores of the high-alexithymic autistic participants were significantly below those of the non-autistic controls in both the unmasked condition [$t(110) = 3.876$, $p < .001$, $d = .745$, $BF_{01} = .008$] and in the masked condition [$t(110) = 4.946$, $p < .001$, $d = .950$, $BF_{01} < .001$]. The accuracy scores of the high-alexithymic autistic participants were also significantly below those of the low-alexithymic autistic individuals in both the unmasked condition [$t(64) = 2.296$, $p = .025$, $d = .615$, $BF_{01} = .429$] and in the masked condition [$t(64) = 2.904$, $p = .005$, $d = .778$, $BF_{01} = .123$]. We note, however, that the difference between the high-alexithymic and low-alexithymic autistic participants in the unmasked condition does not survive Bonferroni correction.

The foregoing results suggest that the low-alexithymic autistic participants and the non-autistic controls did not differ in their expression recognition in either the masked or unmasked conditions. The interpretation of these null results is complicated by the fact that 46 of our 66 autistic participants reached the cut-off for high levels of alexithymia. As such, we have more statistical power to detect differences in the high-alexithymic group, than in

the low-alexithymic group. Nevertheless, the Bayesian analyses (BFs > 3.0) provide statistical evidence for the null hypothesis – that the expression categorisation accuracy of low-alexithymic autistic participants and non-autistic controls does not differ.

General discussion

There has been great interest in whether the recognition of facial expression is impaired in autism (Harms et al., 2010; Uljarevic & Hamilton, 2013). To date, however, the literature is inconsistent. While some studies suggest that autistic and non-autistic participants show similar levels of expression recognition (Adolphs et al., 2001; Brewer et al., 2017; Castelli, 2005; Neumann et al., 2006), other findings suggest that autistic participants are less able to categorise facial affect (Ashwin et al., 2006; Humphreys et al., 2007; Loth et al., 2018). The alexithymia hypothesis offers an explanation for these equivocal findings (Bird & Cook, 2013). According to this account, reports of impaired expression recognition in autism are attributable to co-occurring alexithymia – a trait that i) occurs with higher incidence in the autistic population than in the general population (e.g., Kinnaird et al., 2019), and ii) is associated with expression recognition difficulties (e.g., Grynberg et al., 2012). Samples that contain a high proportion of high-alexithymic autistic individuals may be more likely to exhibit poor expression recognition at the group level than samples with a low proportion of high-alexithymic autistic individuals (Bird & Cook, 2013).

Consistent with the alexithymia hypothesis, there is mounting evidence that differences in alexithymia are predictive of poor expression recognition in autistic participants (Milosavljevic et al., 2016; Ola & Gullon-Scott, 2020) and in pooled samples of autistic and non-autistic participants (Cook et al., 2013; Keating et al., 2022; Oakley et al., 2016). To date, however, it remains unclear if/how the respective contributions of autism and alexithymia vary according to the type of expression stimuli being judged. As a result, a unique contribution of autism may have been overlooked in the existing literature.

It has been argued that autistic individuals may exhibit particular problems when required to make perceptual decisions about the eye-region (Tanaka & Sung, 2016). When viewing faces, they are thought to fixate less on the eye-region than non-autistic individuals, but exhibit typical or heightened interest in the mouth region (Dalton et al., 2005; Spezio et al., 2007). Autistic individuals may therefore develop expertise that aids the detection and interpretation of mouth cues, but fail to develop equivalent expertise for the eye-region. If this view is correct, expression recognition deficits attributable to autism – not alexithymia – may be easier to detect when participants are forced to base their judgements on the eye-region. To test this possibility, we asked 66 autistic participants (46 with and 20 without high levels

of co-occurring alexithymia) and 66 non-autistic controls to categorise facial expressions when the whole face was visible, and when the lower portion of the face was covered with a surgical mask.

When high-alexithymic autistic and low-alexithymic autistic participants were combined in a single autistic sample, we found evidence for a modest expression recognition deficit at the group level – on average, the autistic participants were less accurate than the non-autistic controls. However, analysis of the two subgroups revealed a more nuanced picture. The high-alexithymic autistic participants showed clear evidence of expression recognition difficulties: they correctly identified fewer expressions than both the low-alexithymic autistic individuals and the non-autistic controls. In contrast, the low-alexithymic autistic individuals were unimpaired relative to the non-autistic controls. Importantly, the same pattern of results was seen when judging the whole face (unmasked condition) and just the eye-region (masked condition). We observed no evidence that autistic participants – either those with or without high levels of alexithymia – were disproportionately impaired when basing decisions on the eye-region alone.

