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Article *in* Journal of Autism and Developmental Disorders · May 2020

DOI: 10.1007/s10803-020-04535-y

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In Press: Journal of Autism and Developmental Disorders

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Abstract

A new task ('CARER') was used to test claims of reduced empathy in autistic adults. CARER measures emotion identification (ability to identify another's affective state), affective empathy (degree to which another's affective state causes a matching state in the Empathiser) and affect sharing (degree to which the Empathiser's state matches the state they attribute to another). After controlling for alexithymia, autistic individuals showed intact affect sharing, emotion identification and affective empathy. Results suggested reduced retrospective socio-emotional processing, likely due to a failure to infer neurotypical mental states. Thus, autism may be associated with difficulties inferring another's affective state retrospectively, but not with sharing that state. Therefore, when appropriate measures are used, autistic individuals do not show a lack of empathy.

Keywords: autism; empathy; alexithymia; affect sharing; CARER; continuous affective rating;

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"People with autism don't feel empathy", says a client to a young female hairdresser. The client tries to disguise her embarrassment when the hairdresser reveals she is actually autistic and emphatically disagrees with the client's remark. This real-life conversation, recently witnessed by one of the authors, reflects the negative, stereotypical view of autism that is not uncommon across sections of the general population. Its likely origin is in research claiming that an empathy impairment is a key feature of autism (e.g. Baron-Cohen and Wheelwright, 2004; Decety & Moriguchi, 2007). Here, it is argued that traditional approaches to the study of empathy could, in part, be responsible for the negative association between Autism Spectrum Disorder (ASD) and empathic ability. This study takes an alternative approach in order to examine the reported association between autism and empathy impairment.

Current Theories of Empathy in Autism

The empathy imbalance hypothesis (Smith, 2009). Smith argues that although autistic individuals are known to have impairments, such as in theory of mind, that will impact emotion identification (determining another's emotional state), they also experience a surfeit of affective empathy that may be due to increased affect sharing (the process in which attributing an emotional state to another causes you to share that state). Smith says that as a consequence, those with ASD are susceptible to empathic overarousal, which in turns lead to personal distress. When overwhelmed by the affective state of another, autistic individuals become unable to produce appropriate empathic behaviours (i.e. behaviours which successfully ameliorate the negative state of the empathic target, henceforth, 'Target'), which Smith argues has given rise to the (incorrect) view that individuals with autism lack empathy. However, this interesting theory has thus far received mixed empirical support; while some findings support intact affective empathy in ASD, accompanied by impairment in emotion identification (e.g. Dziobek et al., 2008; Rueda, Fernández-Barrocal & Baron-Cohen, 2014), others do not support Smith's claims (e.g. Shamay-Tsoory, Tomer, Yaniv & Aharon-Peretz, 2002; Lawrence et al., 2004; Baron-Cohen et al., 2003; Adler, Dvash & Shamay-Tsoory, 2015). Overall, Smith's theory could benefit from direct empirical testing. The current study, which employs a new empathy task – see description below – could provide an important test of this theory.

The role of alexithymia in autism and empathy (Bird et al., 2010; Bird & Cook, 2013). The second account relevant to empathic ability in ASD relates to the high comorbidity of alexithymia and autism. The term Alexithymia, literally meaning 'without words for emotions', is used to describe a cluster of cognitive traits including an inability to identify and describe one's own feelings, and externally-oriented thinking (Sifneos, 1973). The estimated prevalence of alexithymia among the general population is 10% (Salminen et al., 1999). However, previous studies of alexithymia in the autistic population suggest an increased prevalence, with approximately 50% of ASD adults reporting severe alexithymia (Hill, Berthoz, Frith, 2004; Bird & Cook, 2013). Furthermore, recent experiments investigating the extent to which alexithymia can predict some of the socio-emotional impairments commonly associated with ASD have shown that: i) reduced eye-fixation (Bird, Press & Richardson, 2011), ii) poor recognition of emotional facial and vocal expressions (Cook, Brewer, Shah & Bird, 2013, Heaton et al., 2012; Trevisan et al., 2016; Bothe, Palermo, Rhodes, Burton, & Jeffery, 2019), and, iii) reduced empathic activation of the insula (Bird et al, 2010; Silani et al., 2008) is explained by alexithymia, and that no autism impairment in these processes is observed after controlling for alexithymia. Thus, the 'alexithymia hypothesis' (Bird & Cook, 2013) suggests that the 'emotional symptoms of autism' (including the claim of reduced empathy in autism) are a product of co-occurring alexithymia. The hypothesis suggests that sampling variance with respect to alexithymia in studies of autistic individuals can explain both the inconsistencies in the results of experimental investigations of emotional processes in autism, and the heterogeneity across individuals with autism with respect to emotional ability. Thus, the alexithymia hypothesis would suggest that apparent empathy impairments in autism should be reduced, or even negated entirely, when alexithymia is controlled for.

Bird & Viding's (2014) Self to Other Model of Empathy (SOME) expands on this hypothesis with respect to the impact of alexithymia and autism on empathy. They argue that autism is associated with theory of mind impairments (e.g. Baron-Cohen, 2000; Frith, 1994, 2012) but not with difficulties recognising facial or vocal expressions of emotion. Thus, one would expect differential contributions of autism and alexithymia to impairments in emotion identification depending on the degree to which theory of mind (autism) or facial/vocal emotion recognition (alexithymia) is required to determine the Target's state. Once identified, it is argued that the degree to which the Target's state affects the Empathiser's state (affect sharing) will solely be affected by alexithymia, not autism (Bird & Viding, 2014; Bird & Cook, 2013; Bird et al., 2010). Accordingly, levels of alexithymia were recorded in the current experiment in order to see whether any empathy-related impairments in autism can be accounted for by alexithymia.

Current Empathy Measures

Although our ability to empathise with others is thought to lie at the heart of successful social interaction, researchers are yet to agree upon what empathy is (e.g. Batson, 2009), or how to measure it. The existing definitions of empathy range from arguably simpler processes such as recognition of emotional facial expressions and emotional contagion, to more complex forms requiring the Empathiser to recognise that their affective state is caused by the emotional state of the empathic target (de Vignemont & Singer, 2006). The lack of an agreed-upon definition is accompanied by a lack of consistent experimental methodology. The most frequently used measures of empathy rely on participants' self-report, with two of the most common being the Interpersonal Reactivity Index (IRI, Davis, 1980) and the Empathy Quotient (EQ, Baron-Cohen & Wheelwright, 2004). However, relying on self-report is particularly problematic to assess the claim of empathy deficits in autism: individuals with autism are continuously told they lack empathy, and so to report typical empathy implies that they think the collection of medical professionals and scientific researchers claiming empathy deficits in autism are wrong, or that their diagnosis of autism (which may be an intrinsic part of their self-identity and/or linked to financial or other support) is wrong.

