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Nuances of double empathy in autistic and non-autistic people: examination using the empathic accuracy paradigm

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Abstract

Background Social communication difficulties in autism were traditionally attributed to deficits in empathy, that is, understanding others' mental states and responding to these with a similar or appropriate emotion, within autistic individuals. The double empathy problem theory proposes that difficulties with cross-neurotype empathy are bidirectional. This study examines predictions from the double empathy problem theory, mainly whether autistic and non-autistic individuals differ in their empathy towards autistic versus non-autistic social targets, using an empathic accuracy paradigm alongside self-report measures of empathy and empathic interest.

Methods A novel empathic accuracy stimulus featuring video-recorded autobiographical stories from five autistic and five non-autistic adult storytellers was used. Participants [141 autistic, 94 non-autistic; mean age: 49.09 years ($SD = 16.41$)] were recruited through the Cambridge Autism Research Database. Each participant viewed two stories (one autistic, one non-autistic storyteller) in a randomized design, continuously rated storytellers' emotional valence, and globally rated the degree to which they believed the storytellers felt each of 12 discrete emotions. Accuracy was computed as concordance with storytellers' own ratings. Participants also self-reported empathy and empathic interest toward the storyteller in the target videos. Mixed linear models examined the effects of rater neurotype, target neurotype, and their interaction. Participants' text responses were qualitatively analyzed using an inductive, data-driven approach to identify patterns within the data, which converged into subthemes and themes.

Results No significant main effects emerged for rater or target neurotype on continuous valence or specific emotions' empathic accuracy. A trend-level interaction ($p = .059$, $d = 0.13$) suggested that autistic raters showed relatively higher continuous valence empathic accuracy toward autistic targets than non-autistic raters. Non-autistic raters reported significantly higher self-reported empathy ($p < .001$, $d = -0.67$) and empathic interest ($p < .001$, $d = -0.43$) regardless of target neurotype. Qualitative analysis revealed that autistic participants described difficulties in identifying emotions and in performing the EA task, and engaged in metacognitive introspection, while non-autistic participants focused more on task design feedback.

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Limitations The use of video-based experimental design may not fully capture the complexity of spontaneous social encounters. The self-selected sample of autistic participants may not represent the full autism spectrum or include individuals requiring greater support, potentially affecting generalizability.

Conclusions Findings suggest partial support for the double empathy problem theory and potential underestimation of autistic participants of their own empathic abilities. Individual variability patterns caution against treating neurotypes as homogeneous categories that alone determine double empathy processes. Future research should examine real-world interactions and include measures of autistic traits across participants.

Keywords Empathy, Empathic accuracy, Double empathy, Autism, Autistic, Emotions

Difficulties in social interaction and relationships have consistently been recognized as a core feature of autism, from its early to recent descriptions [1, 2]. Persistent challenges in social communication are central to the diagnostic criteria for autism [3], and research capturing first-person autistic perspectives also points to social difficulties, describing effort, anxiety, and exhaustion of autistic people during social interactions [4, 5]. Various explanations have been proposed to account for these difficulties, many of them seeking to locate the root cause within the autistic mind. One of the prominent theories suggests that autistic individuals struggle to identify, infer, and understand others' mental states [6–10]. Empirical research has shown the difficulties that autistic individuals present in understanding others' emotions, thoughts, and intentions [11–13], and in recognizing social signals, including facial expressions [14], and tone of voice [15]. Thus, autism has traditionally been associated with difficulties in empathy, that is, understanding others' mental states and responding to these with a similar or appropriate emotion [10, 16–19].

Researchers point to two components included in the multifaceted concept of empathy: cognitive empathy - the intellectual/imaginative apprehension and understanding of others' emotions, and emotional, or affective empathy - the emotional response to others' emotions with a similar or an appropriate emotion [20–24]. The study of empathy in autism has advanced from theories suggesting that autistic people lack empathy [25], or have a deficit in cognitive empathy and an intact emotional empathy [26], to a more nuanced understanding of the challenges autistic individuals may encounter in empathic processes, for example, an intra-individual imbalance between cognitive and emotional empathy [27, 28]. Still, overall, this literature proposes that autistic individuals struggle more than non-autistic people to empathize with others. It is important to consider, though, the limitations of measures used to operationalize and evaluate empathy, as first-person accounts suggest that empathy might be expressed in autistic people differently from non-autistic norms, thus research from non-autistic perspectives may misconstrue observable autistic behaviors [29].

The 'double empathy problem' theory [30, 31] has offered a new conceptualization of the empathy 'problem' in autism. According to this theory, the social communication difficulties between autistic and non-autistic individuals are bidirectional, rather than stemming exclusively from the autistic mind. In Milton's formulation, the double empathy problem concerns a reciprocal mismatch in social communication and mutual understanding between autistic and non-autistic people, such that differences in empathic inference are embedded within broader interactional breakdowns rather than reflecting a unidirectional deficit in autism. This bidirectional framing is also consistent with first-person qualitative reports from autistic adults, which emphasize that the ease and comfort of social interaction they experience also depend on interactional factors, such as the communication partner [4, 5].

In other words, the double empathy problem theory suggests that while it is hard for autistic people to empathize with non-autistic others, it is also hard for non-autistic individuals to empathize with autistic people, due to the fundamental difference between them in the way they perceive and experience the world [30, 31]. This theory, thus, yields the hypotheses that: (1) non-autistic people struggle to empathize with autistic people in a similar way to that autistic people struggle with empathy towards non-autistic people; (2) autistic people show an own-group advantage - they empathize better with other autistic people than with non-autistic people; and (3) autistic people are better at empathizing with other autistic people than non-autistic people are at empathizing with autistic people (meaning autistic people outperform non-autistic people specifically when empathizing with autistic people).

There is an accumulating literature supporting the difficulty of non-autistic people to empathize with autistic people, as outlined in the first hypothesis emerging from the concept of the double empathy problem. For example, studies suggest that it is harder for non-autistic participants to interpret the mental state of autistic individuals than that of other non-autistic individuals based on pictures of facial expressions [32] or video-recorded naturalistic behavior [33], or mental-state attribution based on

perceiving animated movement [34]. Cheang et al. (2024) found that participants from the general population demonstrated lower empathic accuracy, defined as the ability to accurately judge the mental states of others [35], when viewing autobiographical accounts from autistic narrators compared to non-autistic narrators. Using video clips of autistic and non-autistic individuals recounting emotional events to test whether participants could accurately track the emotions of the narrators, the researchers found that it was harder for non-autistic participants to track the emotions of autistic narrators compared to those of non-autistic narrators [36]. It was also found that non-autistic individuals are less willing to socialize with autistic individuals than with non-autistic individuals [37]. Together, these findings imply that the social communication difficulty characterizing and defining autism can indeed be explained not only by the autistic individual's empathic abilities, but also, at least partially, by those of their non-autistic social partners, and their willingness for social interaction with autistic people.

Support for the second hypothesis, according to which autistic people better empathize with other autistic people than with non-autistic people, is implied by a growing body of empirical evidence [38–40], along with first-person accounts from autistic people [41, 42] that show a preference by autistic individuals for same-neurotype interactions (autistic-autistic), with mixed-neurotype interactions (autistic-non-autistic) being more challenging to navigate for them. Recent research suggests that autistic people show a preference for interacting with other autistic individuals, report experiencing deeper social connections with them, and connect more easily with other autistic people compared to with non-autistic people [38, 43–45]. Research has also indicated that autistic and non-autistic individuals are similarly accurate in sharing information with others of the same neurotype, suggesting that autistic individuals possess effective communicative skills during same-neurotype interactions [39, 46]. These findings suggest that autistic peer-to-peer information transfer, social interaction, and relationships can be effective and beneficial for autistic individuals, and that they may prefer same-neurotype interactions over mixed-neurotype interactions. Overall, there is accumulating support for the double empathy model in the sense of broader bidirectional interactional breakdowns in social communication [31, 37–51]. However, while the measures these studies focused on, such as favorable impressions and liking (e.g., [45, 49]), connection and rapport (e.g., [48, 49]), attitudes, and communication (e.g., [39, 46]), are linked to the empathic process, they do not directly and solely target *empathy*. Empathic understanding can facilitate smoother interaction, positive affiliative feelings, and willingness to engage [23, 24]. However, these constructs can also be influenced

by factors such as shared interests, social norms, sense of belonging, or awareness of the other's diagnostic status (see, for example: [47]), and they are not isomorphic with empathy as in the definition we relied on in the present paper: they do not directly index the emotional response, similar to one's perception and understanding of the other's emotion [19].

