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Autistic Traits Predict Underestimation of Emotional Abilities

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People vary in their self-awareness of their own emotions, and this may predict psychological well-being. Evidence suggests that emotional self-awareness is diminished in autism, but these findings may be biased by self-report or confounded by verbal intelligence. To address this issue, we developed the emotional consistency (EC) task, measuring emotional self-awareness through consistency in emotional decision-making. In the EC-Task, we showed participants pairs of emotional images, asking them to judge which evoked the more intense emotional experience. The logical consistency of decision making, based on transitive relationships between stimuli, reflects precision of judgment of experience of emotional intensity, which in turn reflects emotional self-awareness. Emotional consistency significantly correlated with lower self-reported alexithymia but not autistic traits. Instead, autistic traits predicted greater discrepancy between EC-Task performance and self-reported difficulties identifying feelings. Participants with higher autistic traits were more likely to underestimate their emotional self-awareness, possibly because of greater metacognitive difficulties and negative self-beliefs. Our study suggests emotional self-awareness is not diminished in autism and provides a novel method to investigate this issue.

Keywords: emotion differentiation, alexithymia, emotional granularity, autistic traits, mental health

How we experience and describe our own emotions varies from person to person. Some people experience their own emotions very clearly, communicating them in precise terms such as delighted or disappointed. Others have fuzzier experiences, struggling to differentiate between similar states and describing them only in general terms of good or bad. Whereas many concepts have arisen in psychology to describe the ability to make sense of our emotional world, we have chosen to use the term emotional self-awareness. Emotional self-awareness refers to the general ability to make sense of one's own emotions, including the ability to identify experiences of affect as such and to differentiate similar emotional experiences from one another.

Emotional self-awareness is fundamental to psychological well-being, predicting more adaptive emotional regulation and resilience to stress (Smidt & Suvak, 2015). Poor emotional self-awareness is suggested to be a common area of difficulty in autism (Kinnaird, Stewart, & Tchanturia, 2019), predicting socioemotional functions such as emotion contagion and recognition (Bird & Cook, 2013). A key limitation of this research is that emotional self-awareness in autism is almost always measured with self-report questionnaires (although see Gaigg, Cornell, & Bird, 2018 for an exception) or tasks that may be confounded by verbal intelligence (Erbas, Ceulemans, Boonan, Noens, & Kuppens, 2013).

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The study was developed as part of Charlotte F. Huggins's PhD studies, forming part of a wider research program on how emotional self-awareness relates to autism and motor cognition. The consistency task was developed as part of attempts to develop a nonverbal, behavioral measure of emotional self-awareness, suitable for use in child and autistic populations. Inspiration for the consistency task was taken from psychophysics. We expanded this program by conducting cross-cultural research in Japan, implementing the consistency task among Japanese adults in Kyoto, allowing us to examine for cross-cultural differences in the consistency task as well as its correlates. We will also soon begin testing this method among adults with autism; through doing so, we will examine whether emotional self-awareness difficulties are diminished at verbal or nonverbal levels in this population.

The experiment reported in this article was not formally preregistered. Neither the data nor the materials have been made available on a permanent third-party archive; requests for the data or materials can be sent via e-mail to Charlotte F. Huggins at r02ch16@abdn.ac.uk.

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Most research on emotional self-awareness in autism has examined it from the perspective of alexithymia. Alexithymia is a construct from psychosomatic research, originally used to describe the cognitive characteristics and behaviors of clinical patients presenting with somatic symptoms of psychological distress (Sifneos, 1973). Within contemporary research, it is usually defined as a trait reflecting difficulties identifying and describing one's own emotions, usually assessed with self-report questionnaires (Moriguchi & Komaki, 2013; Kinnaird et al., 2019). The Toronto Alexithymia Scale (TAS-20; Bagby, Parker, & Taylor, 1994) is the most frequently used of these self-report tools and forms the basis of much of the evidence for diminished emotional self-awareness in autism as well as other conditions such as eating disorders (Nowakowski, McFarlane, & Cassin, 2013).

In recent years, the alexithymia hypothesis of autism (Bird et al., 2013) has stated that the emotional difficulties commonly observed in autism are the result of the greater level of alexithymia (i.e., more emotional self-awareness difficulties) in this population. In other words, difficulties with socioemotional communication and understanding, such as empathy, may be related to elevated alexithymia, rather than autism itself. In line with this, greater self-reported alexithymia is associated with poorer ability to recognize emotional facial expressions (Cook, Brewer, Shah, & Bird, 2013; Oakley, Brewer, Bird, & Catmur, 2016) and emotional vocalizations (Heaton et al., 2012) in both autistic and nonautistic groups. Moreover, differences between autistic and nonautistic groups disappear when controlling for level of alexithymia in these studies.

On a neural level, alexithymia is associated with hypoactivation in brain areas associated with empathy in both autistic and nonautistic participants (Bird et al., 2010). These findings suggest that alexithymia may predict socioemotional abilities in autism and thus may be an important target for study. A key limitation of this body of work, however, is that alexithymia is largely measured through self-report.

Validation work demonstrates that the test-retest reliability of self-reported emotional self-awareness is stable in both autistic and nonautistic populations (Berthoz & Hill, 2005). Moreover, physiological work has shown that self-reported emotional self-awareness correlates with degree of discrepancy between subjective ratings and physiological markers of emotional experience (Gaigg et al., 2018), suggesting that self-report is a valid way of assessing emotional self-awareness. However, there remain some limitations in measuring emotional self-awareness through self-report that warrant consideration.

Assessing one's own emotional self-awareness requires meta-awareness of emotional abilities (Marchesi, Ossola, Tonna, & De Panfilis, 2014). If this ability is impaired or biased, self-report may be inherently unreliable. Even in typical populations, correlations between self-reported and performance-based measures of emotional abilities tend to be weak (Lumley, Gustavson, Partridge, & Labouvie-Vief, 2005). Although this may be due to poor validity or reliability of objective measures, such weak associations may also suggest that most people are not accurate judges of their own emotional capacities. Therefore, poorer self-reported emotional self-awareness in autism may reflect differences in beliefs about the self, rather than differences in actual ability to understand one's own emotional states.

TAS-20 scores also fluctuate with mental health (Marchesi, Bertoni, Cantoni, & Maggini, 2008; Marchesi et al., 2014), leading to the argument that the TAS-20 measures psychological distress, rather than a stable personality trait (Leising, Grande, & Faber, 2009). Because autistic people show elevated levels of depression and anxiety (Simonoff et al., 2008), such an association may artificially inflate differences in TAS-20 scores between autistic and nonautistic participants.