Recognition that the use of self-report measures can sometimes be problematic has prompted researchers to devise various types of behavioural or neurophysiological tasks, using a range of stimuli, that purport to allow empathy to be measured. For example, some studies use images of facial expressions in which participants (Empathisers) are asked to identify the Target's emotion and to report their own level of arousal and concern after viewing each image (e.g. Dziobek et al, 2008). While the former can be considered a measure of 'emotion identification' (the ability to identify the affective state of others), the latter is interpreted as a measure of emotional/ affective empathy (the extent to which the Target's affective state causes the Empathiser's state to match the Target's emotion, Coll et al., 2017). Other studies, particularly those measuring empathy for pain, record participants' motor-evoked potentials (MEPs) following Transcranial Magnetic Stimulation while they observe images of body parts (hands / feet) in painful or non-painful situations (e.g. Avenanti et al., 2005; Minio-Paluello et al, 2009). A reduction in the amplitude of the motor-evoked potential recorded from the Empathiser's hand is interpreted as an empathic response.

What about Individual Differences in Empathy?

As can be seen, previous research has focused on measuring empathy as the outcome of a process: empathy has occurred if the Empathiser is in the same state as the Target as a consequence of the Target's state. Coll and colleagues (2017) have argued that such a conceptualisation results in a binary outcome – empathy either occurs or it does not – and the reasons for any 'empathy failure' are unclear. Instead, they argued that empathy should be viewed as a process with (at least) two constituent parts: emotion identification and affect sharing. Individual differences in the former process reflect the degree to which one can accurately infer the other's emotional state, while individual differences in the latter reflect individual differences in the degree to which attribution of an affective state to the other causes the same state to be instantiated in the self. Under this definition, a person's empathic abilities reflect the extent to which they feel an emotion that matches the emotion they identified in the Target, even when that emotion differs from what the Target actually feels. This is a significant departure from the traditional view of empathy in which the actual emotion of the Target is the reference point from which the Empathiser's state is judged. Following their definition, Coll et al. suggest that one appropriate measure of affect sharing is the degree to which the state elicited in the Empathiser matches the state the Empathiser identifies in the Target. For example, if Empathiser A has an affective response closer to what A believes to be the affective state of the Target than Empathiser B has to what B believes to be the affective state of the Target, then Empathiser A could be considered more empathic (more formally, they would be considered to have a greater degree of affect sharing).

The perspective offered by Coll and colleagues is a radical departure from both prior empathy research and the lay understanding of empathy. As an extreme example, an individual could be considered empathic (or at least to have typical affect sharing) even when they show the opposite emotion to what the Target is feeling, if their state matches the emotion they identified in the Target. However, adopting Coll and colleagues' methodological recommendation for the analysis of empathic ability enables measurement of individual (or group) differences in the processes necessary to produce an empathic response. For completeness therefore, this study will measure the traditional concept of 'affective empathy' (which can be defined as the degree to which the Target's state causes the Empathiser to be in matching state) in addition to emotion identification (the accuracy with which an Empathiser can determine the Target's state; sometimes called cognitive empathy), and affect sharing (the degree to which the Empathiser's state matches the state they identify in the Target). All three measures will be used to compare neurotypical individuals and individuals with autism using a new empathy task as described below.

The Continuous Affective Rating and Empathic Response (CARER) Task

The CARER task is an extension of the Empathic Accuracy Task (EAT, e.g. Ickes, Stinson, Bissonnette & Garcia, 1990; Zaki, Bolger & Ochsner, 2008). The EAT consists of two phases. In the first phase, individual Targets were invited to the lab to record short video clips describing real-life emotional events. The targets then rated, on a continuous scale, how they felt while telling each story. In the second phase, participants watched these videos and provided continuous ratings of how they thought the target was feeling. The key measure of the EAT task was empathic accuracy, calculated by correlating the Empathisers' ratings of how they thought the Targets felt and the Targets' ratings of their own feelings.

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The new (CARER) task – See Figure 1 – expands on the EAT by including additional variables that enable a better understanding of the various aspects of empathy. First, CARER includes emotionally neutral stories to enable comparisons with the affective stories. Second, Targets in the CARER task were adults representative of the local community in terms of age, gender and ethnicity. Third, in addition to ratings of how they thought the Target was feeling ('Other' ratings), Empathisers were also asked to rate their own feelings in response to each of the stories ('Self' ratings). Fourth, in most empathy studies, affective ratings are collected from Empathisers following exposure to emotional stimuli (offline) and consist of single ratings. Therefore, in order to compare our data with previous studies, we also asked Empathisers to provide single/offline ratings after watching each video. In sum, the CARER task included two blocks. In the first block, Empathisers provided continuous ratings of their own feelings ('Online Self') while watching the video, then once the video had finished, they rated how they thought the Target was feeling ('Offline Other'). In the second block, the order of ratings was reversed (first 'Online Other' followed by 'Offline Self'). The order of blocks was randomised across participants, who completed both blocks in succession. This task design allows emotion identification, affective empathy as classically defined, and affect sharing to be measured. Emotion identification is assessed by comparing the Empathisers' ratings of the Targets' affective state to the ratings provided by the Targets themselves. Affective empathy is assessed by comparing the extent to which Empathisers' self-ratings correspond to the Targets' own ratings. Affect sharing is assessed using the correspondence between the Empathiser's self-ratings and their rating of the Target's state.

The use of both on- and off-line measures is an important feature of the CARER task. The online measure resembles the dynamics involved in real life social interactions, in which the Empathiser is required to respond to the Target's state instinctively, at speeds approaching real time. In contrast, the offline measures (as used in most empathy tasks) are a product of more reflective processing in which the Empathiser is more of an observer. Such offline reflection has been argued to rely on the kind of explicit, verbally-mediated theory of mind which has been shown to be difficult for individuals with autism (Baron-Cohen, Leslie & Frith, 1985 - see Schilbach, 2014; Schilbach et al., 2013 for an in-depth discussion of online vs offline social cognition).