In a study using functional magnetic resonance imaging (fMRI), aimed to directly measure *empathy*, Komeda et al. (2015) examined whether autistic individuals ($n=15$) experience empathy toward autistic (fictional) characters in a social judgment reading task. They found that the ventromedial prefrontal cortex was significantly activated in autistic participants in response to reading about autistic characters, and in non-autistic participants ($n=15$) in response to non-autistic characters. They also reported that the frontal–posterior network between the ventromedial prefrontal cortex and the superior temporal gyrus participated in processing non-autistic characters in non-autistic individuals, whereas an alternative network was involved when autistic participants processed autistic characters. The researchers suggested that autistic participants exhibit affective empathy toward other autistic individuals, possibly through an atypical form of empathic process [52]. In an additional study, the same group, Komeda et al. (2019) [53], examined the empathic responses of autistic ($n=22$) and non-autistic ($n=20$) participants to written stories featuring protagonists with characteristics of autism or with 'non-autistic' characteristics. They found that autistic participants showed greater empathetic responses to stories featuring autistic characters than non-autistic participants did, whereas non-autistic participants showed greater empathetic responses to "non-autistic stories" than autistic participants did.

Under the double empathy problem theory framework, it is expected that not only non-autistic individuals empathize better with other non-autistic people than with autistic people (hypothesis 1), and that autistic people will empathize better with other autistic individuals compared to non-autistic individuals (hypothesis 2), but also that autistic people will be better than non-autistic people in empathizing with autistic social targets of empathy (hypothesis 3). The literature reviewed above offers support for hypothesis 1 (e.g., Cheang et al. [36]) and, albeit indirectly, supports hypothesis 2 as well. Regarding hypothesis 3, we are aware of only the one small-scale study described above (Komeda et al. [53]), which also implied some support for this hypothesis and calls for further research. The present study aims to directly examine these three predictions of the double empathy problem theory in a nuanced, quantifiable manner by investigating the empathy of autistic and non-autistic

individuals towards both autistic and non-autistic social targets, using the empathic accuracy paradigm.

In the field of empathy research, empathy is operationalized and measured in various ways, from self-report questionnaires [e.g., EQ [54]; IRI [55]] to laboratory-based objective performance tests that compare participants' output to predefined 'correct' responses [56–58]. Such tasks, which usually include emotion recognition in still pictures or reading a vignette describing a mental state or a social situation, usually fail to capture the complexities and dynamic nature involved in social communication, including rapid and nuanced changes in facial expression, gestures, and pragmatic characteristics of the speech of the target of empathy [59]. They also usually rely on 'correct' or 'wrong' responses, which are predefined by the researcher or the tool they use. Empathic accuracy (EA) tasks have sought to provide a more ecological setting for measuring empathic abilities, specifically the ability to accurately judge others' mental states, using the target's own reports as the criterion for accuracy [35, 60].

One of the used empathic accuracy paradigms typically involves a videorecorded target sharing an autobiographical emotional narrative and providing self-ratings of their affect while recounting the event; perceivers then watch the recorded target and are asked to infer the target's feelings, and EA is computed as the correspondence between perceiver ratings and the target's own reports [60–63]. Reviewing the literature on empathic accuracy in clinical populations, Rum and Perry [2020 [64]] summarized the results from eight studies focusing on EA in the context of autism [65–72]. Overall, findings of these studies suggest that autistic individuals exhibit difficulties in EA when empathizing toward a non-autistic target, and that more pronounced autistic traits in non-autistic individuals were associated with poorer EA [65, 67]. However, some findings also pointed to EA abilities in autistic participants, indicating that they perform better in more structured settings and with active participation [69–71]. When autistic participants who had to infer the feelings of a target in a videotaped interaction also took part in these pre-recorded interactions, they did not differ from a non-autistic comparison group in their EA scores, nor in their "readability" [69] (i.e., did not yield lower EA scores in perceivers).

Another study using the EA task [73] found that autistic participants showed difficulties in EA specifically for the presentation of anger, but did not differ from non-autistic participants in overall EA. Notably, most of these studies were focused on the EA performance of autistic participants towards non-autistic targets. To investigate the present study's research questions, which involve the full "double empathy model", we created an EA stimulus based on autistic and non-autistic short video recordings

of stories, presenting storytellers' lived experiences. We used this stimulus to examine whether autistic and non-autistic individuals differ in their ability to empathize with autistic and non-autistic social targets. Based on the literature, we hypothesized that non-autistic participants would better empathize with non-autistic social targets than with autistic social targets; we aimed to explore further whether autistic participants would better empathize with autistic social targets than with non-autistic social targets, and whether autistic participants would be better than non-autistic participants in empathizing with autistic social targets.

Methods

The present method is based on a procedure devised by Zaki and Ochsner [59] and Jospe and colleagues [61] to measure empathic accuracy (EA). A measure of EA is generated by computing the concordance between a perceiver's (the empathizer, the subject of the EA measure) view of a social target (the object of the EA measure) and the target's own report on their internal states [35]. The specific EA paradigm employed in the present study is the type termed by Rum and Perry (2020) *the story inferring paradigm* [64]. It is based on the empathizer's interpretation of a target's videotaped autobiographical story as the stimulus and the correlation between the empathizer's and the target's ratings of how the target felt while storytelling [59, 61, 62, 74].

Previous studies relied mainly on non-neurodivergent storytellers as targets, i.e., participants who are not neurodivergent and have no health or mental health conditions [64]. In the present study, we included both autistic and non-autistic individuals as storytellers to create a novel stimulus set. Other adaptations to the procedure were made following consultation with an advisory committee of five autistic adults (3 females, 2 males), recruited through social media, who reviewed the planned protocol and provided comments and suggestions. These included phrasing instructions and reviewing language (and the collection of qualitative data, not presented in the present paper).

The procedures described below were reviewed by the Cambridge Psychology Research Ethics Committee (PRE.2023.103) and the Hebrew University ethics committee (2025HLE011), and were carried out after participants in both the stimulus developing phase and the data collection phase gave informed consent to participate.

Stimulus

The stimulus included clips of five autistic (two females, two males, one self-identifies as "other") and five non-autistic adults (two females, three males) (henceforward, will be referred to as the "storytellers") who were video-recorded online using the Zoom platform. Each

storyteller was recorded sharing three autobiographical stories. All storytellers were asked to think of autobiographical events that had elicited any sort of emotion in them (without a limitation on the content or which emotions they felt), that could be shared in the framework of a few-minute-long story, and that they are willing to share in a procedure that is being recorded. After the recording, storytellers were asked to watch the recorded clips and instructed to use a sliding scale, anchored at 'negative' on the left and 'positive' on the right to continuously rate the affective valence they had felt while telling the story, such that the rating indicated whether the feeling was positive or negative and also how much positive or negative the feeling was in every moment. The scale's position was recorded every .5s. Right after watching the story, the storytellers were also asked to rate the degree to which they felt 12 emotions (embarrassment, anger, sadness, happiness, disgust, pride, fear, excitement, contentment, stress, calmness, and alertness) on a scale of 0 ("Not at All") to 8 ("Very Much"). These emotions were selected based on previous established empathic accuracy research [61–64] and incorporated basic emotions, theoretically and empirically supported by various models in affective research [75–79], and also included a variety of emotions that reflect positive and negative affect, and described in affective research as high and low on the dimensions of activation/deactivation and pleasant/unpleasant [80]. In the end, storytellers were asked whether they had given the research team permission to use each story in future research.