To address these issues, emotional self-awareness needs to be measured objectively. However, emotional states are subjective and unobservable and thus difficult to measure. As a result, few robust measures of emotional self-awareness exist in the literature.

One possibility is to compare physiological responses to reported emotional responses, as was done by Gaigg et al. (2018). They found that the relationship between skin conductance response and arousal ratings of emotional images inversely correlated with self-reported alexithymia for individual participants. This suggests that comparing self-reported arousal to physiological markers of arousal may be a useful way to quantify alexithymia physiologically. However, given the technical demands of carrying out such measures, we aimed to examine emotional self-awareness at a purely behavioral level.

Behavioral measures of emotional self-awareness have emerged in emotion differentiation research. Emotion differentiation is the ability to distinguish between discrete emotional states (Barrett, Gross, Christensen, & Benvenuto, 2001), most commonly measured through experience sampling (Smidt et al., 2015). In experience sampling studies, participants rate their experience of different emotions over time. Ability to differentiate between emotional experiences is quantified through examining correlations between similar emotional states, with lower correlations reflecting greater emotional differentiation. Whereas this avoids self-report biases, this method is time consuming and complex to implement (Pejovic, Lathia, Mascolo, & Musolesi, 2016). Moreover, the participant burden results in high attrition (Christensen, Barrett, Bliss-Moreau, Lebo, & Kaschub, 2003) and is impractical for most child and clinical samples. Finally, these methods still rely on participants translating their emotional experiences into language, and differentiation scores tend to be strongly dependent on verbal intelligence quotient (IQ) (Israelashvili, Oosterwijk, Sauter, & Fischer, 2019). As such, it is difficult to determine whether greater emotion differentiation is simply the product of greater language skill, such as vocabulary or verbal IQ.

Addressing some of these issues, Erbas, Ceulemans, Lee Pe, Koval, and Kuppens (2014) introduced the photo emotion differentiation task (PED-task). This brief, laboratory-based analogue of experience sampling requires participants to rate how strongly they feel emotional terms in response to photographs. Correlations between similar emotional states are then examined in much the same way as experience sampling tasks, producing indices of emotional differentiation. It has been validated in child (Nook, Sasse, Lambert, McLaughlin, & Somerville, 2018) and autistic groups (Erbas et al., 2013), demonstrating its potential for application to diverse populations. Despite this, the task still relies on participants translating their emotional experiences into emotional language. It thus remains difficult to separate emotional self-awareness from vocabulary and the ability to link feeling states to words.

We aimed to design a task that measured emotional self-awareness through behavior while making minimal verbal demands. We achieved this by focusing on perceived intensity of emotion rather than type of emotion, examining how well participants could differentiate between intensity of emotional experiences evoked by different stimuli. In our task, participants viewed two emotional images on the screen at the same time. They selected whichever image they found more upsetting or pleasing, depending on the condition. Every image was paired with every other image in the condition once. We examined the logical consistency of these emotional decisions, on the basis that participants more able to discriminate between similar emotional experiences would make more consistent emotional decisions. Thus, we developed a way to measure emotional self-awareness through nonverbal behavior.

We compared emotional consistency task performance to self-reported emotional self-awareness, autistic traits, and psychopathology. We sought to test two hypotheses. The first was that autism traits are associated with reduced emotion self-awareness as measured by the behavioral task. The second was that autistic traits would not be associated with poorer EC-Task performance but would be associated with greater self-reported emotional self-awareness difficulties. We therefore also examined discrepancy between self-report measures and task performance. We studied this through examining the discrepancy between consistency scores and scores on the difficulty identifying feelings (DIF) subscale of the TAS-20. The DIF subscale was selected because this subscale most clearly reflected the ability the EC-Task was designed to tap into: the ability to identify one's own feelings.

Method

Ethics Statement

This study was approved by the University of Aberdeen School of Psychology Ethics Committee, and testing was carried out in accordance with the Declaration of Helsinki.

Participants

Participants were 103 adults (18 male, 85 female), recruited from the Aberdeen area, through participant pools, posters, mailing lists, and social media. Participants were offered course credit or £10 cash to thank them for their time.

Seven participants were excluded: five because of technical issues and two because of missing self-report data. The final sample consisted of 96 participants (18 male, 78 female), with a median age of 21 years.

Power Calculation

Because of the novelty of the emotional consistency task, it was difficult to estimate appropriate sample sizes. Based on previous work by Lumley et al. (2005), the TAS-20 correlates with behavior-based measures of emotional intelligence at $r = -.37$. Assuming the emotional consistency task, as a behavioral measure of emotional self-awareness, would show a similar relationship, 55 participants were calculated to be necessary to obtain .80 power at $p = .05$. To account for the novelty of the measure, we set a target of 100 participants.

Emotional Consistency Task

Assessing emotional self-awareness through behavior is problematic because emotional experiences are inherently idiosyncratic and cannot be directly observed. Although emotional image databases often include normative valence and arousal scores for each image (Marchewka, Żurawski, Jednoróg, & Garbowski, 2014), these represent average ratings of tested populations rather than objective values. Therefore, participant ratings that deviate from these norms represent individual differences rather than poor awareness of one's own emotional experiences. To account for the idiosyncratic nature of emotional experience, we compared emotional responses on a within-person basis. Choices made between emotional stimuli were only compared with other decisions by that individual, based on how that participant implicitly ranked the stimuli in each set.

In the EC-Task, participants are shown five sets of 11 images, previously rated as causing similar arousal but a variable degree of valence. Images are presented in pairs. Every image is paired with every other image in that set at least once, resulting in a total of 55 pairs per set. For each pair, participants select the image that evokes the stronger emotional response. In the positive conditions, this was whichever image evoked a stronger positive response and in the negative conditions, whichever evoked a stronger negative response. Participants do not explicitly rate stimuli at any point during the task.

Emotional self-awareness was indexed by the logical consistency of an individual's decisions. Consistency was calculated by examining the transitive relations between images, based on the participant's own choices between images. To illustrate, if a participant chooses image A over image B ($A > B$) and then image B over image C ($B > C$), these decisions are all consistent with one another. Yet if the participant then chose image C over image A, this would be inconsistent with their previous judgments. Consistency requires participants to differentiate precisely and reliably between the degree of emotion evoked by each image. Thus, inconsistent decisions are likely to stem from difficulty distinguishing between similar emotional experiences. Emotional consistency therefore reflects greater ability to discriminate between similar emotional experiences, and thus greater emotional self-awareness.