In summary, this study adopts a new methodological approach to the study of empathy in autism. Using a novel empathy task, affective empathy as classically defined (the degree to which the Empathiser's affective state matches that of the Target), emotion identification (the degree to which the Empathiser can accurately identify the Target's affective state), and affect sharing (the degree to which the Empathiser's affective state matches that they identify in the Target), can all be measured. To the degree that alexithymia can explain any deficits in these measures in autism, one would expect any apparent autism-related deficits to be reduced to non-significance after controlling for alexithymia.

Method

Participants

Due to the difficulties inherent in recruiting individuals with a condition with low prevalence such as autism, we used an opportunity sampling method. To avoid sole reliance on null hypothesis significance testing, we (a) perform additional Bayesian analysis; and (b) report effect size measures in the Results section. Our autism group consisted of 21 individuals with an independent clinical diagnosis of autism (13 female, age range: 18-55, *Mean age* =29, SD = 2.06) and 45 adults without an autism diagnosis (29 female, age range: 18 -53, *Mean age* =25, SD = 1.22) who all volunteered to take part in the study in exchange for a small monetary reimbursement. The groups did not differ in terms of age, $t(34.5) = 1.82$, $p = .08$, or gender $\chi^2(1) = .04$, $p = .84$**.** In light of the memory component of the empathy task – recalling a story during the offline rating condition – we used the logical memory subscale of the Weschler's scale, fourth edition (WMS-IV, Wechsler, 2009), to measure immediate recall. No group differences were found on this measure [t(63) = -.17, $p = .86$; ASD: M=26.38, SD = 7.24; Controls: M = 26.68, SD = 5.96].

Due to the nature of the empathy task, which involved exposure to emotionally charged stories, participants were required to complete the Beck's Depression Inventory (BDI-II; Beck, Steer &

Brown, 1996) prior to taking part in the experiment. Only those scoring below 30 (the cut off for clinical depression) on the BDI were invited to take part in the experiment. Since the BDI measures depressive symptoms over a two-week timeframe, it was administered again at the beginning of the experimental session in the lab. No participants were excluded on the basis of BDI, however, there was a significant group difference on BDI scores, $t(29.89) = 2.74$, $p = .01$, $d = .76$; ASD $M = 10.48$, *Range* = 0 – 24; $SD = 7.2$; Controls: $M = 5.68$, *Range* = 0 – 20, $SD = 5.15$. Ethical approval was granted by the Cambridge Psychological Research Ethics Committee, and all participants provided written informed consent.

[Insert Table 1 about here]

Table 1 – Demographics of ASD Group

Participant	Gender	Age	AQ Score	BDI	Logical Memory	TAS-20
1	M	22	36	7	32	50
2	F	20	36	5	27	46
3	M	30	42	3	22	63
4	M	24	49	20	39	74
5	F	40	30	18	31	65
6	F	18	42	17	38	72
7	F	29	47	15	31	68
8	M	33	48	24	19	80
9	F	23	45	11	20	65
10	F	21	16	21	18	72
11	M	40	8	14	22	69
12	F	19	38	5	28	61
13	F	27	11	0	38	61
14	F	24	45	12	21	76
15	F	23	42	15	29	78
16	F	22	33	10	27	46
17	M	41	39	3	17	61
18	F	55	39	2	28	59
19	M	33	26	0	14	60
20	F	39	32	12	21	63
21	M	26	30	6	32	70
Group Means		*29*	*35*	*10.48*	*26.38*	*64.71*

Materials and Procedures

Empathy task (CARER). As described above, this task consisted of two phases. In phase 1, we invited adult volunteers (Targets) to the lab. Each Target recorded two brief videos (approximately 30 seconds each). Prior to the recordings, Targets were instructed that one of the videos should describe a real-life event when they felt particularly sad (affective story) and the second video should also be a real-life event but devoid of affective language, for example, a description of their journey to work, a daily routine, what they do for a living, what subject they are studying, etc. (neutral story). Targets had full control over the events they chose to describe, that is, the stories were not scripted. Following the video recordings, Targets were asked to watch each video and provide continuous ratings of how they felt when they were telling the story. The continuous rating scale was presented vertically next to the video display and the values ranged from 0 (extremely calm) to 10 (extremely upset).

Figure 1 shows the sequence of the second phase of the CARER task. During this phase, participants (Empathisers) were presented with the videos described above. A total of 32 trials (16 affective and 16 neutral) were presented in two blocks of 16 trials each in a pseudorandomized order, such that no more than three trials of the same type were presented in succession. In Continuous Self blocks participants were asked to rate how they feel while watching each video (Online Self rating) and once the video finished, they were asked to rate how the Target felt (Offline Other rating), using a scale from 0 (extremely calm) to 10 (extremely upset). During Online Other blocks the rating was for the Target (how is the person in the video feeling?) and the offline rating was for the self (how do you feel?). The online ratings were continuous, participants could provide as many ratings as they wished, so that their real-time response to the Target could be recorded. The order in which the blocks were completed was counterbalanced across participants. After each video, participants were asked to record a brief video message to the Target based on the story they just watched. The video responses were scored independently by researchers blind to the experimental design and participant group. The researchers coded the following variables: *frequency of empathic phrases* (e.g. I'm sorry to hear…, that sounds awful, I feel for you, I can't image…, etc), *frequency of verbal signs of personal distress* (e.g. soft tone of voice, breaking voice, slow speech, sadness), and *frequency of non-verbal signs of* *distress* (e.g. teary, sad facial expressions – turned down mouth eyebrows raised/knitted –, hand over mouth or chest). The task took approximately 35-40 minutes to complete.

[Insert Figure 1 about `]