The five stories of autistic storytellers and the five stories of non-autistic storytellers (mean video length: 2:33 min) selected for presentation to the study participants were drawn from a pool of stories previously collected to build a wide and diverse EA stimulus set. This full set of storytellers comprises 30 autistic adults (16 males; 13 females; 1 identifies as "other") and 18 non-autistic adults (5 males; 13 females). To build this large stimulus set, storytellers were recruited via the Cambridge Autism Research Database (CARD), social media postings, word of mouth, and the Cambridge Psychology Web site for volunteers from the general population interested in taking part in research. To participate, storytellers had to be aged 18 years or older and not be diagnosed with major clinical depression, schizophrenia, or personality disorders, as these conditions in targets were found to be associated with EA performance [64]. Storytellers were defined as autistic or non-autistic based on their own self-reports, and autism diagnosis was not independently verified in the study. All stories were collected using the procedure described above, with each storyteller requested to narrate three stories. To minimize visual or environmental variability across recordings, backgrounds were standardized by asking all

participant storytellers to join the recording Zoom session with a plain, blank background behind them, with no windows, pictures, or shelves (Zoom's blurring or artificial backgrounds were not allowed).

To be included in the stimuli set for the present study, stories had to meet the following criteria: The storytellers gave their consent for use in future studies; Length between 1:30 and 3:30 min; Good technical quality of the recording throughout, including meeting the standardized background requirement; Storytellers had no technical issues with either the recording or the self-rating. Stories in which the storytellers mentioned personal information (such as name or address) or explicitly stated that they are autistic during the storytelling were not eligible for inclusion. After applying these criteria, out of the 144 initially recorded stories, 78 stories were not eligible for inclusion in the present study's stimulus set. The final set of 10 stories selected out of the remaining stories for this study was decided in consultation between the first and second authors to include all recorded genders/sexes and a range of ages, while aiming to choose a set of stimuli balanced in the number of videos with these characteristics and as similar as possible between autistic and non-autistic storytellers. In this process, from each chosen storyteller, we selected the shortest story that met the eligibility criteria. Importantly, across the 10 selected stories, all 12 discrete emotions were reported by storytellers at varying levels. In each story, one or more emotions were rated 0, but the specific emotions receiving a 0-rating differed across stories. Thus, no single emotion was absent across all stories, and no story reflected only one reported emotion. Rather, the selected stories reflected complex combinations of the 12 emotions at varying levels, alongside varying degrees of overall positive-to-negative feeling, according to the storytellers' own reports.

In the EA task, participants (empathizers) are presented with the stimuli (the video-recorded story/ies) and are required to infer the storyteller's emotions using the same valence and discrete emotion rating scales. The reports of the empathizers are compared with reports of the storytellers to extract measures of continuous EA and specific emotions EA.

Participants

A total of 255 participants (perceivers/empathizers; hereafter referred to as "raters") were recruited through the Cambridge Autism Research Database (CARD) and word of mouth. Similar to the procedure for recruiting the storytellers, participants' autism status was defined based on their self-reports, and autism diagnosis was not independently verified in the study. Prior to analysis, 20 were excluded due to: reporting significant background noise when performing the task (eight participants); insufficient information about autism status (e.g., missing

data or reporting being self-diagnosed but not meeting criteria for receiving a formal diagnosis; 11); reporting not understanding the task (one participants). One video response was excluded for two participants due to reported audio issues, and for nine participants due to an incorrect response to an attention check question. The final sample consisted of 235 participants (125 females, 104 males, and six participants who identified as “other”; $M_{\text{age}}=49.09$, $SD=16.41$). Most participants originated from English-speaking countries (56.7% from the UK, 13.5% from the USA, 2.1% from Canada, and 1.7% from Australia), and the rest were English-speakers residing in other countries, including Germany, the Netherlands, Israel, and Brazil. Of the final sample, 141 participants were autistic (51.8% females, 45.4% males, 2.8% identified as “others”; $M_{\text{age}}=47.6$, $SD=16.9$), and 94 were non-autistic (56.4% females, 41.5% males, 2.1% others; $M_{\text{age}}=51.2$, $SD=15.7$) individuals.

Procedure and design

All study information, questionnaires, and the EA task were implemented on an online, secure platform (Qualtrics), and participants completed them from their own computers by clicking the link distributed. After being presented with a clip explaining the EA task, each participant was presented with two stories, one featuring an autistic storyteller and one featuring a non-autistic storyteller, in a two-fold randomized design: the computerized task employed a randomized choice of one of the five clips of autistic/non-autistic storytellers, and a randomized presentation of the order in which an autistic or non-autistic storyteller was presented first or second. Participants were not informed that one of the storytellers was autistic. The randomization procedure also balanced the assignment of a similar number of participants for rating each clip (ranging from 43 to 50 raters per target). While viewing the clip, participants (raters) were asked to continuously rate the storyteller’s valence (positive to negative) feelings, using the same computerized slider as the targets did themselves anchored at “negative” on the left and “positive” on the right, and the scale’s position was recorded every .5s the same way it was for the storyteller’s own ratings. Immediately after each clip, they were asked to rate the specific emotions of the storytellers, again using the same scale the storytellers used, of 0–8 for each emotion. The design of rating two video clips per participant was chosen to reduce the risk of fatigue, dropout, and low-quality responding. Finally, participants were asked to self-report their feelings of empathy and interest towards the storyteller. Self-report measures were included to capture participants’ subjective interpersonal responses to the target. Whereas empathic accuracy indexes how accurately participants infer the target’s emotional state, self-report measures

assess participants’ own perceived empathy and affiliative interest toward the target. Including both types of measures allowed us to also examine whether patterns were specific to accuracy-based empathic inference or also extended to participants’ self-perceived empathic and social responses.

Participants also completed a demographic survey to collect information, including age, sex, and autism diagnosis, and were invited to write any comments or thoughts they had about the study and their participation. The responses to this open-ended question were analyzed using a qualitative approach. By inviting the participants to use their own words to describe their experience of participating and allowing them to provide any comment they wished, we aimed to capture experiences that we could not anticipate, and to allow for contextualized interpretation of the quantitative and experimental results [81–83], taking into account participants’ own perspectives. We took this approach based on recommendations from the autistic advisory committee that provided feedback on the creation of the EA stimuli set, and on research highlighting concerns about inferring inner experience from behavior alone, specifically in the context of autism [84, 85].

Measures

Empathic accuracy (EA)

Continuous valence EA This measure was calculated as the correlation between each participant and the storyteller’s continuous ratings of positive-to-negative feelings (of the storyteller) at each moment of the video-recorded story (using all time points sampled every 0.5s) [86].

Specific emotions EA The absolute distances between the participant’s rating and the storyteller’s rating for each of the 12 emotions were calculated. This scale was reversed, so maximum accuracy in a given emotion received 8 points, and minimum accuracy received 0 points. The sum of all reversed distances reflects the general emotion-recognition accuracy, from 0 to 96. This scale was then rescaled to 0–100 for easier interpretation. The aggregation of the 12 emotions into a single EA score follows established procedures in empathic accuracy research [61–63, 87].

Self-reports

Self-reported empathy Participants were asked to rate the item: “To what extent did you feel empathy towards the storyteller?” on a 0–8 Likert scale, with higher scores indicating greater self-reported feeling of empathy (0 = Not at all, 8 = Very much). No definition of “empathy” was provided prior to the question; rather, this measure reflects

self-reported felt empathy, according to each participant's subjective concept of what "empathy" is.

Empathic interest Participants were asked to rate the item: "How interested are you in hearing another story from this storyteller?" using the same 0–8 scale, as an indirect measure of empathic interest.