We stress that whereas the calculation of consistency utilizes similar principles to transitive reasoning, the EC-Task is not a transitive reasoning task. Transitive reasoning is a form of logical inference with a correct answer, whereas our choices are subjective and idiosyncratic. In transitive reasoning tasks, participants learn objective associations between different objects (i.e., Jack is taller than Jeff, Jeff is taller than Tony) and are then asked a question that requires them to make a logical inference from these data ('Is Tony taller than Jack?') (Thayer & Collyer, 1978). Our task does not ask participants to make logical judgments with right or wrong answers but instead make subjective judgments based on emotional responses. Therefore, the participant's goal was not to answer questions about transitive relationships correctly but merely indicate personal response to the images.

Moreover, completing the task using transitive reasoning would require participants to remember all individual choices in each pair, something beyond most people's memory capacities. We confirmed this through including a working memory task. We also included a nonemotional colorfulness control task to test that consistency scores related to emotional self-awareness rather than more general cognitive mechanisms associated with decision making.

We reasoned that participants should make more logically consistent decisions when stimuli are very different and less so when they are similar. Therefore, we first tested the validity of our measure by manipulating the emotional similarity of stimuli across four conditions in a 2 (difficulty: easy/hard) by 2 (valence: positive/negative) design.

Task Construction

The task was composed of one nonemotional control condition and four emotional experimental conditions. Each condition consisted of 11 individual images presented in all 55 possible unique pairs. Eleven images were selected as this rendered the length of the task adequate for acceptable response variability but brief enough to be practical. Images were taken from the Nencki Affective Picture System (Marchewka et al., 2014). There were 11 images in each of the five sets, and no image appeared in more than one set.

In the nonemotional control condition, participants chose between neutral images based on whichever they found more colorful. Further details of the control condition can be read in *Task Procedure*. The four experimental conditions varied by valence (positive vs. negative) and difficulty (easy vs. hard). Valence was manipulated by selecting images with highly positive or highly negative ratings based on Nencki normative scores. Images were selected to evoke emotion while minimizing risk of serious distress, avoiding potentially triggering content such as gore or common phobias (e.g., spiders). We also sought to minimize differences between stimuli in arousal level as far as was possible.

In the positive conditions, participants selected whichever image they found more pleasing for each pair. In the negative conditions, participants selected whichever image they found more upsetting for each pair.

Participants were instructed verbally as follows:

"Next you will see pairs of emotional images. For each pair, I want you to select whichever image you find more [pleasing/upsetting]. This isn't about what the image represents, or how you think other people, on average, respond to the images. It is about your own personal response—whichever image evokes a stronger emotional response in you."

Participants were also advised that new instructions would appear for every condition, but the same basic principle applies in every condition.

Task difficulty was manipulated by selecting images that covered either a broad range (easy condition) or a narrow range (hard condition) of average valence values while maintaining arousal levels at a reasonably constant level (see Table 1). However, to avoid floor or ceiling effects, differences in range and variability between hard and easy conditions had to be limited. Despite this, we still found a significant difference in the valence variance between conditions (Levene's test of homogeneity: positive-easy vs. positive-hard: $F(1, 20) = 18.171$, $p < .0001$; negative-easy vs. negative-hard:, $F(1, 20) = 11.557$, $p = .003$).

Task Procedure

Conditions were presented in sets. In each set, participants viewed pairs of images on a computer screen and chose between each pair based on the condition criteria. Short written instructions indicating how to use the paradigm preceded each set.

Colorfulness Control Condition

Participants always completed the colorfulness controls set first. We selected colorfulness as a control because it is a similarly subjective judgment but is unrelated to emotional experience. The control condition was intended to check whether association between consistency scores in the emotion conditions may be accounted for by general decision-making mechanisms or transitive reasoning rather than anything specifically related to emotion.

In this set, participants viewed 11 images of objects and landscapes. These images were selected to have neutral valence and low arousal properties, and none depicted humans or animals. Images varied in both overall brightness and variety of colors present to prevent there being clear, objective answers to which is more colorful. See Figure 1 for examples.

Participants were presented with instructions that read "You are about to see pairs of images. For each pair, please select the image you find more COLORFUL. Colorfulness was not defined in any further detail during the task, and it was stressed that this was a subjective judgment.

After participants completed the colorfulness condition, the experimenter gave them the opportunity to ask any questions.

Table 1
Means and Standard Deviations of Valence and Arousal Scores for Images Used in Each Experimental Condition

	Valence			Arousal		
Variables	*M*	*SD*	Range	*M*	*SD*	Range
Positive-hard	7.55	0.37	6.80–8.21	4.75	0.42	4.20–5.76
Positive-easy	6.52	1.06	5.04–7.92	4.39	0.62	3.17–5.43
Negative-hard	3.11	0.37	2.24–3.49	6.60	0.61	5.89–7.73
Negative-easy	3.88	1.11	2.15–5.58	5.99	0.84	4.65–7.61
Control	5.75	0.44	5.21–6.56	4.45	0.23	4.00–4.72

Figure 1. Example of images used in colorfulness task condition. See the online article for the color version of this figure.

After that, the experimenter explained that the rest of the task would ask participants to make decisions based on subjective emotional experiences rather than colorfulness. The colorfulness condition was always completed first because of concerns that switching between colorfulness and emotion-based rules for decision making without explanation from the experimenter may have been confusing.

Emotional Conditions

In the emotional sets, participants viewed 11 images, all of which depicted humans. Images were presented in pairs, and participants chose between them based on whichever evoked a stronger emotional reaction. Each condition was preceded by on-screen instructions stating: "You are about to see pairs of images. For each pair, please select the image you find more PLEASING/UPSETTING." Only the words pleasing and upsetting changed across task instructions for each set.

Participants completed the four experimental sets in a randomized order. For each pair of images, participants indicated their choice by pressing the right or left arrow keys, indicating the right or left image, respectively. A fixation cross was shown for 0.5 s between each image pair to maintain attention and make it easy to tell when the image pair changed. Order of pairs was randomized, and each image appeared on the left and right side of the screen equally. Participant choice and reaction time were recorded for each pair. There were no time limits for making choices, and participants were given the opportunity to take brief breaks between sets. See Figure 2 for illustration of paradigm procedure.

Calculating Consistency

Consistency scores were calculated for each individual set. We quantified consistency of decision making by comparing a participant's overall pattern of responses with their individual choices as follows:

First, we quantified how participants ranked images in each set, and the number of times the participant chose each image was summed, producing rank scores. If a participant made completely consistent decisions in a set, rank scores would follow a linear sequence. In a set of perfectly consistent decisions, the image that the participant found most emotionally intense should be chosen in all 10 image pairs (score = 10) followed by the second-highest being chosen in nine of 10 pairs (score = 9), and so on until reaching the least emotional image, which is never chosen in any pairs (score = 0).