These results provide important new evidence for the alexithymia hypothesis. The fact that high-alexithymic autistic individuals showed expression recognition impairment, while low-alexithymic autistic individuals did not, suggests that these difficulties are attributable to alexithymia, not autism *per se*. These results accord well with previous reports that autistic individuals with high levels of alexithymia have more difficulties categorising facial expressions, than autistic individuals with low levels of alexithymia (Milosavljevic et al., 2016; Ola & Gullon-Scott, 2020). Importantly, however, we show that the high-alexithymic autistic group – but not the low-alexithymic autistic group – was impaired relative to non-autistic controls drawn from the general population. This finding provides key evidence for the view that the inconsistent reports of expression recognition impairment in the extant literature reflect differences in the relative proportions of high-alexithymic and low-alexithymic autistic participants in research samples (Bird & Cook, 2013).

It is perhaps unsurprising that the high-alexithymic autistic individuals showed poor expression recognition in both the unmasked and masked viewing conditions. Alexithymia is associated with functional (FeldmanHall, Dalgleish, & Mobbs, 2013; Kano et al., 2003; Moriguchi et al., 2007) and structural (Ihme et al., 2013) differences in the anterior insula and anterior cingulate cortex – regions implicated in the subjective experience of emotion and affect recognition (Etkin, Egner, & Kalisch, 2011; Singer, Critchley, & Preuschoff, 2009). Poor expression recognition in alexithymia is thought to reflect an aberrant top-down

contribution from these structures that hinders the interpretation of affective stimuli (Bird & Cook, 2013). The resulting deficit appears to impact a wide range of affective decisions. For example, those with high levels of alexithymia also find it hard to describe the emotional content of vocal stimuli (Heaton et al., 2012) and music (Allen, Davis, & Hill, 2013).

It is more surprising that the low-alexithymic autistic individuals showed typical expression recognition in both the unmasked and masked viewing conditions. It has been suggested that autistic individuals may have particular problems using information from the eye-region (Tanaka & Sung, 2016). As such, one might well expect all autistic participants – even those without high levels of alexithymia – to struggle in the masked condition, in which participants were forced to focus on the eye-region. Nevertheless, our findings accord with a previous result described by Oakley and colleagues (2016). In a pooled sample of non-autistic controls (N = 23) and autistic participants (N = 19), Oakley et al. found that participants' alexithymia scores were predictive of performance on the RMET. Consistent with our results, participants' AQ scores – a measure of autistic symptomology – were not predictive of RMET performance once individual differences in alexithymia were accounted for.

Our findings add to those of Oakley and colleagues (2016) in two ways. First, our larger sample of autistic participants allowed us to consider low-alexithymic and high-alexithymic subgroups separately. This analysis confirmed that autistic individuals with low-levels of alexithymia exhibit typical levels of expression categorization accuracy. This overcomes any potential difficulties interpreting the null effect of AQ scores – viewed by some as an imperfect measure of autistic symptomology (e.g., Ashwood et al., 2016) – described by Oakley et al. (2016). Second, the RMET is an unconventional expression recognition task. Its verbal and mentalizing demands are especially high (Peñuelas-Calvo et al., 2019) and there is variability in gaze direction (i.e., different targets are shown with mutual and averted gaze) - a feature that is tightly controlled in most tests of expression recognition, including the present one. Despite these differences, however, our findings accord well with those described by Oakley and colleagues (2016). The results of both studies suggest that autistic individuals with low-levels of alexithymia are able to detect and interpret expression cues from the eye-region.