Data analysis

Data was analyzed using RStudio software (R Core Team, 2025). To examine the effect of the storyteller's neurotype group on the participants' (raters) EA scores, a mixed linear model was used with fixed effects of storyteller neurotype group (autistic/non-autistic), and raters' neurotype group (autistic/non-autistic), and random intercepts for both by-participants (raters), and by specific story (video clip). The categorical variables of storytellers' and raters' neurotype group were effect-coded (1 = non-autistic, -1 = autistic). The linear mixed-effects models were fitted using the lme4 package in R [88]. A description of the valence ratings alignment over time between each target and the corresponding rater groups was detailed to provide context and to display each target individually for a more nuanced illustration of moment-to-moment empathic accuracy alignment between each storyteller and both rater groups.

Text responses to the open-ended, optional question were thematically analyzed in a qualitative approach. An inductive, data-driven approach was used to identify patterns of information within the data, which converged into key elements [89]. Texts were first divided into basic units for analysis - quotes. A quote was defined as a statement that expressed one central idea and was separated from quotes before or after hand by Punctuation, by changing the main idea expressed, or both. Prior to analysis, each participant's text was assigned a number (participant ID), and each quote was assigned a serial number from 1 to n. Thus, every quote had a number indicating its source. An Excel sheet was used to group quotes with similar sentiments into categories. The analysis began with open coding, where primary repeated patterns in the data were located. Data extracts and initial categories suggested by the second author (NF) were audited by the first author (YR), and disagreements were discussed. When categories were finalized, axial coding and entry criteria for each category were formulated, and then a directed coding analysis continued until all the data were classified into categories. A theoretical integration was then made, and the finalized set of categories was grouped into sub-themes and then into themes, with both authors refining themes until a consensus was reached [81, 82, 89].

Results

Empathic accuracy

Continuous valence EA

The model fitted to examine the continuous valence rating showed a significant intercept ($\beta = 0.303$, $p = .048$), indicating that EA at the reference levels was significantly above zero (the overall ratings across neurotype groups and across participants were positive). No significant main effect was found for rater group ($\beta = -0.018$, $p = .132$) or target group ($\beta = 0.115$, $p = .402$), indicating no meaningful difference between autistic and non-autistic in overall valence "readability" (i.e., how accurate raters were in rating the targets' moment-by-moment positive to negative feelings). The interaction showed a trend-level effect ($\beta = 0.021$, $p = .059$, $d = 0.13$, 95% CI [0.06, 0.32]), suggesting a possible pattern where autistic raters showed relatively higher continuous valence EA toward autistic targets (see Fig. 1), albeit with a small effect size.

Post hoc analyses To test whether autistic raters show higher empathic accuracy for autistic targets, we conducted simple effects analyses using estimated marginal means (model-adjusted means that account for random effects of rater and target). We compared rater groups within each target group (using the emmeans package). Within autistic targets, autistic raters showed higher EA Continuous Valence (estimated marginal $M = 0.228$, $SE = 0.184$) than non-autistic raters (estimated marginal $M = 0.149$, $SE = 0.185$), estimate = 0.079, $SE = 0.033$, $t_{(423)} = 2.38$, $p = .018$, $d = 0.35$, 95% CI [0.014, 0.144]. Within non-autistic targets, there was no significant difference between autistic (estimated marginal $M = 0.415$, $SE = 0.184$) and non-autistic raters (estimated marginal $M = 0.421$, $SE = 0.185$), estimate = -0.006, $SE = 0.033$, $t_{(422)} = -0.19$, $p = .848$, $d = -0.03$, 95% CI [-0.071, 0.059]. The interaction contrast testing the differential effect of rater group across target groups was marginally significant, estimate = 0.085, $SE = 0.045$, $t_{(219)} = 1.89$, $p = .060$, 95% CI [-0.003, 0.173]. These results support an own-group advantage: autistic raters showed a small-to-medium effect size advantage in empathic accuracy for autistic targets, while no meaningful difference was observed for non-autistic raters on non-autistic targets ($d = -0.03$).

Emotion valence over time Here, alignment refers to the degree to which raters' continuous valence judgments track targets' continuous self-reported valence over the course of each video (i.e., similarity of the two time series). For non-autistic targets, the valence ratings alignment over time showed that raters' continuous valence traces generally tracked the targets' self-reported valence with positive alignment (that is, rater and target traces generally move together over time, corresponding to stronger moment-to-moment tracking, as reflected

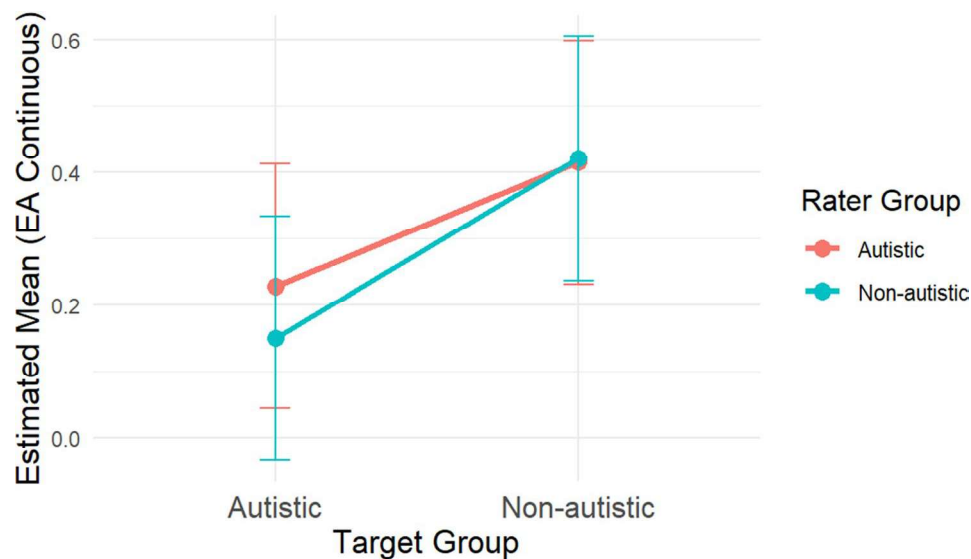


Fig. 1 Adjusted means of continuous valence empathic accuracy by target and rater's group. Note. Points mark the estimated marginal means (EMMs) from a linear model including target group (Autistic vs. Non-autistic), rater group (Autistic vs. Non-autistic), and their interaction; lines connect rater-group means within each target group. Error bars represent 95% confidence intervals around the EMMs. Higher values indicate greater empathic accuracy

in higher continuous EA for that clip), alongside apparent between-target variability. For autistic targets, the valence ratings alignment over time showed positive alignment for some storytellers, alongside pronounced between-target heterogeneity, including near-zero alignment (when the raters' trace shows little correspondence with the target's trace over time, corresponding to weaker tracking, as reflected in EA near zero for that clip). Small target-specific differences emerged between rater groups; non-autistic raters exceeded autistic raters for some targets, while autistic raters exceeded non-autistic raters for others (see Supplementary Materials for figures S5 and S6). This could be interpreted anecdotally as “who is being rated” mattered more than “who is rating.” This pattern is consistent with the mixed-effects results, where target-level variance exceeded rater-level variance (see supplementary).

Specific emotions EA

No significant effects were found for rater group ($\beta = 0.354$, $p = .319$), or target group ($\beta = 1.54$, $p = .108$), nor their interaction ($\beta = 0.719$, $p = .56$) (See Fig. 2).

A further exploratory analysis by specific emotions was conducted using independent t-tests to compare groups on the match between raters' and targets' ratings of each of the 12 emotions. This analysis is presented in full in the supplementary materials. Two differences initially reached statistical significance: autistic raters demonstrated higher empathic accuracy for anger ($p = .037$; $d = 0.205$; specifically, towards non-autistic targets) and alertness ($p = .009$, $d = 0.253$; specifically, towards autistic targets). However, these differences did not hold after

correction for multiple comparisons (Benjamini–Hochberg FDR).