Second, we examined how this overall ranking of images related to individual decisions between image pairs. Images with a higher rank score should elicit a stronger emotional response than those with lower rank scores. An inconsistent decision is thus when a lower-ranking image is chosen over a higher-ranking image.

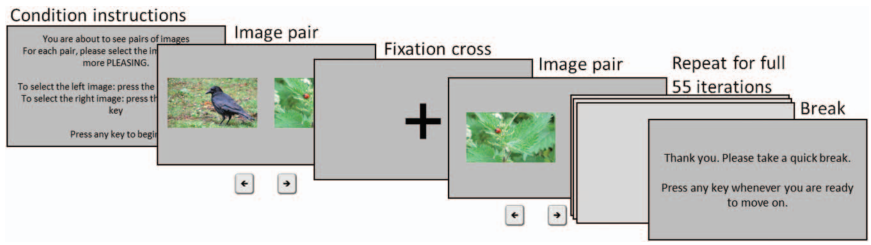

Figure 2. Procedure in single condition of the consistency task. See the online article for the color version of this figure.

For each decision, the rank score of the unchosen item was subtracted from the rank score of the chosen item, producing item differences. In consistent decisions, wherein a higher-ranking image is chosen over a lower-ranking image, the item difference would be above zero. In inconsistent decisions, wherein a lower-ranking image is chosen over a higher-ranking image, the item difference would be less than or equal to zero. More severe inconsistencies, such as choosing the lowest ranked item over the highest ranked item, result in even lower item differences.

Item differences were then summed to produce the total consistency score for that condition, with greater scores reflecting higher consistency and thus greater emotional self-awareness.

Consistency scores were calculated separately for each set. If a participant made no inconsistent decisions, their score would be 220 for one set and 880 for all four experimental sets.

Other Outcomes

The TAS-20 (Bagby et al., 1994) was used to assess self-reported alexithymia. The TAS-20 has three subscales: DIF, difficulty describing feelings (DDF), and externally oriented thinking (EOT). These subscales assess the ability to identify one's own emotional states, the ability to describe one's own emotions, and the tendency to focus on external stimuli over internal experiences respectively.

Autistic traits were assessed with the Broad Autism Phenotype Questionnaire (BAPQ; Hurley, Losh, Parlier, Reznick, & Piven, 2007), a questionnaire designed to assess autistic traits in the general population. The BAPQ reports three subscales: aloofness, pragmatic language and rigidity. These subscales reflect social disinterest, difficulties with social communication, and rigidity in habits and routine.

Depression and anxiety symptoms were assessed using the Hospital Anxiety and Depression Scale (HADS; Zigmond & Snaith, 1983). Empathy was assessed with the Actions and Feelings Questionnaire (Williams, Cameron, Ross, Braadbaart, & Waiter, 2016) and the Interpersonal Reactivity Index (Davis, 1980).

Participants also completed a version of the PED-task (Erbas et al., 2014), the results of which are included in another publication (Huggins, Cameron, & Williams, 2019) and thus will not be elaborated on in detail here. The only outcome of interest for the PED-task was emotion differentiation scores, reflecting how well participants differentiated between similar emotional states.

Working memory was assessed with a digit span task. In this task, the experimenter read out a string of single digits in a slow, clear voice and the participant verbally recalled the string as accurately as possible. Strings began with digits, with a digit added every other trial until reaching a total of either nine digits (digit-forward condition) or eight digits (digit-backward condition). The total number of correctly recalled strings represented working memory score.

Results

To account for potential gender effects, one-way ANOVAs were first conducted to test for gender differences in TAS-20 scores and BAPQ scores. No significant gender differences emerged for either TAS-20 scores, $F(1, 94) = .271$, $p = .604$, or BAPQ scores, $F(1, 94) = .1.852$, $p = .177$.

Validation of the Emotional Consistency Task

The consistency task yielded four scores of emotional consistency (positive-easy, positive-hard, negative-easy, and negative-hard) as well as a nonemotional control score. All consistency scores were negatively skewed. Some participants showed perfect consistency in each condition (see Table 2). Total consistency was calculated by summing the four emotional consistency scores.

All consistency scores were log transformed to fit assumptions of normality. Following transformation, higher scores reflected poorer consistency. For sake of clarity, these transformed scores are referred to as inconsistency scores in the rest of the paper.

Linear regression showed that working memory did not predict total inconsistency scores, $F(1, 94) = .099$, $p = .754$, $R^2 = .01$. Working memory was therefore not further investigated as a potential mediator of consistency task performance. One-way

Table 2
Averages and Variances of Consistency Scores and Number of Perfect Scorers in Each Condition

Variables	Median	IQR (range)	Number of perfect scorers
Positive-easy	208	19 (138–220)	14
Negative-easy	212	20 (132–220)	21
Positive-hard	202	28 (108–220)	10
Negative-hard	204	27 (120–220)	15
Control†	195.67	17.64	7
Total emotional consistency	815	60.5 (562–872)	0

† Uses mean and standard deviation rather than median and interquartile range.

ANOVAs found no significant gender differences on outcomes from any of the five EC-Task conditions (positive-easy: F [1, 94] = .185, p = .668; negative-easy: F[1, 94] = 1.318, p = .254; positive-hard: F[1, 94] = 1.223, p = .272; negative-hard: F[1, 94] = .656, p = .420).

A 2 × 2 repeated ANOVA was used to compare consistency scores in the four experimental conditions, including performance in the control task as a covariate. No difference in consistency emerged in the positive compared with negative conditions, $F(1, 94) = .444$, $p = .507$, $d = .142$. However, as expected, participants were significantly less consistent in the hard compared with easy conditions, $F(1, 94) = 4.957$, $p = .028$, $d = .489$. No interaction emerged between difficulty and performance in the control task, $F(1, 94) = 1.413$, $p = .223$. There was also no significant interaction between difficulty and valence, $F(1, 94) = .010$, $p = .922$.

Correlations between separate inconsistency scores can be seen in Table 3. Bonferroni multiple comparison corrections were conducted based on $N = 10$, setting the alpha level to .005. By these standards, control inconsistency scores were not significantly correlated to any emotional scores.

Linear regression showed that consistency in the colorfulness control condition did not predict total emotional inconsistency scores, $F(1, 94) = 3.692$, $p = .058$, $R^2 = .038$.