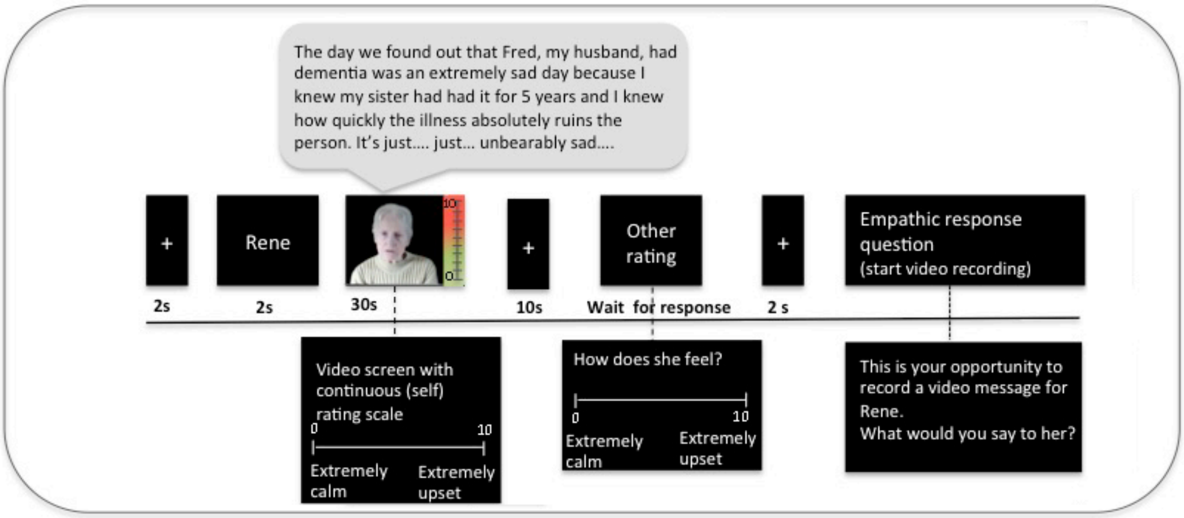

Figure 1. Example of a trial from the Continuous Self block of the Continuous Affective Ratings and Empathic Response (CARER) task. A control trial would contain a neutral story devoid of emotional language, for example, a description of a routine journey into work. Continuous Other blocks required online continuous ratings of how the Target feels, and an offline rating of how the Empathiser (participant) feels.

Self-report measures

Following the empathy task, participants completed 3 self-report questionnaires: the Interpersonal Reactivity Index (IRI; Davis, 1980) which consists of 4 subscales: empathic concern, fantasy, personal distress, and perspective taking to measure empathy; the Autism Quotient (AQ; Baron-Cohen et al., 2001) to measure autistic traits; and the Toronto Alexithymia Scale (TAS-20; Bagby, Taylor & Parker, 1994) to measure alexithymia. The TAS-20 consists of 3 subscales, difficulty describing feelings, difficulty identifying feelings and externally-oriented thinking. The entire experimental session lasted approximately 80-90 minutes.

Data analysis

The CARER task enables three dependent variables to be calculated: (i) Emotion Identification (Target's self rating– Empathiser rating of the Target's state) where lower scores indicate more accurate Emotion Identification; (ii) Affective Empathy (Target's self rating – Empathiser's self rating) – where lower scores indicate higher Affective Empathy[1]; and (iii) Affect Sharing (Empathiser's rating of the Target's state – Empathiser's self rating) – where lower scores indicate higher Affect Sharing. These three values can be calculated from both online and offline ratings.

With respect to online ratings, in principle participants' ratings could be treated as a continuous time series. However, a preliminary inspection of the data revealed that the rating data showed a consistent pattern whereby ratings were low in the first half of videos (where Targets were providing the background to the emotional event) and higher in the latter stages of the video (where the emotional climax of the video occurred). Thus, online rating data were split into two epochs (first and last 15 seconds of each video) and averaged within epoch. For offline analyses, participants provided a single score while Target ratings were continuous scores. Debriefing confirmed that all participants provided the highest affective rating for each story as their offline rating, therefore, we subtracted the participants' offline ratings from the Target's maximum rating. Thus, nine dependent variables were obtained: Early and Late Online, plus offline versions of Emotion Identification, Affective Empathy and Affect Sharing scores.

The data were analysed with SPSS (version 26). The Online data were analysed using ANCOVA with Story type (affective vs control) and Time (early vs late) as within-subject factors, Group (autism vs control) as a between-subjects factor and Alexithymia scores as a covariate. The analysis of the offline data included the same factors, with the exception of Time. Where sphericity

[1] Negative scores would indicate 'excessive' Affective Empathy, showing that the Empathiser's reaction to the Target's affective state is stronger than the Target's own reaction.

assumptions were not met, Greenhouse-Geisser corrected values are reported. Bonferroni corrections were used for post-hoc multiple comparisons.

A series of subsequent multiple regression analyses identified the unique variance explained in each CARER variable by autism, alexithymia and gender. Accordingly, multiple regression models included TAS scores, AQ scores and gender (note that the pattern of significance was the same if diagnostic status was coded as a categorical binary variable).

Results

Individual Differences Approach Accounting for Alexithymia

Emotion Identification Online. This analysis revealed no main effects or interaction reached significance[2], all *ps* $\geq$ .083. We further tested the strength of evidence for the null hypothesis of no interaction between Story type and Group with a Bayesian analysis using JASP (JASP Team, 2019). A Bayes Factor (BF_{10}) above 3 indicates substantial support for H1 and a BF less than 0.33 indicates substantial support for H0 (Jeffrey, 1961; Raftery, 1995). JASP default priors were used as the model for H1. Bayes Factors of 1.27 and 0.28 were obtained for the two- (Story type x Group) and three-way (Story type x Group x Time) interactions respectively. Thus, Bayesian analyses provided little support for either the null or alternative hypotheses with respect to the two-way interaction, and substantial support for the null with respect to the three-way interaction.

Emotion Identification Offline. Figure 2 (Panel A) shows the offline data for Emotion Identification. We found no main effects of Story type (p = .36), or Group (p = .081). However, the

[2] When checking for homogeneity of variance using Levene's test, the variable affective emotion identification was significant at T2. Therefore, findings from the ANCOVA relating to the crucial Group x Story type interaction were re-assessed using the non-parametric Kruskal-Wallis test in JASP (JASP Team, 2019). We calculated a difference score between affective and neutral trials to obtain a single difference score and compared this score between the groups. The results of this analysis showed the same pattern of significance as the ANCOVA results ($X^2_{(1)}$ =.2, p = .655).

Story type × Group interaction was significant[3], $F(1,63) = 5.64$, $p = .021$, $\eta^2_p = .08$, 90% CI [.006, .201]. Post-hoc tests revealed that this was driven by a reduction in emotion identification in the autistic group on affective trials ($M = 2.69$, $SEM = .53$), compared to controls ($M = 1.11$, $SEM = .31$; $F(1,63) = 5.15$, $p = .027$, $\eta^2_p = .08$, 90% CI [.005, .192]. The Group contrast on neutral trials was not significant, $p = .92$. A Bayes Factor of 6.915 was obtained for the two-way (Story type x Group) interaction, providing substantial support for the alternative hypothesis.

Affective Empathy Online. No main effects or interactions reached significance, all *ps* ≥ .10. Bayes Factors of 1.426 and 2.13 were obtained for the two- (Story type x Group) and three-way (Story type x Group x Time) interactions. Thus, Bayesian analyses provided little support for either the null or alternative hypotheses with respect to both the two- and three-way interactions.