Self-reports measures

Self-reported empathy

The results revealed a main effect of rater group ($\beta = 0.722$, $p < .001$, $d = 0.48$), indicating that non-autistic raters reported significantly higher self-reported empathy ($M = 6.05$, $SD = 1.801$) compared to autistic raters ($M = 4.56$, $SD = 2.486$). No significant effect was found for the target group ($\beta = 0.093$, $p = .648$) or the interaction ($\beta = 0.077$, $p = .288$). The model also revealed relatively large variability in self-reported empathy across individual raters ($SD = 1.614$), suggesting notable individual differences. Variance between targets was smaller ($SD = 0.572$), indicating a limited effect of storyteller identity, and a residual variance ($SD = 1.507$) reflecting trial-level differences.

Empathic interest

A significant main effect was found for rater group ($\beta = 0.546$, $p < .001$, $d = 0.34$), suggesting that non-autistic raters expressed more empathic interest ($M = 4.9$, $SD = 2.45$) compared to autistic raters ($M = 3.83$, $SD = 2.61$). No significant effects were found for the target group ($\beta = 0.002$, $p = .987$) or the interaction ($\beta = 0.073$, $p = .349$).

Descriptive statistics for all measures across rater and target groups are presented below (Table 1).

Multiple-comparison correction was applied to the exploratory family of tests comparing EA across the 12 discrete emotions (Benjamini–Hochberg FDR). The primary analyses comprised four separate pre-specified

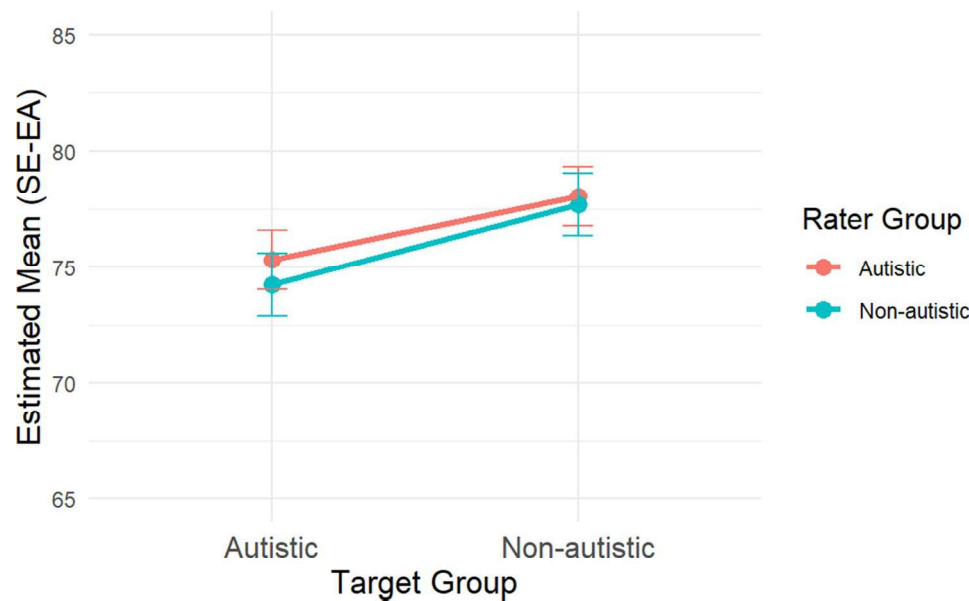


Fig. 2 Adjusted means of specific emotion empathic accuracy by target and rater group. Note. Points represent the estimated marginal means (EMMs) of SE-EA, calculated from a linear model including target group (Autistic vs. Non-autistic), rater group (Autistic vs. Non-autistic), and their interaction. Error bars indicate 95% confidence intervals around the EMMs. Higher values reflect greater accuracy in identifying the target’s specific emotions

Table 1 Descriptive means for each measure by rater and target group

Rater → Target	n	Empathic Accuracy		Self-Reports	
		Continuous Valence (M, SD)	Specific Emotions (M, SD)	Empathy (M, SD)	Empathic Interest (M, SD)
A → A	137	0.267 (0.498)	75.275 (6.079)	4.518 (2.618)	3.898 (2.590)
A → N	138	0.417 (0.284)	78.071 (8.125)	4.609 (2.357)	3.768 (2.648)
N → A	91	0.144 (0.592)	74.201 (5.576)	5.912 (1.811)	4.868 (2.553)
N → N	94	0.426 (0.342)	77.822 (8.174)	6.191 (1.810)	5.011 (2.376)
A → All	275	0.344 (0.409)	76.705 (7.320)	4.564 (2.486)	3.833 (2.615)
N → All	185	0.285 (0.502)	76.011 (7.208)	6.054 (1.811)	4.941 (2.459)
All → All	460	0.321 (0.448)	76.431 (7.276)	5.163 (2.354)	4.278 (2.608)

Note. A=Autistic; N=Non-Autistic

mixed models for distinct outcomes; we did not apply an additional multiplicity adjustment across these models.

Because each participant could view two storytellers of the same or different sex, we conducted a sensitivity analysis in which we refitted the primary models, including a rater-target sex-match term (see supplementary). This term did not significantly predict outcomes, and the pattern of focal inferences was consistent with the primary models.

Full results for all models and figures are available in the supplementary materials.

Qualitative analyses of participants’ text responses

Text responses from participants to the invitation to comment on the study and their participation were analysed qualitatively. An inductive, data-driven approach was employed to identify patterns of information within the texts [90]. Texts were divided into basic units for analysis—quotes: statements that expressed one central idea [91]. Quotes with similar sentiments and repeated patterns in the data were categorized, with initial categories suggested by the second author (NF), and audited by the first author (YR); disagreements were discussed. A theoretical integration was then made, the finalized set of categories was grouped [90], and three main themes were identified: Difficulties Descriptions (Identifying emotions; Performing the EA task); Feedback (Task design; General positive feedback); Personal Interest and Sharing (Interest in the study’s results; Introspection on the EA process; Sharing personal information). Table 2 presents the themes, categories, number of quotes, and examples of text responses for each category.

For autistic respondents, the two most prevalent categories were descriptions of difficulties in identifying emotions and introspection on their abilities and performance. For non-autistic respondents, the most prevalent categories were feedback on the task design and technical issues, and general positive feedback. These two were the least prevalent among the autistic respondents, alongside interest in the results, while among non-autistic respondents, the least prevalent categories were descriptions of difficulties in identifying emotions and performing the task, alongside introspection on their abilities and

Table 2 Main themes and categories of text responses of participants

Theme	Difficulties Descriptions			Feedback		Personal Interest & Sharing		
Category	Identifying Emotions (n quotes) "Text example"	Performing the EA Task (n quotes) "Text example"	Task Design & Technical Issues (n quotes) "Text example"	General Positive Feedback (n quotes) "Text example"	Interest in Results (n quotes) "Text example"	Introspection (n quotes) "Text example"	Personal information (n quotes) "Text example"	
Autistic Respondents	(10) "Emotions are complicated. There is no possible way for me to tell how the speaker is feeling; there may be more than I can see."	(8) "I found it difficult: to follow what was being said when I was trying to work out the emotion at the same time."	(5) "The boxes for putting in the answers (...) should be bigger."	(5) "I'd be happy to do more."	(4) "Would like to see the findings"	(11) "My personal experiences ... closely mirrored those of the two people in the videos, so I may have felt more empathy and understanding for them than if the speakers had been talking about experiences, I was not familiar with."	(5) "... As a late-diagnosed autistic woman ... I've been excluded ... and really struggle to envision any sort of future... Participating in research helps me to at least feel like maybe my responses will do a small way towards helping other autistic people..."	
	(4) "I found it more difficult to assess the emotions of the first speaker. She was smiling throughout the delivery of the story so her feelings were not as clear-cut."	(3) "I found it quite difficult; I was caught up in the story details and at the same time thinking about my own experience related to both scenarios, while trying to read their facial expressions and voice tone."	(11) "A back button might have been helpful."	(10) "I really like the user interface. It's very cool being able to input my thoughts throughout any given point of the video."	(3) "I would be interested to see the results when they're available!"	(3) "Completing the study, I consider that, just like my marking as a teacher and more generally throughout life in all respects, I'm unable to offer high "marks""	(2) "The talks seem very anodyne - I am currently working on people's experience of prejudice"	

performance, and interest in the results. Meaning, while autistic participants mostly described their difficulties and reflected on their performances and abilities, presenting a “self-focused” evaluation of their performance, non-autistic participants rarely provided such descriptions and mostly focused on offering feedback about the study and task design.