Consistency and Individual Differences

All self-report outcomes were normally distributed. Relationships between self-report outcomes were assessed with Pearson's correlations. TAS-20 scores moderately correlated with BAPQ scores, $r(94) = .406$, 95% confidence interval [CI; .187, .591], $p < .001$ and HADS scores, $r(94) = .423$, 95% CI [.232, .594], $p < .001$. BAPQ and HADS scores likewise moderately correlated with one another, $r(94) = .496$, 95% CI [.319, .634], $p < .001$. TAS-20 scores also correlated with working memory, $r(94) = -.218$, 95% CI [−.401, −.019], $p = .033$.

Partial correlations controlling for both working memory and colorfulness task performance found that TAS-20 correlated with total inconsistency scores, $r(90) = .232$, 95% CI [.051, .428], $p = .024$, indicating that greater inconsistency in emotional decision making was associated with greater alexithymia. See Table 4 for correlations between all inconsistency scores with TAS-20 scores and subscales. Applying Bonferroni multiple comparison corrections based on $N = 20$, alpha level for significance was set to 0.0025.

A stepwise linear regression was conducted to examine how total TAS-20 scores and subscales predicted total inconsistency scores. The DIF subscale alone predicted total inconsistency, $F(1, 94) = 13.864$ $p < .001$, accounting for 12.9% of variance (see Figure 3). The total TAS-20 score (β = −.173, p = .328), DDF (β = −.156, p = .235) and EOT subscales (β = −.055, p = .571) did not reach significance and were excluded from the model.

Partial correlations controlling for colorfulness condition scores showed that total inconsistency scores were correlated with HADS scores, $r(91) = .244$, 95% CI [.042, .421], $p = .017$, but not BAPQ scores, $r(91) = .141$, 95% CI [−.066, .382], $p = .173$. This indicates that greater inconsistency was associated with greater psychological distress, but not autistic traits.

Discrepancy Between Consistency and Self-Reported Emotional Self-Awareness

We calculated discrepancy through comparing consistency scores to TAS-20 DIF subscale scores. We selected the DIF subscale as this subscale is designed to assess the same outcome as the EC-Task: the ability to identify one's own emotions rather than describe them in language. Because DDF and EOT subscales reflect ability to communicate emotions and general tendency to focus on external stimuli over internal subjective experience, these subscales are less relevant to the EC-Task. This assumption supported by earlier findings, indicating the DIF is the strongest predictor of total consistency scores.

To align with raw consistency scores, DIF scores were first reversed ('DIF), such that higher scores reflected greater ability to identify one's own emotional experiences. Because consistency scores and DIF scores are highly different in scaling, both were converted to Z scores ('DIFZ and CZ). 'DIFZ scores were subtracted from CZ scores to produce discrepancy scores (Discrepancy = CZ − 'DIFZ).

Discrepancy scores below 0 indicates that 'DIFZ was higher than CZ, suggesting that a participant's self-report overestimates their actual ability to judge their own emotional experiences. Scores above zero indicate that CZ was higher than 'DIFZ, in which case performance was higher than self-reported ability, indicating underestimation of emotional self-awareness abilities. Notably, discrepancy scores were bipolar, with 0 representing no discrepancy. High scores reflect high underestimation, and low scores reflect high overestimation. As such, a significant correlation between discrepancy and any other variable does not suggest a linear relationship wherein discrepancy increases or decreases with the correlated outcome.

Discrepancy was significantly correlated with BAPQ scores, $r(94) = .351$, 95% CI [.171, .522], $p < .001$, and HADS scores, $r(94) = .291$, 95% CI [.100, .462] $p = .004$. This suggests that low

Table 3
Correlations Between Inconsistency Scores

Variables	Positive-easy	Positive-hard	Negative-easy	Negative-hard
Control	$r = .260, p = .011$	$r = .149, p = .149$	$r = .121, p = .240$	$r = .003, p = .977$
Positive-easy	—	$\mathbf{r = .300, p = .003}$	$\mathbf{r = .295, p = .004}$	$r = .158, p = .124$
Positive-hard		—	$\mathbf{r = .289, p = .004}$	$\mathbf{r = .296, p = .003}$
Negative-easy			—	$r = .136, p = .185$
Negative-hard				—

Note. Bolded indicates correlation significant at α = .005, following Bonferroni correction for multiple correlations.

Table 4
Partial Correlations Between Inconsistency Scores and TAS-20 Scores, Controlling for Working Memory and Control Task Performance

	Total		Subscales	
TAS-20 scales	Total	DIF	DDF	EOT
Total inconsistency	$r = .232, p = .024$	$\mathbf{r = .365, p < .001}$	$r = .136, p = .191$	$r = -.051, p = .626$
Positive-easy	$r = .233, p = .302$	$r = .233, p = .302$	$r = .147, p = .158$	$r = -.194, p = .626$
Positive-hard	$r = .179, p = .084$	$r = .223, p = .030$	$r = .090, p = .390$	$r = .105, p = .312$
Negative-easy	$r = .252, p = .014$	$\mathbf{r = .328, p = .001}$	$r = .097, p = .353$	$r = -.194, p = .061$
Negative-hard	$r = .057, p = .583$	$r = .187, p = .072$	$r = .037, p = .724$	$r = -.147, p = .156$

Note. TAS-20 = Toronto Alexithymia Scale; DIF = difficulty identifying feelings; DDF = difficulty describing feelings; EOT = externally oriented thinking. Bolded indicates correlation significant at $\alpha = .0025$, following Bonferroni correction for multiple correlations.

BAPQ scores were associated with overestimation of abilities, whereas high BAPQ scores were associated with underestimation. A stepwise linear regression was conducted to assess how HADS subscales predicted discrepancy scores. Depression scores alone predicted discrepancy scores, $F(1, 94) = 8.111$, $p = .007$, accounting for 7.5% of the total variance.

In stepwise linear regressions including both HADS subscales and BAPQ total scores, only BAPQ was a significant predictor of discrepancy scores, $F(1, 94) = 13.389$, $p < .001$, accounting for 12.5% of the variance. Accounting for total BAPQ score, both anxiety ($\beta = .124$, $p = .242$) and depression ($\beta = .133$, $p = .231$) scores were nonsignificant and subsequently excluded from the model.

Comparing BAPQ subscales, only pragmatic language scores predicted discrepancy scores, $F(1, 94) = 20.982$, $p < .001$, accounting for 18.2% of variance (see Figure 4). Neither aloof ($\beta = .049$, $p = .484$) or rigidity ($\beta = .105$, $p = .271$) reached significance and were subsequently excluded from the model.