Affective Empathy Offline. Figure 2 (Panel B) shows the offline data. The analysis revealed a significant Group × Story type interaction, $F(1,63) = 3.98$, $p = .05$, $\eta^2_p = .06$, 90% CI [.000, .171]. Pairwise comparisons showed that while there were no Group differences on neutral stories ($p = .43$), significant differences between the Groups were present on affective stories, with reduced affective empathy scores in the autism Group ($M = 4.58$, $SEM = .68$) compared to the control Group ($M = 2.60$, $SEM = .40$); $F(1,63) = 4.79$, $p = .032$, $\eta^2_p = .07$, 90% CI [.003, .186]. A Bayes Factor of 6.59 was obtained for the two-way (Story type x Group) interaction, providing substantial support for the alternative hypothesis.

Affect Sharing Online. This analysis revealed no significant main effects or interactions, all *ps* ≥ .12. Bayes Factors of 0.38 and 0.39 were obtained for the two- (Story type x Group) and three-way (Story type x Group x Time) interactions respectively. Thus, Bayesian analyses provided anecdotal support for the null hypothesis with respect to both the two- and three-way interactions.

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[3] The Levene's test for the variable emotion identification for affective stories was significant, therefore, the Group x Story type interaction found in the ANCOVA was further assessed with a non-parametric Kruskal-Wallis test. We calculated a difference scores between affective and neutral stories to obtain a single difference score and compared this score between the groups. This analysis supported the ANCOVA results, ($\boldsymbol{X}^2_{(1)} = 6.88$, $p = .009$).

Affect Sharing Offline. Figure 2 (Panel C) shows the offline data for Affect Sharing. In common with the online analysis, the offline data showed no significant main effects or interactions, Crucially, in contrast to the offline Emotion Identification and Affective Empathy analyses, the Group × Story type interaction failed to reach significance (p = .85). Again, we carried out a Bayesian analysis, which yielded a BF of 0.593, thus providing little support for either the null or alternative hypothesis.

[*Insert Fig. 2 about here*]

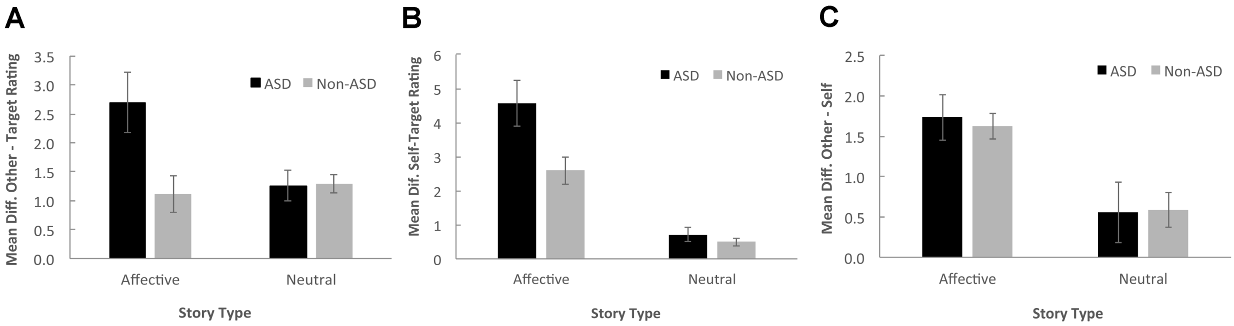

Figure 2. Offline data for Emotion Identification (Panel A, calculated by subtracting participants' ratings of how the Targets feels from the Targets' own ratings), Affective Empathy (Panel B, calculated as the difference between participants' self ratings and the Targets' own ratings) and Affect Sharing (Panel C, calculated by subtracting the Empathiser's own state (self ratings) from Empathiser's judgement of the Target's state (other ratings). In all measures, lower scores indicate better performance of the measure in question. *Error bars represent the SEM.*

Video Responses. Figure 3 shows the box plots for each of the measures derived from the video responses: *frequency of empathic phrases* (e.g. I'm sorry to hear…, that sounds awful, I feel for you, I can't image…, etc), *frequency of verbal signs of personal distress* (e.g. soft, breaking, slow, sadness), and *frequency of physical signs of distress (*e.g. teary, sad facial expressions – turned down mouth eyebrows raised/knitted –, hand over mouth or chest). Two researchers blind to the experimental design independently scored the participants' video responses. One researcher coded all video responses from the whole sample, to ensure reliability of these ratings a second researcher scored the responses of 46 randomly selected participants. Both coders were mostly unaware if participants were autistic or not, however, two participants explicitly mentioned in the videos that they had an ASD diagnosis. We tested inter-rater reliability with intraclass correlation coefficients (ICC) estimates and their 95% confidence intervals, which were calculated based on a median rating (k=2), absolute agreement, 2-way mixed effects model. A high degree of ICC reliability was found for the three measures (*frequency of empathic phrases,* ICC = .95, 95% CI = .91 to .97, $F(45,45) = 21.30$, $p < .001$); *frequency of verbal signs of personal distress,* ICC = .97, 95% CI = .94 to .98, $F(45,45) = 35.07$, $p < .001$); *frequency of physical signs of distress* ICC = .85, 95% CI = .73 to .92, $F(45,45) = 6.63$, $p < .001$).

Mann-Whitney tests on the video response variables indicated group differences during affective trials for frequency of empathic phrases used, $U = 283$, $p = .005$, the ASD group (*Mean Ranks* = 24.48) used fewer empathic phrases than controls *(Mean Ranks* = 37.07). Group differences were also found in the frequency of verbal signs of personal distress $U = 219$, $p < .001$ (*Mean Ranks* ASD = 21.45, controls = 38.51) and frequency of physical signs of distress $U = 299$, $p = .005$ (*Mean Ranks* ASD = 25.24, controls = 36.70). Notably, the direction of the group differences in the measures of personal distress, both for verbal and non-verbal cues – see Fig. 6 – do not support the empathy imbalance hypothesis' prediction that ASD individuals' potential empathy overload leads to higher levels of personal distress. Our data show the opposite pattern, with ASD individuals displaying fewer signs of personal distress than neurotypicals. No significant group differences were found on any these measures for the neutral videos, all *ps* >.05.