This conclusion is hard to reconcile with the view that autism is associated with problems using information from the eye-region (Tanaka & Sung, 2016). One possibility is that eye-region avoidance in autism is actually attributable to alexithymia; i.e., where observed, atypical fixation behaviour is a product of co-occurring alexithymia, not autism. For example, difficulties interpretating facial affect may cause alexithymic observers to sample facial

regions idiosyncratically. Conversely, autistic individuals with low-levels of co-occurring alexithymia may have no difficulty attending to the eye-region. Consistent with this possibility, it is has been reported that participants' level of alexithymia is predictive of eye-region fixations when viewing complex social scenes (Bird, Press, & Richardson, 2011). Alexithymia has also been linked to elevated levels of anxiety in autism (e.g., Maisel et al., 2016). This is noteworthy as it is argued that autistic people avoid the eye-region because they find it socially threatening (Tanaka & Sung, 2016).

A second possibility is that autistic individuals may have reduced *propensity* to use facial information from the eye-region, not reduced *ability* to use facial information from the eye-region. Autistic individuals may often elect to avoid the eye-region because they find it threatening. However, when forced to attend to the eyes (e.g., when interactants are wearing surgical masks), they may be able to detect and interpret cues from this region without impediment. While this is perfectly plausible, one might still expect low-alexithymic autistic participants to show expression recognition deficits in the whole-face condition if they were extracting less information from the eye-region. For example, the expression categorisation of non-autistic participants is less accurate when the eye-region of each stimulus faces is occluded (Noyes, Davis, Petrov, Gray, & Ritchie, 2021). Contrary to this prediction, we find that low-alexithymic autistic individuals exhibit unimpaired expression recognition in the whole-face condition.

Face masks and social interaction

Our findings confirm previous reports that expression recognition is greatly impaired by the presence of a face mask (Carbon, 2020; Noyes et al., 2021; Tsantani, Podgajecka, Gray, & Cook, 2022). For example, Noyes and colleagues presented facial stimuli that were either angry, disgusted, fearful, happy, sad, surprised, or emotion neutral, for 1 sec. When the expression stimuli were presented unmasked, mean categorisation accuracy was higher (80.5%) than when faces were shown with a face mask (61.5%). Several facial expressions (happiness, sadness, disgust, fear, surprise, but not anger) are also judged to be less intense when the mouth and nose regions are occluded by a face mask (Tsantani et al., 2022). These findings support the prevailing view that the use of face masks hinders non-verbal communication and social interaction (Pavlova & Sokolov, 2022; Saunders, Jackson, & Visram, 2021).

We found no evidence that face masks disproportionately impact the expression recognition of autistic participants, relative to non-autistic participants. On average, recognition accuracy dropped by ~20% in autistic and non-autistic groups, irrespective of the presence of high or

low levels of alexithymia. It is possible, however, that the detrimental effects of widespread mask wearing during the COVID-19 pandemic may have been felt particularly keenly by high-alexithymic autistic individuals. A drop in accuracy of ~20% may represent a mild inconvenience for those whose expression recognition approaches ceiling levels under normal circumstances. However, a performance decrement of ~20% may be far more problematic for those who already find expression recognition challenging – i.e., an inconvenience may become debilitating.

Limitations

The present study was conducted online - an approach that is increasingly common. Carefully-designed online tests of cognitive and perceptual processing can yield high-quality data, indistinguishable from that collected in the lab (Crump, McDonnell, & Gureckis, 2013; Germine et al., 2012; Woods, Velasco, Levitan, Wan, & Spence, 2015). To give recent examples from our own research, we have found that online testing has produced clear, replicable results in visual search and attention cueing experiments (Vestner, Gray, & Cook, 2022; Vestner, Gray, & Cook, 2021; Vestner, Over, Gray, & Cook, 2021), and studies of visual illusions (Bunce, Gray, & Cook, 2021; Gray et al., 2020). However, this approach also has some well-known limitations. For example, it is not easy to control the testing environment, participants' viewing distance, or their monitor settings.

A further limitation of the present work is the lack of diversity within our autistic sample and our face stimuli. The overwhelming majority (~95%) of our autistic participants identified as White (typically White-British). For this reason, we opted to use facial stimuli that also depicted White individuals. This choice ensured that face processing impairments, where observed, could not be attributed to so-called 'cross-race' effects, whereby participants sometimes experience perceptual difficulties when viewing types of faces with which they are less familiar (Furl, Phillips, & O'Toole, 2002; Sangrigoli, Pallier, Argenti, Ventureyra, & de Schonen, 2005). As such, however, it remains unclear how well our findings generalise to faces of other ethnicities and more diverse autistic populations.