One participant had a discrepancy score more than 3 *SD* below the mean. To account for this, main findings were reanalyzed with this participant excluded. This has little effect on the results. Discrepancy remained significantly correlated with BAPQ scores (with outlier: $r[94] = .351$, 95% CI [.171, .522], $p < .001$; without outlier: $r[93] = .360$, 95% CI [.170, .523], $p < .001$) as well as with total HADS scores (with outlier, $r[94] = .291$, 95% CI [.100, .462] $p = .004$; without outlier: $r[93] = .337$, 95% CI [.145, .504] $p = .001$). The association between pragmatic language scores and discrepancy scores was only slightly affected (with outlier: $F[1, 94] = 20.982$, $p < .001$, accounting for 18.2% of variance; without outlier $F[1, 93] = 18.003$, $p < .001$, accounting for 16.2% of variance).

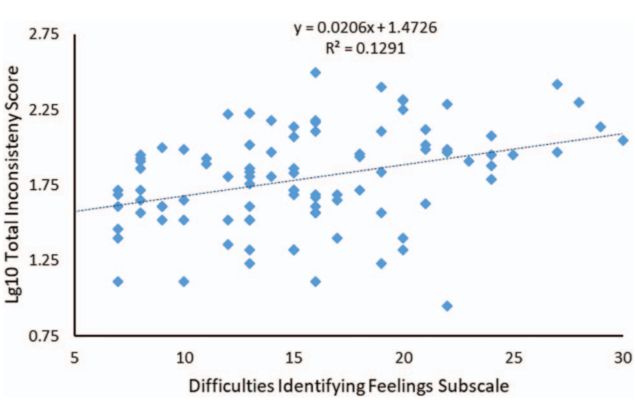

Figure 3. Scatterplot showing DIF scores against total inconsistency scores. DIF = difficulty identifying feelings. See the online article for the color version of this figure.

Estimation of Emotional Self-Awareness

Because discrepancy scores are a bipolar, rather than unipolar, scale, this may raise some issues with the use of correlations

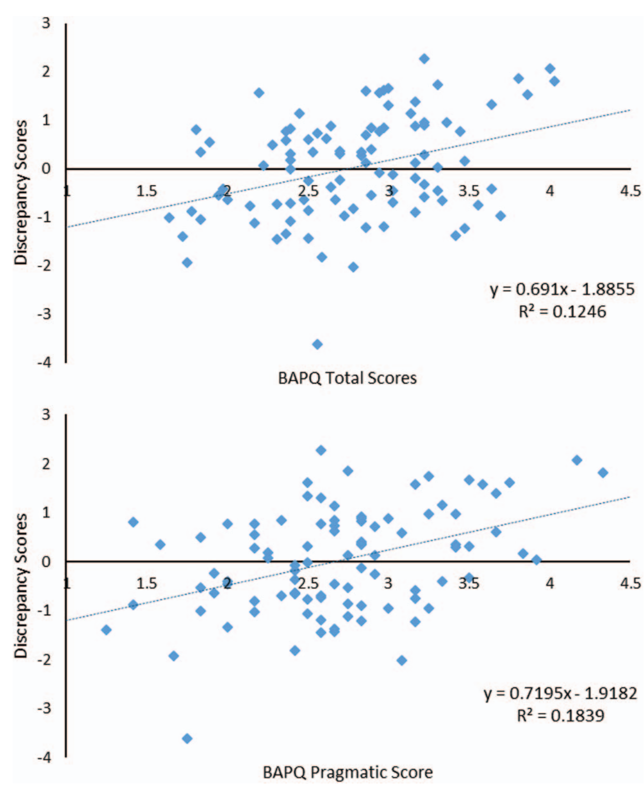

Figure 4. Scatterplots showing discrepancy scores against BAPQ total scores and BAPQ pragmatic language difficulties subscale scores. BAPQ = Broad Autism Phenotype Questionnaire. See the online article for the color version of this figure.

(Batyrshin et al., 2017). Moreover, correlations do not indicate how under- and overestimation of abilities relate to autistic traits and mental health outcomes. To clarify this issue and verify the above correlation findings, we decided to compare outcomes by high and low discrepancy scores.

Because of the novelty of the EC-Task, robust standards for categorizing scores have yet to be established. Because of this, while quartile splits can be problematic, they were judged as the best way to group participants in the current study. Quartile splits were chosen over a median split because the latter would not account for participants whose estimation of their own abilities were relatively accurate.

Participants with discrepancy scores below the 25th percentile (−.761) were classed as overestimators (n = 24). Participants with scores above the 75th percentile (.814) were classed as underestimators (n = 24). The remaining participants (n = 48) were classed as having relatively accurate estimates of their emotional self-awareness.

A one-way ANOVA was conducted to assess differences between estimator groups in BAPQ scores. Significant differences emerged in total BAPQ scores, $F(2, 93) = 8.819$, $p < .001$, as well as all three subscales. Bonferroni post hoc analyses showed that underestimators (M = 3.14, SD = .480) had significantly greater BAPQ scores than both overestimators (M = 2.57, SD = .60), $p < .001$, and accurate estimators (M = 2.70, SD = .47), p = .002. These findings indicate that autistic traits were significantly higher in those who underestimated their emotional self-awareness.

BAPQ subscale aloofness scores were significantly higher in underestimators (M = 2.96, SD = .66) compared with overestimators (M = 2.40, SD = .69), p = .021 but not for accurate estimators, p = .298. BAPQ subscale pragmatic scores were significantly higher in underestimators (M = 3.17, SD = .61) compared with overestimators (M = 2.46, SD = .56), $p < .001$, and accurate estimators (M = 2.61, SD = .58), p = .001. BAPQ subscale rigidity scores were significantly higher in underestimators (M = 3.30, SD = .77) compared with accurate estimators (M = 2.82, SD = .68), p = .041, but not overestimators (M = 2.84, SD = .89), p = .118 (see Figure 5).

PED-Task outcomes have been partially reported in another publication (Huggins et al., 2019), so we do not want to report them here. The only outcome of interest is that neither negative, $r(87) = -.085$, p = .428, nor positive, $r(82) = -.003$, p = .978, differentiation significantly correlated with total inconsistency scores.