Since significant differences between the groups were found in the video responses, the correlations between these measures, AQ and alexithymia scores were further explored. For alexithymia scores, the TAS subscales (difficulty identifying feelings, difficulty describing feelings and externally-oriented thinking) were deemed to be more informative in this analysis than the total alexithymia score. AQ scores correlated with all three measures: frequency of empathic phrases [*r* (63) = -.27, *p* = .03]; frequency of verbal signs of personal distress [*r* (63) = -.26, *p* = .041] and frequency of physical signs of distress [*r* (63) = -.29, *p* = .023]. Furthermore, significant correlations between video responses and the alexithymia subscales were also present. For example, difficulty describing feelings was correlated with frequency of empathic phrases [*r* (64) = -.28, *p* = .027]; frequency of verbal signs of personal distress [*r* (64) = -.27, *p* = .031] and frequency of physical signs of distress [*r* (64) = -.34, *p* = .005]. For difficulty identifying feelings the only significant correlation was with frequency of physical signs of distress [*r* (64) = -.35, *p* = .005]; whereas no significant correlations were found between externally-oriented thinking and any of the video responses.

[*Insert Figure 3 about here*]

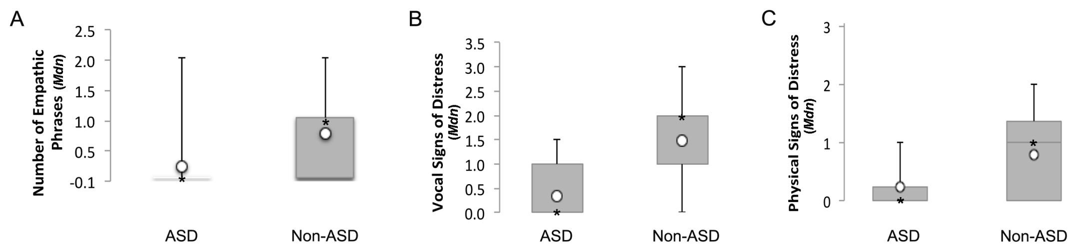

Figure 3. Box plots of each of the measures used in the analysis of video responses: A) Number of empathic phrases, B) Verbal signs of distress, C) Physical signs of distress. The bottom and top whiskers represent the minimum (Q1) and maximum (Q3) values respectively. The diagram also shows the median (asterisk) and mean (circle) observation for each group.

Self-Report Measures. Due to technical difficulties one participant's AQ score, and a second participant's IRI score were not recorded, both participants were from the control group. As expected, the groups differed in their AQ score, $t(63) = 7.16$, $p <.001$, $d = 1.89$, 95% CI [1.28, 2.50], (ASD *M* = 35, *SEM* = 2.54; controls *M* = 16, *SEM* = 1.34). The Alexithymia scores were also significantly different between the groups, *t*(64) = 8.83, *p* <.001, *d* = 2.33, 95% CI [1.67, 2.98]; with higher scores found for the ASD group (*M* = 64.71, *SEM* = 2.07) compared to controls (*M* = 43.33, *SEM* = 1.34). This pattern was repeated for three of the four IRI subscales, empathic concern, *t*(63) = -4.74, *p* <.001, *d* = 1.25, 95% CI [.69, 1.81], (autistics: *M* = 14.67, *SEM* = 1.29; controls: *M* = 20.84, *SEM* =.66); perspective taking, *t*(63) = -4.13, *p* <.001, *d* = 1.09, 95% CI [.54, 1.64], (autistics: *M* = 13.33, *SEM* = 1.03; controls: *M* = 18.86, *SEM* =.78); and fantasy, *t*(63) = -4.12, *p* <.001, *d* = 1.08, 95% CI [.53, 1.64], (autistics: *M* = 11.62, *SEM* = 1.33; controls: *M* = 17.43, *SEM* =.74). The personal distress subscale scores did not significantly differ between the groups (autistics: *M* = 14, *SEM* = 1.43; controls: *M* = 11.7, *SEM* =.70, *p* = .16).

Correlations. Table 1 shows the correlations between all dependent variables across all participants. Of particular interest were correlations with the key variables from the CARER task: affective empathy, emotion identification and affect sharing, both online and offline. With respect to the study hypotheses, we found that autism traits (AQ) were negatively correlated with emotion identification offline, *r*(65) =.40, *p* = 001, and with affective empathy, both online - *r(65)* = .31*, p* = .01 – and offline - *r*(65) =.43, *p* <.001. Furthermore, AQ scores were positively correlated with alexithymia scores, *r*(65) = .66, *p* <.001 (and all TAS subscales) and negatively correlated with the following IRI subscales: empathic concern, *r*(64) = -.40, *p* = .001; perspective taking, *r*(64) = -.34, *p* = .006; and fantasy, *r*(64) = -.403, *p* = .001. However, contrary to the prediction from the empathy imbalance hypothesis in autism, we found no correlation between AQ scores and the IRI personal distress subscale, *r*(64) = .097, *p* = .447.

Notably, we also found a negative correlation between overall alexithymia scores (TAS) and affective empathy both online – *r*(66) = .28, *p* = .025 – and offline - *r*(66) =.34, *p* = .006; and with affect sharing offline, *r*(66) = .28, *p* = .022. Total alexithymia scores were also negatively correlated with all the IRI subscales: empathic concern $r(65) = -.62$, $p < .001$; perspective taking, $r(65) = -.48$, $p < .001$, fantasy ($r(65) = -.478$, $p < .001$) and personal distress ($r(65) = .266$, $p = .032$.

Multiple Regressions. Finally, a multiple regression analysis was performed on each of the CARER variables which included the following predictors: AQ scores, TAS scores and Gender in an attempt to understand the contribution of each of these independent variables on the performance of the CARER task (see Supplemental Materials for full model information). Tests for multicollinearity indicated that a very low level of multicollinearity was present (*VIF* = 1.80 for AQ scores, 1.79 for TAS scores, and 1.04 for Gender). None of the models, or independent variables within the models, were significant predictors of the online measures. However, the model was a significant predictor of offline emotion identification, $F(3, 64) = 4.28$, $p = .008$, $R^2 = .174$, $R^2_{adjusted} = .133$, and out of the three independent variables AQ was the only significant predictor, ($\beta = .07$, $t(.02) = 3.19$, $p = .002$). The model predicting offline affective empathy was also significant, $F(3, 64) = 6.29$, $p = .001$, $R^2 = .236$, $R^2_{adjusted} = .199$. In this model, AQ was a significant predictor, ($\beta = .08$, $t(.08) = 2.69$, $p = .009$). Finally, the model for predicting affect sharing offline was also significant, $F(3, 64) = 4.20$, $p = .009$, $R^2 = .17$, $R^2_{adjusted} = .13$. In this model, Gender was a significant predictor, ($\beta = 1.18$, $t(.44) = 2.68$, $p = .009$) and alexithymia scores were a marginally significant predictor, ($\beta = .04$, $t(.02) = 1.88$, $p = .065$).