Discussion

By employing a naturalistic task that measures multiple facets of empathy - including felt empathy and empathic accuracy - this study revealed nuances of double empathy in autistic and non-autistic people. A novel empathic accuracy story-inferring paradigm stimuli set was used to examine predictions derived from the double empathy problem theory [30, 31], specifically, investigating whether autistic and non-autistic individuals differ in empathizing with autistic versus non-autistic social targets. The findings reveal a nuanced picture of empathic accuracy that challenges simplistic deficit-based models of autism and highlights the complexity of cross-neurotype versus same-neurotype social understanding, alongside notable differences between results based on self-report measures of empathy and those based on task performance. While the results provide partial support for the double empathy problem framework, they also reveal patterns and considerable individual variability that warrant careful interpretation and further investigation.

No significant main effects of rater neurotype or target neurotype on either continuous valence empathic accuracy or specific emotions empathic accuracy were found. In other words, non-autistic participants in this study did not outperform autistic participants in tracking continuous valence or in identifying specific emotions of video-recorded autistic and non-autistic social targets. This finding is not in line with most of the (limited) empathic accuracy literature in the context of autism, which suggested a general difficulty with empathic accuracy among autistic participants [65, 66, 68, 72], or a more specific difficulty around the presentation of embarrassment [66] and anger [73]. These emotions can also be shaped by mental health, trauma, and sensory factors, which we did not assess in the present study and which may be important to examine in future research. For example, the reduced empathic accuracy for embarrassment in autistic participants reported by Adler et al. (2015) was observed in a laboratory-based study [66], whereas in the present study, participants completed the task from their own computers, which may better accommodate the sensory needs of some autistic participants. These results not only challenge the deficit model in autism but also diverge from previous findings of worse performance of

autistic people in tasks designed to measure aspects of empathy [14].

The fact that the stimuli set included autistic social targets and not only non-autistic social targets as in previous studies, might help explain the present study's findings and their divergence from the previous literature in more than one way. First, because participants evaluated both autistic and non-autistic storytellers, autistic raters might have had the opportunity to encounter both less “readable” targets and targets who were more readable and relatable for them. Alexandrovsky et al. (2026) recently showed that autistic adults report stronger relatedness and more positive evaluations of autistic-content videos than non-autistic-content videos when rating and interpreting short social videos [51]. Although our empathic-accuracy task differs in aims and procedures (and our raters were not informed which storytellers were autistic), this work supports the plausibility that including autistic storytellers could alter engagement and subjective “fit” with the stimuli relative to stimulus sets composed only of non-autistic storytellers. It could be that the stories' content or the behavioral nuances of the autistic storytellers were more relatable to them and evoked greater empathy. It could also be that including autistic storytellers had a positive impact on autistic participants' attention, motivation, or both. This speculation is supported by the qualitative analyses of the text responses, which revealed engagement among the autistic participants in the task, including reflections on their difficulties, connections to personal details, and introspections about the empathic process.

In Ponnet et al.'s (2005) study, the better-than-expected empathic accuracy of autistic raters (i.e., performance similar to non-autistic raters) was attributed to their active participation in the task. Similarly, the design of the present study and its stimulus set might have evoked greater engagement on the part of autistic participants, compared to a task in which their rating had not included autistic social targets. It was previously found that knowing that a social target is autistic in an empathic accuracy task improves empathic accuracy towards them among non-autistic raters [63]. In the present study, participants were not informed that some of the storytellers were autistic, yet because the call for participation invited both autistic and non-autistic participants, participants may have been attentive to the possibility of seeing autistic storytellers. It could, thus, be that for autistic individuals, similarly to non-autistic individuals, knowing (or expecting) that a storyteller is autistic positively impacts empathic accuracy. These speculative explanations of greater attention, motivation, or engagement on the part of autistic participants when autistic social targets are included in the study design as the source of

better-than-expected empathic accuracy performance should be directly examined in future research.

Another interesting finding is a trend-level interaction effect for continuous valence empathic accuracy, suggesting that autistic raters may show relatively higher accuracy when tracking the moment-to-moment emotional valence of autistic social targets. Although with a very small effect size, this finding, alongside the overall empathic accuracy that was similar to that of non-autistic raters, offers partial support for the double empathy problem theory. Examination of individual target performance revealed substantial between-target variability within both neurotype groups, with some autistic targets yielding high mean EA scores and others near-zero or negative scores, mirroring similar heterogeneity among non-autistic targets. This implies that individual characteristics of the social targets play a crucial role beyond neurotype group, so the double empathy model is one variable among a complex set associated with a social target's "readability" for autistic and non-autistic raters, the empathizers. Such variables might be storytelling skills, physical appearance, or expressivity [60], and specifically, it could be that autistic and non-autistic people differ in expressive style [92]. Future research should assess the role of such variables within the context of the double empathy model.

Beyond these design-related explanations, the pattern of results also provides some support for neurotype-matching effects. The exploratory analyses of specific emotions revealed that autistic raters demonstrated higher empathic accuracy for two specific emotions: anger and alertness, although these differences were not significant after correction for multiple comparisons. For anger, autistic raters achieved the highest accuracy when rating non-autistic targets, whereas for alertness, they showed superior accuracy when rating autistic targets. The enhanced recognition of alertness within the autistic-to-autistic condition may reflect subtle within-group attunement, aligning with the trend revealed in the continuous empathic accuracy measure, and broadly converging with the double empathy literature [31]. In contrast, the higher accuracy in recognizing anger in non-autistic targets may reflect heightened sensitivity to non-autistic expressions of anger, perhaps due to repeated exposure to anger directed at them in real-world social interactions, as autistic people report experiencing frequent misunderstandings, tensions, and conflicts in social interactions in various environments [93], including in the family [40]. Interestingly, in examining non-autistic people's ability to identify emotions on the faces of autistic and non-autistic people in short videos without sound, Foster et al. (2026) found that non-autistic observers were more accurate at identifying anger in autistic faces than in non-autistic faces.

They suggested that this greater accuracy in perceiving negative emotion could reflect a perceptual bias toward greater negativity when viewing autistic expressers [92]. This finding, "in the opposite direction" from the present exploratory analyses' results, alongside previous conflicting findings of difficulties among autistic participants in identifying anger [73], calls for further research.

The findings from the present exploratory secondary analyses should be interpreted with caution, given the non-significance after correction for multiple comparisons and the mixed findings in the literature. However, they do imply that empathic accuracy may also be emotion-specific rather than a global construct, and that neurotype-matching effects may vary depending on the emotional states being inferred. These differences in two specific emotions did not hold after correction for multiple comparisons, and there were no differences in the overall specific-emotions' empathic accuracy measure, in which all emotions were assessed together. It is possible that the initial significant differences observed in the exploratory analyses were merely the result of multiple comparisons (i.e., statistical "noise"), but it is also possible that assessing empathic accuracy of a group of emotions together is masking nuanced differences between autistic and non-autistic people in some specific emotions. It will be interesting in future research to examine particular emotions more closely within the double empathy model.