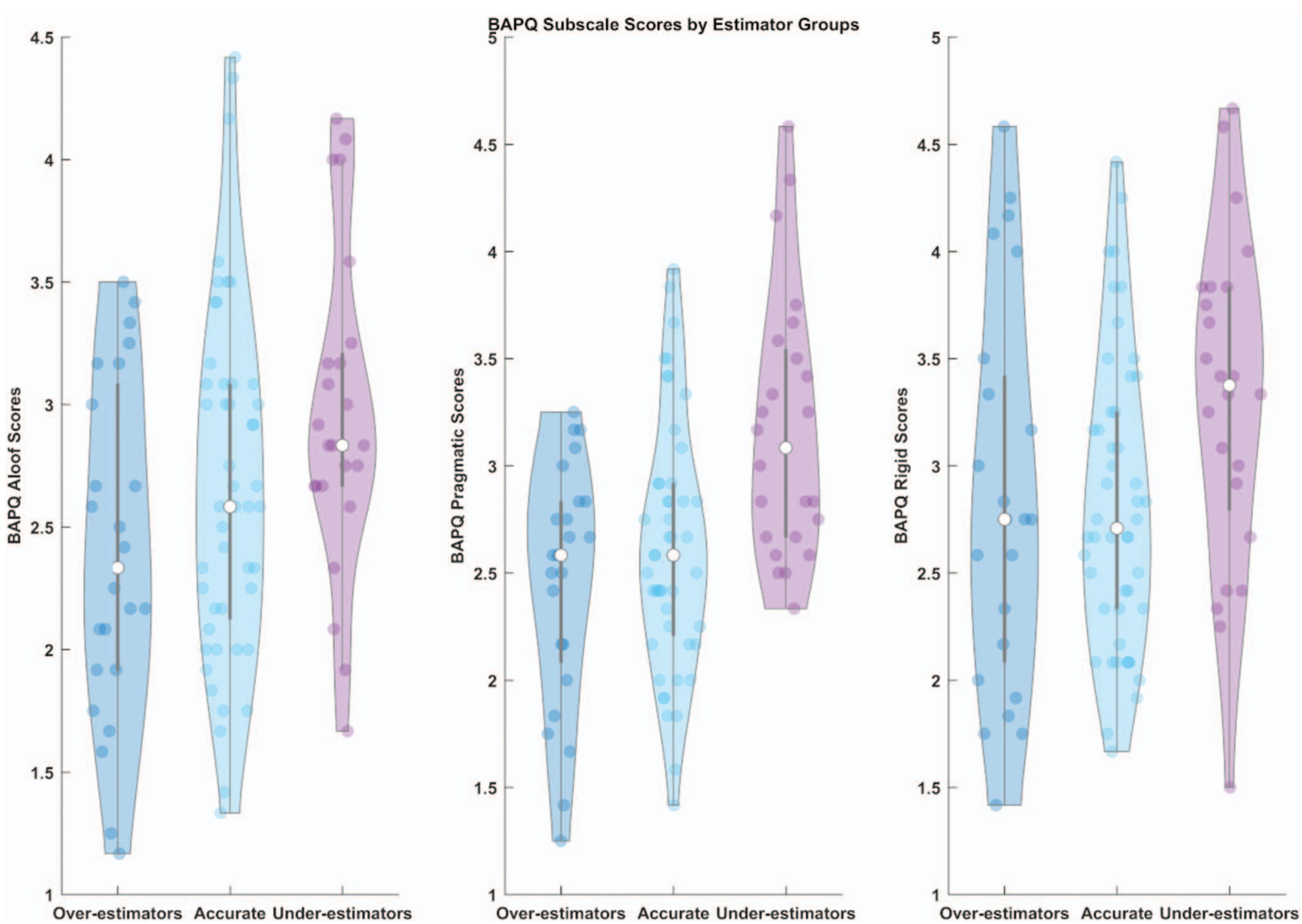

Figure 5. Violin plots of BAPQ subscale scores by estimator groups. BAPQ = Broad Autism Phenotype Questionnaire. See the online article for the color version of this figure.

Discussion

Our study compared self-reported with behavioral emotional self-awareness, as quantified by the EC-Task. The EC-Task is a novel behavioral task that quantifies emotional self-awareness through nonverbal decision making. The method allows brief assessment of emotional self-awareness, is easy to apply in the laboratory, and has minimal verbal demands. Consistency correlated with depression and alexithymia but not autistic traits. Instead, high autistic traits predicted discrepancy between self-reported and behavioral emotional self-awareness with respect to emotional intensity. Those with high autistic traits underestimated their own ability to judge the intensity of their emotional experiences. Likewise, those with low autistic traits overestimated their own abilities in this respect.

We first validated the EC-Task as a measure of emotional self-awareness by demonstrating that as a group, participants made more inconsistent decisions when choosing between stimuli with more similar emotional valence values, compared with when stimuli were more dissimilar. Moreover, emotional consistency was not accounted for by general consistency in decision making or working memory capacity, indicating that consistency is specific to emotional self-awareness rather than other cognitive abilities.

Furthermore, consistency was significantly associated with the DIF subscale of the TAS-20, accounting for 12.9% of variance in total inconsistency scores. This is comparable with the amount of variance in interoceptive sensitivity accounted for by DIF (Herbert, Herbert, & Pollatos, 2011). As discussed farther below, interoceptive abilities are often taken to reflect emotional self-awareness, to the extent that self-report alexithymia scores are used as a proxy of interoception (Murphy, Brewer, Catmur, & Bird, 2017). Consistency accounts for a similar amount of variance in the TAS-20 as interoceptive sensitivity, further validating consistency as a measure of emotional self-awareness.

Autistic people are often assumed to have diminished emotional self-awareness. Yet this assumption is largely based on self-report evidence (Kinnaird et al., 2019). Our findings suggest these emotional self-awareness difficulties may be due to methodological bias. Potentially, emotional self-awareness is intact, but metacognitive awareness of abilities is diminished. This supports other findings reporting intact emotional contagion (Fan, Chen, Chen, Decety, & Cheng, 2014; Gu et al., 2015) and emotion perception (McMahon, Henderson, Newell, Jaime, & Mundy, 2016) in autism, suggesting that difficulties begin to arise when cognitive and metacognitive demand increases (Rogers, Dziobek, Hassenstab, Wolf, & Convit, 2007).

Language is thought to be critical for the experience and expression of emotion (Barrett, 2006; Hoemann, Xu, & Barrett, 2019). In support of this position, self-report alexithymia is associated with lower verbal IQ (Montebarocci, Surcinelli, Rossi, & Baldaro, 2011; Wotschack & Klann-Delius, 2013). Moreover, linguistic difficulties are common among autistic people (Groen, Zwiers, van der Gaag, & Buitelaar, 2008), and this may be particularly pertinent for emotional language. Qualitative studies have found that autistic children produce fewer emotional terms when describing emotional scenes (Teh, Yap, & Rickard Liow, 2018) and describe their own emotional experiences in less structured and coherent ways compared with age- and IQ-matched typical children (Losh & Capps, 2006). Review work suggest that both the production and comprehension of emotional language is impaired in autism, independently of general IQ (Lartseva, Dijkstra, & Buitelaar, 2015).