Table 2. Correlations between key variables from the CARER task and self-reported questionnaires

	1	2	3	4	5	6	7	8	9	10	11	12	13.	14	15
1. Emotion Ident Online															
2. Emotion Ident. Offline	.26*														
3. Affect. Empathy Online	.28*	.40**													
4. Affect. Empathy Offline	.08	.70**	.48**												
5. Affect Sharing Online	-.26*	-.16	.33**	-.02											
6. Affect Sharing Offline	-.16	-.06	.26*	.67**	.14										
7. AQ	.09	.40**	.31*	.43**	-.13	.18									
8. TAS-20	.15	.18	.28*	.34**	-.13	.28*	.66**								
9. TAS – DDF	.08	.16	.25*	.37**	-.02	.35**	.65**	.90**							
10. TAS – DIF	.10	.17	.20	.29*	-12	.23	.63**	.88**	.72**						
11. TAS – EOT	.21	.11	.24*	.13	-.20	.08	.28*	.63**	.44**	.27*					
12. IRI Fantasy	-.16	-.11	-.30*	-.28*	-.04	-.28*	-.40**	-.48**	.48**	-.27*	-.48**				
13. IRI Empathic Concern	-.14	-.40**	-.39**	-.37**	.02	-.12	-.40**	-.62**	-.58**	-.48**	-.48**	.50**			
14. IRI Perspective Taking	-.03	-.32**	-.40**	.36**	.02	-.17	-.34**	-.48**	-.36**	-.45**	-.37**	.35**	.67**		
15. IRI Personal Distress	.16	-.22	-.13	-.24	-.15	-.12	.01	.27*	.19	.34**	.07	.14	.01	.02	

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).
Abbreviations: AQ = Autism Quotient, TAS-20 = Toronto Alexithymia Scale - 20 items, DDF = difficulty describing feelings, DIF = difficulty identifying feelings, EOT = externally oriented thinking, IRI = Interpersonal Reactivity Index.

Discussion

The findings of this study suggest that adopting a new methodological approach to empathy research can challenge previous claims that individuals with autism lack empathy. Past research has focused on measuring affective empathy - the degree to which the Empathiser's state matches that of a Target – which is the outcome of a number of cognitive processes. It has been suggested that it may be more useful to examine those constituent processes which may, or may not, result in an outcome which would be defined as affective empathy, in order to examine the empathic abilities of a group of individuals (Coll et al., 2017). This was the approach taken in this study; a group of individuals with autism and a control group completed a novel task (CARER) which provided a measure of classic affective empathy, and also emotion identification – the ability to identify accurately another's affective state –, and affect sharing – the degree to which the Empathiser's state matches the state they judge the Target to be in. The CARER task provides on- and off-line measures of each of these processes, with the former relying on rapid intuitive judgement, and the latter on slower, reflective processing thought to rely primarily on theory of mind (Schilbach, 2014; Schilbach et al., 2013). Initial analyses focused on group comparisons with an individual differences approach to examine the extent to which co-occurring alexithymia could account for any effect of autism (Bird & Viding, 2014; Bird & Cook, 2013).

Results showed that, after accounting for alexithymia, individuals with autism showed lower offline emotion identification and affective empathy compared to non-autistic controls. However, we found no evidence of reduced online emotion identification and affective empathy in our autistic participants. Crucially, our findings also indicate that after controlling for alexithymia scores, autism is not associated with affect sharing either online or offline.

It has previously been argued that an impairment in emotion identification will, in almost all cases, lead to a deficit in affective empathy (Coll et al., 2017). Affective empathy is defined by the degree to which the Empathiser's state matches that of the Target; if the Empathiser does not know which state the Target is in, then it is unlikely their state will match that of the Target. Coll and colleagues argued that affect sharing is a more appropriate measure of the empathic process, as it reflects the degree to which the Target's state, as judged by the Empathiser, affects the Empathiser's state. It is interesting, then, that after controlling for alexithymia no deficit in affect sharing was observed in the autism group.

What might be responsible for the less accurate emotion identification and reduced affective empathy in autism? Emotion identification is a process that may rely on a multitude of processes depending on the experimental stimuli and time available for processing. These processes include rapid recognition of facial and vocal expressions of emotion, and slower incorporation of theory of mind and understanding of the social situation in order to infer the Target's emotion (Bird & Viding, 2014; Coll et al, 2017). Meta-analyses have suggested that emotion recognition is not consistently impaired in autism (Harms et al., 2010), and indeed may be a product of co-occurring alexithymia (Bothe et al., 2019; Brewer et al., 2016, Cook et al., 2013; Trevisan et al., 2016). Studies of theory of mind in autism, however, consistently demonstrate that individuals with autism are impaired when inferring the mental states of others (Baron-Cohen, 2000; Frith 1994, 2012). Thus, it is possible that theory of mind impairments hinder the ability of individuals with autism to identify the emotion of the Target, which, as described above, would result in reduced affective empathy but not impact affect sharing. Such a possibility is consistent with the claim by Schilbach and colleagues (Schilbach, 2014; Schilbach et al., 2013) that offline processing – the only type of processing for which individuals with autism were impaired – is characterised by an increased reliance on theory of mind.

The current study also found that, compared to non-autistic controls, individuals with autism used reduced affective language when recording a video response for the Targets. This finding is in line with previous research showing atypical affective language processing in autism (see review by Lartseva, Dijkstra & Buitelaar, 2015). Such difficulties processing affective language have been observed in studies of memory and attention. For example, individuals with ASD do not show a memory advantage, consistently observed in neurotypicals, when processing emotional words (Beversdorf et al., 1998; Gaigg and Bowler, 2008, 2009b). In the attention domain, affective language processing in autism has been studied in the context of the 'attentional blink' effect. In the attentional blink paradigm, the likelihood of participants detecting a target word depends on the time elapsed between presentation of the previous target word (T1) and the current target word (T2). If by the time T2 is presented, the participant's attention is still engaged in T1, then they are less likely to detect T2. However, affective words tend to override the attentional blink effect as they are detected with high accuracy regardless of timing of presentation. Researchers have found that individuals with autism do not show this advantage for emotional words and instead show no difference between emotional and neutral words when presented as T2s (Corden et al., 2008; Gaigg and Bowler, 2009a). Furthermore, a similar pattern of results has been found in neurotypical adults with high levels of autistic traits in studies using emotional faces stimuli (English, Mybery & Visser, 2017; 2019). Overall, research in both the memory and attention domains suggest that individuals with autism tend to process both affective and neutral language similarly.