Conclusion

High-alexithymic autistic participants correctly identified fewer expressions than non-autistic controls. In contrast, the expression recognition of low-alexithymic autistic participants was unimpaired relative to non-autistic controls. The same pattern of results was seen when judging the whole-face and the eye-region alone. We find no evidence that autistic participants – either with or without co-occurring alexithymia – are disproportionately impaired when forced to base decisions on the eye-region. These results lend further

support to the view that reports of impaired expression recognition in samples of autistic individuals are attributable to co-occurring alexithymia, not autism *per se* (Bird & Cook, 2013; Cook et al., 2013).

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Figures

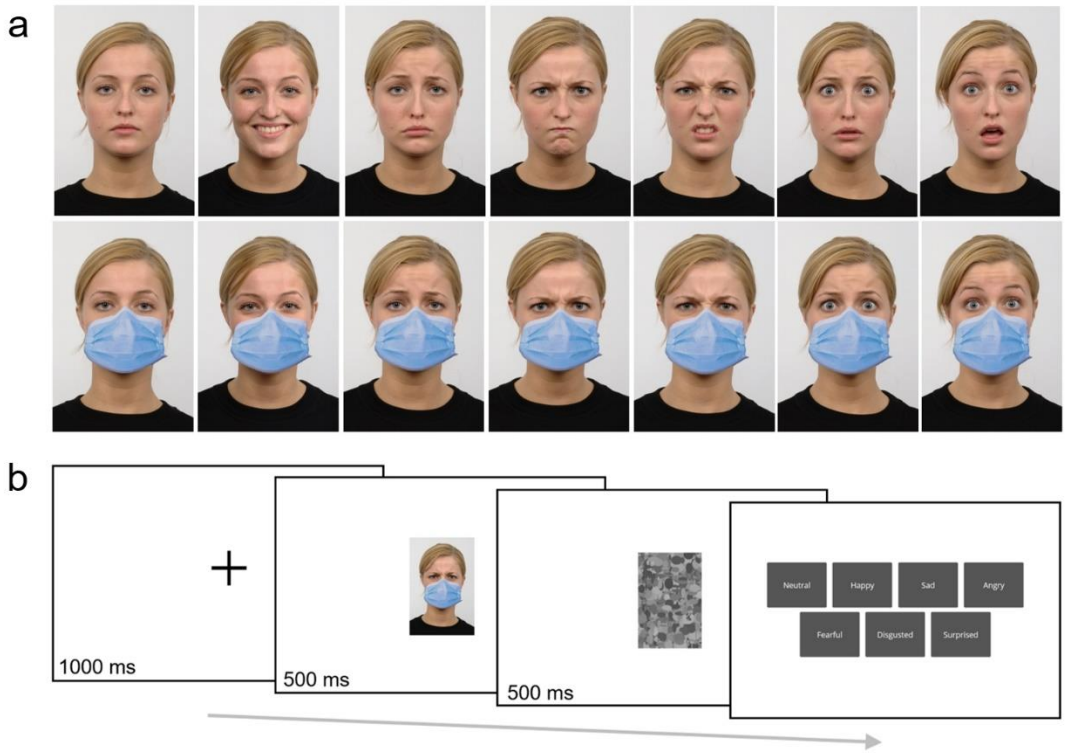

Figure 1. Overview of the experimental task. (a) Example stimuli from the expression recognition task. The original images were sourced from the Radboud Face Database (Langner et al., 2010). (b) Illustration of a trial sequence.