We found that the discrepancy between self-reported and performance-based emotional self-awareness was driven by scores on the self-reported pragmatic language difficulties scale of the BAPQ. This may at first seem puzzling because the task is largely nonverbal, requiring only that participants comprehend that pleasing refers to positive valence and upsetting to negative valence. However, the pragmatic language subscale of the BAPQ does not correlate with consistency directly. Instead, greater self-reported language difficulties reflect underestimation of emotional competence. As such, this may reflect difficulties with responding to self-report measures accurately.

Moreover, the pragmatic language subscale is not a measure of language ability. Rather it is a self-report measure of conversational and social difficulties, including abilities to detect and respond appropriately to social cues. It is therefore much less surprising that participants not confident in their capacity to identify their feelings should also have low confidence in their social abilities.

Our findings also parallel some findings from the interoception literature. Interoception, the sense of the current state of the body, has long been considered fundamental to the conscious awareness of emotional experience (James, 1884; Damasio, 1994; Barrett, 2017). Greater sensitivity to different interoceptive cues, such as heartbeat or muscle strain, predict greater emotional self-awareness (Murphy, Catmur, & Bird, 2018). It is therefore widely held that interoception predicts emotional abilities.

Interoception is not a simple unitary construct. Garfinkel & Critchley (2013; Garfinkel, Seth, Barrett, Suzuki, & Critchley 2015; Garfinkel et al., 2016) argue that self-report and performance-based measures of interoception are dissociable, representing two separate dimensions on interoception: sensibility, beliefs about interoceptive abilities, and sensitivity, actual sensitivity to interoceptive cues. In addition, there is a third dimension: interoceptive awareness, the accuracy of beliefs about own abilities. This latter dimension is thought to reflect metacognitive ability and is significantly poorer in autism (Garfinkel et al., 2016), a finding that parallels our own findings regarding discrepancy scores and autistic traits.

Whereas this similarity is encouraging, Garfinkel et al. (2016) found that autistic participants tended to overestimate their abilities, whereas we found that autistic traits predicted underestimation of abilities. Yet Garfinkel et al.'s study focused on interoception rather than emotional self-awareness. The interoceptive sensibility measure used by Garfinkel et al. has also been criticized for potentially relating more to anxiety-related hypervigilance toward negative bodily cues rather than interoceptive awareness itself (Mehling, 2016). As such, autistic overestimation may relate to greater focus on negative bodily sensations in this population rather than overestimation of emotional abilities.

Additionally, if our association between discrepancy and autistic traits was exclusively due to general metacognitive impairment, high autistic traits should predict both overestimation and underestimation. Instead, our findings suggest that low autistic traits predicted overestimation of abilities just as much as high autistic traits predicted underestimation. As such, discrepancy effects may be associated with general self-esteem rather than metacognitive difficulties. In support of this, we found a strong association between autistic traits (BAPQ) and depression (HADS) scores. The negative self-bias that accompanies these higher depressive symptoms may lead to overreporting of emotional difficulties and underestimation of one's own abilities. Despite this, we also found that the association between HADS and emotional awareness discrepancy was insignificant when accounting for BAPQ scores.

The most parsimonious interpretation of our findings would therefore be that both metacognitive ability and negative self-bias drive underestimation effects, with the former increasing error and the latter driving it in a downward direction. This in turn suggests that low BAPQ scores reflect positive self-bias, potentially driven by a general tendency toward socially desirable responding on self-report measures.

Limitations

Because our study examined only a typical population, the generalizability of our findings to clinical groups is limited. Regardless, there is a strong association between depression and autism (Simonoff et al., 2008), suggesting that autistic participants as a group may well be negatively self-biased. In addition, the TAS-20 has been associated with general psychological distress (Leising et al., 2009), raising the possibility that negative self-bias inflates TAS scores. A clear implication of our findings to be tested is that people with autism have intact emotional self-awareness but lack confidence in their own abilities. Furthermore, future work may benefit from explicitly measuring metacognitive abilities.

Another limitation is that the EC-Task is designed to investigate only the inner experience of emotional intensity. It does not measure the capacity to distinguish between different types of emotional experience or the capacity to communicate and express the nature of the experience of emotional states. The lack of association with differentiation scores from the PED-Task demonstrates that performance on the consistency task may be distinct from ability to differentiate between different emotion terms. Finally, we chose to hold the arousal-qualities of the stimuli constant while varying the valence qualities. Potentially, a different pattern of results may emerge if one were to vary arousal while maintaining valence constant, and future replications may benefit from taking this alternative approach. However, because image valence ratings were more variable than arousal ratings, it would have been difficult to obtain a suitable range of images using this approach without using potentially distressing high-valence images. Finally, it is possible that inconsistency in the EC-Task represents genuine variability in subjective experience, of which the participant is actually aware. Utilizing a physiological paradigm (such as that used by Gaigg et al., 2018) alongside the EC-Task may clarify this issue.

Future work may also benefit from examining how consistency compares with interoceptive sensitivity. Whereas interoceptive abilities are assumed to predict emotional self-awareness, TAS-20 scores may be more strongly associated with self-reported interoceptive abilities (Palser et al., 2018; Zamariola, Vlemincx, Corneille, & Luminet, 2018) than actual performance in interoceptive tasks. It should be noted that these studies did not control for confounding factors such as body mass index and resting heart rate, and not accounting for such factors is suggested to obscure correlations between interoception and alexithymia (Murphy et al., 2018). Regardless, the inclusion of the EC-Task as an objective measure of emotional self-awareness will allow researchers to further examine whether interoception is associated with awareness of one's own emotions on a behavioral level.

Conclusion

In summary, our study validated a novel method measuring emotional self-awareness through nonverbal decision making. Because most comparable measurement tools are self-report, language based, or have high participant burden, this represents a potentially valuable contribution to the emotion research toolbox. Furthermore, we found that autistic traits themselves are not associated with poorer emotional self-awareness but with a tendency to underestimate awareness of own emotions. This may be driven by poor metacognitive awareness and negative self-bias. This raises question of whether emotional self-awareness is diminished in autism or whether difficulties are exaggerated by metacognitive difficulties and negative self-belief. The EC-Task offers a novel method for testing this idea in future clinical research.

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