Interestingly, a divergence emerged in the present study's findings between the empathic performance discussed above and the self-report measures of empathy and empathic interest. While autistic and non-autistic raters showed comparable objective empathic accuracy, and autistic participants even demonstrated an advantage towards autistic targets, to some extent, non-autistic raters reported significantly higher self-reported empathy and empathic interest, regardless of social targets' neurotype. This dissociation suggests that self-reported empathy may reflect factors beyond actual empathic accuracy, potentially including meta-cognitive awareness, social desirability, or differing conceptualizations of empathy. As no definition of 'empathy' was provided prior to the request from participants to report how much empathy they felt towards the storyteller, the self-reported empathy measure also reflected each participant's subjective concept of what 'empathy' is. This aspect should also be considered when interpreting the divergence between self-reported empathy and empathic accuracy results. Much of the research on empathy and autism is based on self-report measures, and the findings of the present study highlight that the choice of how to operationalize empathy is not only a methodological decision, but also an epistemological one: studying how empathic people believe they are, or how much empathy they feel, does

not necessarily reflect how accurate they are in identifying and understanding others' emotions.

If the present study had employed self-report measures alone, the nuances of partial support for the double empathy problem would have been missed; instead, a simplistic interpretation of support for a deficit model of autism would have emerged. On the other hand, relying solely on empathic accuracy performance might have painted a partial picture as if empathizing with others is not at all a challenge for autistic people. The self-report measures, alongside the notable theme of difficulties in performing the task, emerged from the qualitative analyses imply that the autistic participants were less confident in their performance, reported less empathy and interest than non-autistic participants, and perhaps ultimately underestimated their empathic abilities. Employing both measures allowed for capturing more of this complex process of empathizing, which includes both self- and other-aspects, and thus for a more nuanced understanding of the double empathy challenge in the context of autism.

In summary, the present study's findings provide a nuanced account of partial support for the double empathy problem model. As for the first hypothesis that non-autistic participants would better empathize with non-autistic social targets than with autistic social targets, it was partially supported by the (trend level) interaction effect in the continuous tracking of positive to negative emotions. Across the four measures, raw mean scores indicated greater empathy among non-autistic raters towards non-autistic targets; however, these differences did not reach significance in the statistical model, meaning, after accounting for individual differences in the target and the raters' level. In the self-report measures, this trend of higher empathy towards non-autistic targets among non-autistic raters did not reach significance, perhaps due to a ceiling effect, as non-autistic participants reported high empathy towards targets from both groups.

As for the question of whether autistic participants would better empathize with autistic social targets than with non-autistic social targets, although some text responses could be interpreted in this direction, the quantitative data measures did not suggest such a trend. It could be that previously found effects of better communication transfer [39], emotional connection and bond [42, 43] in autistic-autistic interaction compared to autistic-non-autistic interaction involve not solely empathy but also other factors such as identity and attitude. For example, in examining autistic and non-autistic participants interacting within autistic, non-autistic, and mixed autistic-non-autistic dyads, Efthimiou et al. (2025) found that autistic participants reported lower rapport regardless of their partner's diagnostic status, though awareness

of their partner's diagnostic status had a moderating effect. Additionally, it is important to note that findings from a one-time experimental design measuring empathy towards a stranger do not necessarily apply to real-life, long-term interpersonal relationships, which are beyond the scope of the present study. Lastly, regarding the question of whether autistic participants would be better than non-autistic participants at empathizing with autistic social targets, the findings imply such a trend, again, by the trend-level interaction and the post hoc analyses, suggesting that autistic participants rated autistic targets slightly better than non-autistic raters did.

However, despite the comparable performance of the autistic raters, this does not reflect in their self-reported empathy. Furthermore, the text responses suggest that some autistic participants are preoccupied with the perceived difficulty of tracking others' emotions. Autistic participants provided detailed, reflective insights, showing high metacognitive awareness of the task's emotional and cognitive demands. While their objective performance on empathic accuracy tasks was comparable to, or even better than, that of non-autistic participants, their qualitative comments more frequently reflected confusion and uncertainty. Bervoets et al. (2021) connect mistaken assumptions about the objectivity of uncertainty to the double empathy problem and argue that uncertainty is not a fixed, objective feature of stimuli but depends on expectations and how prediction errors are weighted [84]. This perspective may help interpret why autistic participants' text responses more often emphasized the task's difficulty than non-autistic participants did. Speculatively, dynamic social-affective tracking may subjectively feel less stable or more effortful for some autistic participants, independent of overall accuracy.

Taking all findings together, it could be that autistic participants tend to be less aware of or underestimate their empathic abilities. This possible explanation might align with research on metacognitive monitoring in autism, showing that meta-level judgments about one's own performance may be reduced on average and heterogeneous across metacognitive task formats, compared to non-autistic individuals [94]. It would be interesting to examine in future research whether this might be related to what autistic people hear about their abilities from others, or to their own concepts of the social challenges of autism, and to their awareness that autism is defined by difficulty in social communication [95]. As these factors were not measured or addressed in the present study, these speculative interpretations should be treated as directions for future research rather than explanations for the present quantitative results.

Another possible explanation for the divergence between empathic accuracy and self-report measures results is that autistic individuals might be less prone

to social desirability than non-autistic individuals, and thus less inclined to report higher empathy because it is socially expected, though this, as well, remains speculative. It would be interesting to assess differences in social desirability in the context of empathy and autism in future studies, although assessing socially desirable responding in autistic samples might involve distinct methodological challenges and non-equivalent interpretations of common self-report bias indices [96] - considerations that should inform future measure selection and interpretation.

Limitations

The results, interpretations, and conclusions discussed above should be considered within the scope of the study and its limitations. First, it utilized an experimental design in which participants responded to videos of strangers on a screen. This design is more ecological than those that rely on still pictures or text vignettes to measure empathy, but it still carries much distance from real-world social interaction, which tends to involve less structured, more “noisy” stimuli and demands more immediate, real-time responses. The video-based format may also offer richer cues than real-life interactions [73], and participants had an “ideal” environment in which to perform the task (on their own computers). The findings are also limited in their generalizability regarding empathy in the context of a relationship or social interaction with a familiar person.

Second, the distribution and recruitment methods for this study might yield samples with unique characteristics. The autistic group is composed of autistic individuals who are able to engage in a computerized task, read, comprehend detailed instructions, and independently activate an online interface. There are individuals on the autism spectrum who would require support to perform such tasks, and such individuals are not represented in the sample. It is also possible that participants, particularly autistic participants, who chose to take part in the study had greater self-awareness or a personal interest in communication and empathy. As for the non-autistic sample, respondents to a call for participation seeking autistic and non-autistic participants might attract non-autistic participants with a special interest in autism, such as relatives of autistic people. Future studies could benefit from a more detailed characterization of the samples to control for important demographics, and including a measure of autistic traits among both autistic and non-autistic participants might also be valuable.

Of course, larger numbers of targets and sample sizes in future studies could help detect small effects that are still valuable to identify. While the design of rating two videoclips per participant allowed for relatively large-scale data collection with minimal threats to the validity

and quality of the data collected from raters’ responses due to fatigue, dropout, and low-quality responding, it also limited experimental control over clip-level factors such as narrative style and the storyteller’s expressivity. We addressed this in two ways: multiple targets per group in the stimulus set, and random intercepts for target identity in all primary models. Still, target-group differences may partly reflect features of the sampled videos in addition to neurotype-related tendencies. Beyond the storyteller neurotype, empathic accuracy varied across individual target videos. This between-target heterogeneity (described in the Results) may partly reflect clip differences in emotional intensity, emotion profiles, and stylistic storyteller characteristics in addition to neurotype. The small number of targets (videos of storytellers) in the stimulus set also limits its ability to represent autistic and non-autistic populations more generally. Thus, these preliminary and stimulus-bound findings should be replicated with a larger target set.