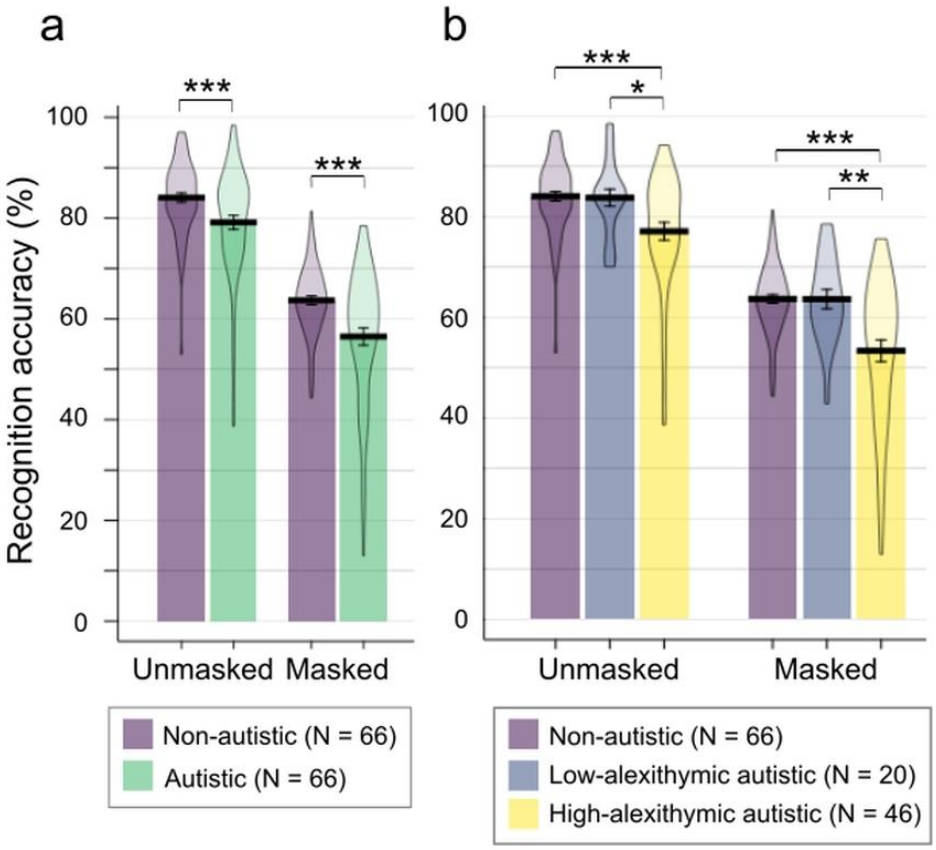

Figure 2. Recognition accuracy (%) across the two groups. (a) Performance of the non-autistic and autistic groups. (b) Performance break-down for the low-alexithymic and high-alexithymic autistic subgroups. *** denotes significance at $p < .001$, ** denotes significance at $p < .01$, * denotes significance at $p < .05$.

Supplementary material

The analyses described in the main paper were run on a control group of 66 non-autistic participants. This group included 6 participants who scored above cut-off for high levels of alexithymia. We elected to retain these individuals in our primary analyses to ensure that the control sample is representative of the general population. In the supplementary analyses described here, we show that similar patterns are obtained if these 6 non-autistic participants are removed from the control group. As in the primary analyses, we first describe a 'traditional group analysis' whereby the accuracy scores for the non-autistic control group (N = 60) are compared against those from a single autistic group (N = 66). We then describe an alexithymia subgroup analysis in which the performance of high-alexithymic (N = 46) and low-alexithymic (N = 20) autistic participants is considered separately.

Traditional group analysis

Accuracy scores were analysed using ANOVA with Viewing Condition (unmasked, masked) as a within-subjects factor and Group (non-autistic, autistic) as a between-subjects factor (Figure S1a). This first analysis reflects the traditional approach of combining low-alexithymic and high-alexithymic autistic individuals in a single 'autistic' group.

We observed a significant main effect of Group [$F(1,124) = 13.985$, $p < .001$, $\eta_p^2 = .101$], whereby the non-autistic controls were more accurate than the autistic participants, and a significant main effect of Viewing Condition [$F(1,124) = 678.343$, $p < .001$, $\eta_p^2 = .845$], whereby participants were more accurate in the unmasked condition. We observed no Group × Viewing Condition interaction [$F(1,124) = 2.602$, $p = .109$, $\eta_p^2 = .012$]. The accuracy scores of the autistic participants were significantly lower than those of the non-autistic participants in both the unmasked condition [$t(124) = 2.867$, $p = .005$, $d = .511$, $BF_{01} = .136$] and the masked condition [$t(124) = 3.807$, $p < .001$, $d = .679$, $BF_{01} = .009$].

Alexithymia subgroup analysis

Next, the accuracy scores were analysed using ANOVA with Viewing Condition (unmasked, masked) as a within-subjects factors and Group (non-autistic, high-alexithymic autistic, low-alexithymic autistic) as a between-subjects factors (Figure S1b). This analysis examined the possibility that autistic individuals with and without high levels of alexithymia might differ in their expression recognition ability.