In the current study, when asked to record a message for the Target in the video clip, participants are required to utilise theory of mind and their ability to produce spontaneous affective language. Both, theory of mind (Baron-Cohen, 2000; Frith 1994, 2012) and spontaneous use of affective language (Capps et al., 2000; Barnes et al., 2009) are known to be impaired in autistic individuals. The current experimental design does not allow to speculate on the origin of impoverished affective language in ASD; however, our data do show that the use of affective language correlates with both AQ scores and, perhaps not surprisingly, with the TAS subscale difficulty describing feelings. Future work could further examine the nature of these correlations with affective language, for example by a) including both theory of mind and alexithymia measures; and b) testing ASD participants with a wider range of alexithymia scores.

How do findings relate to current theories of empathy in autism?

On the whole, results did not support the emotional imbalance hypothesis advanced by Smith (2009). This theory suggests that individuals with autism have a surfeit of affective empathy and are more likely to experience empathic personal distress compared to neurotypical individuals. This increase in personal distress is argued to lead to the behavioural differences in empathy frequently reported in autistic individuals. However, the results of the current study revealed reduced affective empathy in the autistic individuals, and evidence of reduced, rather than excessive, personal distress. The reduction in personal distress was observed in two of the three measures; two measures derived from the participants' responses to the Target (verbal and non-verbal signs of personal distress) showed reduced distress in the autistic group, while the autistic participants' responses on the IRI personal distress subscale were not significantly different to those of the neurotypical participants. It should be noted, however, that the neurotypical raters may have misinterpreted or missed signs of distress in the autistic individuals, as several studies suggest that neurotypical individuals are quite poor at reading the emotional expressions of autistic individuals (e.g. Brewer et al., 2016; Volker et al., 2009; Faso et al., 2015). In future, the inclusion of physiological measures of personal distress (or at least arousal), such as heart rate, skin conductance or electromyography (EMG) recordings, could be added to the CARER task to provide more objective evidence of personal distress.

Can alexithymia explain any empathic impairment in autism? The data support the co-occurrence of alexithymia in ASD, as autistic participants scored significantly higher on the TAS than the control group. Furthermore, alexithymia scores across all participants were negatively correlated with affective empathy – both online and offline – and offline affect sharing. This means that those with higher alexithymia scores reported emotional responses to the Target's state that were further away from both the Target's actual state, and their estimate of the Target's state. In addition, controlling for alexithymia caused several apparent empathy-related deficits in autism to become non-significant. Notably, alexithymia could not explain the reduced offline emotion identification and affective empathy seen in the autism group. However, if this result is explained by poorer theory of mind in the autism group as argued above, it would be consistent with work suggesting that theory of mind is not impaired in alexithymia (Oakley, Brewer, Bird, & Catmur, 2016; Silani et al, 2008).

Nevertheless, it should be noted that the ability of alexithymia to explain CARER task performance over and above autistic traits was limited to offline affect sharing. This may be a product of a failure to match the autism and control groups for alexithymia (while 76% of participants in the autism group scored above the alexithymia cut-off on the TAS, only 27% of the control group did). In addition, the design of the CARER task mitigates one of the main difficulties in alexithymia; identification of emotion. For both Self and Target ratings participants were required to judge the intensity of emotion (from calm to upset) but not to determine whether the Target (or themselves) was angry, afraid, or sad. Thus, it is likely that alexithymic difficulties would become more apparent if the task required a judgement of what emotion is being felt, as well as the intensity of that emotion. Thus, future work could investigate any alexithymia deficits in tasks requiring not only the intensity of emotion to be judged, but also the type of emotion to be recognised.

Another important way in which the CARER task could be enhanced in future studies is by adding positive emotions to investigate if the pattern of performance observed here is consistent with empathy for positive emotions. The current study focused on negative emotions as this enabled comparison with previous empathy research, which has overwhelmingly focused on negative emotions. However, positive empathy is an emerging field (Morelli, Lieberman & Zaki, 2015), which has the potential to contribute to current knowledge about the relevance of empathy for social interactions and relationships in both neurotypical (Andreychik, 2017) and clinical populations (Morrison et al., 2016). Finally, this work can also be extended by including other developmental groups such as children and adolescents with and without autism. The inclusion of different age groups could provide an insight into the developmental trajectory of empathic abilities and the contribution of alexithymia to these abilities, both in neurotypical and autistic individuals.

The findings reported here imply that when appropriate measures are used, autistic individuals do not show a lack of empathy. Note, however, that since we relied on self-reported ASD trait measurements future work should seek to extend our results to examine if they hold when additional measures of autism traits such as social skills, adaptive abilities, attention to detail, etc., are assessed.

Concluding remarks

Contrary to previous work, our study, which employs a different methodological approach to empathy research, shows that individuals with autism are not devoid of empathic abilities. Instead they show less accurate retrospective emotion identification which, in turn, influences the extent to which they report their affective state resembles that of the Target after a delay. Furthermore, there was no effect of autism on affect sharing, implying that just like neurotypicals, individuals with autism are able to share what they believe to be the emotions of others.

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Individuals with Autism Share Others' Emotions:
Evidence from the Continuous Affective Rating and Empathic Responses (CARER) Task

Footnotes

1. Negative scores would indicate 'excessive' Affective Empathy, showing that the Empathiser's reaction to the Target's affective state is stronger than the Target's own reaction.

2. When checking for homogeneity of variance using Levene's test, the variable affective emotion identification was significant at T2. Therefore, findings from the ANCOVA relating to the crucial Group x Story type interaction were re-assessed using the non-parametric Kruskal-Wallis test in JASP (JASP Team, 2019). We calculated a difference score between affective and neutral trials to obtain a single difference score and compared this score between the groups. The results of this analysis showed the same pattern of significance as the ANCOVA results ($X2(1) = .2$, $p = .655$).

3. The Levene's test for the variable emotion identification for affective stories was significant, therefore, the Group x Story type interaction found in the ANCOVA was further assessed with a non-parametric Kruskal-Wallis test. We calculated a difference scores between affective and neutral stories to obtain a single difference score and compared this score between the groups. This analysis supported the ANCOVA results, ($X2(1) = 6.88$, $p = .009$).