We observed a significant main effect of Group [$F(2, 123) = 13.776$, $p < .001$, $\eta_p^2 = .183$] and a significant main effect of Viewing Condition [$F(2, 123) = 552.809$, $p < .001$, $\eta_p^2 = .818$]. Once again, there was no Group × Viewing Condition interaction [$F(2, 123) = 2.385$, $p =$

.096, η_p^2 = .037]. The non-autistic and low-alexithymic autistic groups did not differ in their categorisation accuracy in either the unmasked condition [*t*(78) = .156, *p* = .876, *d* = .040, BF_{01} = 3.772] or in the masked condition [*t*(78) = .234, *p* = .816 *d* = .060, BF_{01} = 3.725]. However, the accuracy scores of the high-alexithymic autistic participants were significantly below those of the non-autistic controls in both the unmasked condition [*t*(104) = 3.640, *p* < .001, *d* = .713, BF_{01} = .016] and in the masked condition [*t*(104) = 4.956, *p* < .001, *d* = .971, BF_{01} < .001]. The accuracy scores of the high-alexithymic autistic participants were also significantly below those of the low-alexithymic autistic individuals in both the unmasked condition [*t*(64) = 2.296, *p* = .025, *d* = .615, BF_{01} = .429] and in the masked condition [*t*(64) = 2.904, *p* = .005, *d* = .778, BF_{01} = .123]. We note, however, that the difference between the high-alexithymic and low-alexithymic autistic participants in the unmasked condition does not survive Bonferroni correction.

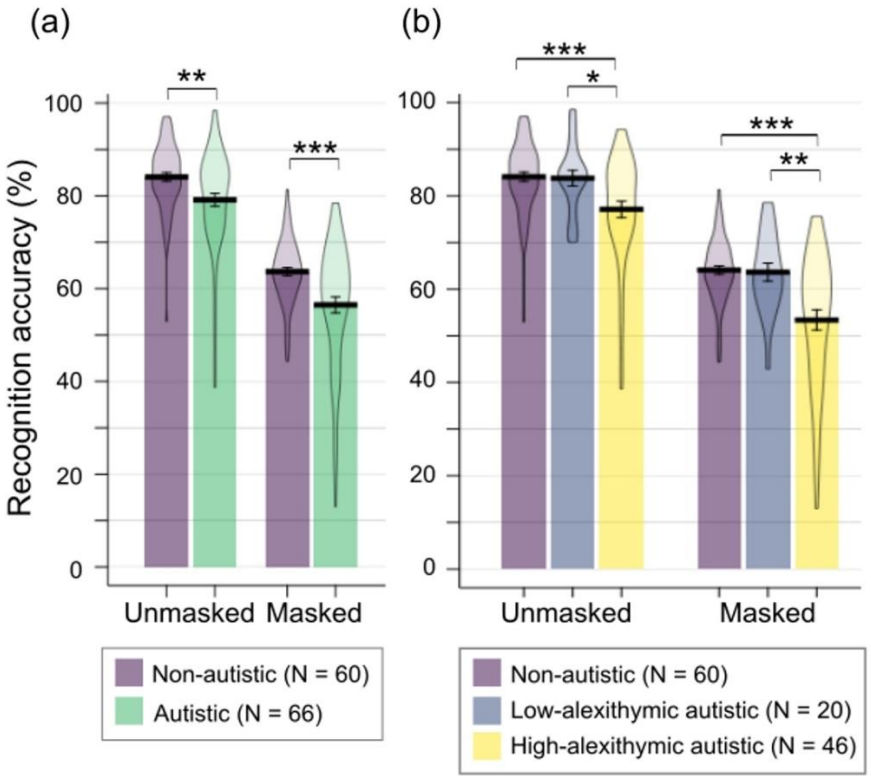

Figure S1. Recognition accuracy (%) across the two groups. (a) Performance of the non-autistic (N = 60) and autistic groups. (b) Performance break-down for the low-alexithymic and high-alexithymic autistic subgroups. *** denotes significance at *p* < .001, ** denotes significance at *p* < .01, * denotes significance at *p* < .05.