Lastly, although we applied eligibility and balancing criteria when selecting the stimuli for the empathic accuracy task, we could not systematically match stories on thematic content, and residual differences in topic and narrative focus may remain between individual targets and between autistic- and non-autistic-target videos. Moreover, judgments of whether stories are similar or different in content and theme are partly subjective and depend on interpretation; attempts to equate stimuli on these dimensions are therefore inherently limited, and what one might treat as comparable might reasonably be viewed differently by another. Relatedly, thematic and emotional differences between autistic and non-autistic storytellers are not necessarily nuisances to be eliminated: to the extent that such differences might reflect genuine variation in how emotional experiences are conveyed and understood across neurotypes, overly strict “matching” could obscure phenomena that are central to double-empathy accounts of mutual understanding. More broadly, the empathic accuracy paradigm is relatively ecological in that it uses real autobiographical narratives rather than standardized stimuli; that strength comes with trade-offs, including less experimental control over story content than in fully standardized tasks. Thus, the same ecological feature that improves relevance to everyday social inference also limits tight stimulus control, and findings should be interpreted accordingly.

Conclusions

Given the dyadic nature of empathy, both the target and the empathizer contribute to empathy and empathic accuracy. The empathizer’s ability to accurately infer the target’s thoughts and feelings depends not only on their states and traits but also on the various characteristics of the target. This study considered the neurotype of the

target, the empathizer, and the target–empathizer interaction to present nuances of double empathy. While it challenges simplistic deficit-based models of empathy in autism and provides partial support for the double empathy problem theory, it also highlights individual variability and divergences between performance in and feelings of empathy and challenges in empathy, which warrant further investigation. Future research should examine whether these patterns extend to spontaneous interactions, test the role of specific individual characteristics beyond neurotype, and investigate whether awareness of empathic strengths improves autistic individuals' self-perception and social confidence.

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s13229-026-00723-2>.

Supplementary Material 1

Author contributions

YR conceptualized the research question, YR & NF conducted the literature review, led data collection, contributed to statistical analysis, and drafted the manuscript. All authors contributed to the study concept and design, data interpretation, and writing of the manuscript.

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Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The research procedures were reviewed by the Cambridge Psychology Research Ethics Committee (PRE.2023.103) and the Hebrew University ethics committee (2025HLE011), and were carried out after participants in both the stimulus developing phase and the data collection phase gave informed consent to participate, and voluntary participation as well as confidentiality were kept in accordance with the Declaration of Helsinki.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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References

1. Happé F, Frith U. Annual Research Review: Looking back to look forward – changes in the concept of autism and implications for future research. *J Child Psychol Psychiatry*. 2020;61(3):218–32. <https://doi.org/10.1111/jcpp.13176>.
2. Jackman A, Zwaigenbaum L. The History of Autism Spectrum Disorder. In: Eisenstat DD, Goldowitz D, Oberlander TF, Yager JY, editors. *Neurodevelopmental Pediatrics*. Cham: Springer International Publishing; 2023. pp. 215–26. https://doi.org/10.1007/978-3-031-20792-1_12.
3. American Psychiatric Association, editor. *Diagnostic and statistical manual of mental disorders: DSM-5*. 5 ed. Washington, DC: American Psychiatric Assoc; 2013. p. 947.
4. Cummins C, Pellicano E, Crane L. Autistic adults' views of their communication skills and needs. *Int J Lang Commun Disord*. 2020;55(5):678–89. <https://doi.org/10.1111/1460-6984.12552>.
5. Black MH, Clarke PJF, Deane E, Smith D, Wiltshire G, Yates E, et al. That impending dread sort of feeling: Experiences of social interaction from the perspectives of autistic adults. *Res Autism Spectr Disord*. 2023;101:102090. <https://doi.org/10.1016/j.rasd.2022.102090>.
6. Baron-Cohen S. Theory of mind and autism: a review. *International Review of Research in Mental Retardation*. Academic; 2000. pp. 169–84. [https://doi.org/10.1016/S0074-7750\(00\)80010-5](https://doi.org/10.1016/S0074-7750(00)80010-5).
7. Baron-Cohen S, Leslie AM, Frith U. Does the autistic child have a theory of mind? *Cognition*. 1985;21(1):37–46.
8. Baron-Cohen S, Campbell R, Karmiloff-Smith A, Grant J, Walker J. Are children with autism blind to the mentalistic significance of the eyes? *Br J Dev Psychol*. 1995;13(4):379–98. <https://doi.org/10.1111/j.2044-835X.1995.tb00687.x>.
9. Frith U. *Autism: Explaining the enigma*, 2nd ed. Malden: Blackwell Publishing; 2003. ix, 249 p. (Autism: Explaining the enigma, 2nd ed).
10. Happé F. Autism as a neurodevelopmental disorder of mind-reading. *J Br Acad*. 2015;3. <https://doi.org/10.5871/jba/003.197>.
11. Frith U, Frith CD. Development and neurophysiology of mentalizing. *Philos Trans R Soc Lond B Biol Sci*. 2003;358(1431):459–73. <https://doi.org/10.1098/rstb.2002.1218>.
12. Gaigg SB. The interplay between emotion and cognition in autism spectrum disorder: implications for developmental theory. *Front Integr Neurosci*. 2012;6. <https://doi.org/10.3389/fnint.2012.00113>.
13. Schwenck C, Mergenthaler J, Keller K, Zech J, Salehi S, Taurines R, et al. Empathy in children with autism and conduct disorder: group-specific profiles and developmental aspects. *J Child Psychol Psychiatry*. 2012;53(6).
14. Baron-Cohen S. Another advanced test of theory of mind: evidence from very high functioning adults with autism or asperger syndrome. *J Child Psychol Psychiatry*. 1997;38(7).
15. Rutherford MD, Baron-Cohen S, Wheelwright S. Reading the Mind in the Voice: A Study with Normal Adults and Adults with Asperger Syndrome and High Functioning Autism. *J Autism Dev Disord*. 2002;32(3):189–94. <https://doi.org/10.1023/A:1015497629971>.
16. Baron-Cohen S. The extreme male brain theory of autism. *Trends Cogn Sci*. 2002;6(6):248–54.
17. Baron-Cohen S. Autism. The Empathizing–Systemizing (E–S) Theory. *Ann N Y Acad Sci*. 2009;1156(1):68–80. <https://doi.org/10.1111/j.1749-6632.2009.04467.x>.
18. Castelli F, Frith C, Happé F, Frith U. Autism. Asperger syndrome and brain mechanisms for the attribution of mental states to animated shapes. *Brain*. 2002;125(8):1839–49.
19. Cuff BMP, Brown SJ, Taylor L, Howat DJ. Empathy. A Review of the Concept. *Emot Rev*. 2016;8(2):144–53. <https://doi.org/10.1177/1754073914558466>.
20. Baron-Cohen S. *Zero degrees of empathy: a new theory of human cruelty*. Perseus Books Group; 2011.
21. Baron-Cohen S, Wheelwright S. The empathy quotient: an investigation of adults with Asperger syndrome or high functioning autism, and normal sex differences. *J Autism Dev Disord*. 2004;34:163–75.
22. Davis MH. Empathy: negotiating the border between self and other. In: The social life of emotions. In: Leach W, editor. In L. Z. Tiedens & C. Cambridge University Press; 2004. pp. 19–42. <https://doi.org/10.1017/CBO9780511819568.003>.
23. Decety J, Bartal IBA, Uzefovsky F, Knafo-Noam A. Empathy as a driver of prosocial behaviour: highly conserved neurobehavioural mechanisms across species. *Philos Trans R Soc B Biol Sci*. 2016;371(1686):20150077. <https://doi.org/10.1098/rstb.2015.0077>.
24. Uzefovsky F, Knafo-Noam A. *Empathy development throughout the life span*. Social Cognition. Routledge; 2016. pp. 89–115.

25. Decety J, Jackson PL. The Functional Architecture of Human Empathy. *Behav Cogn Neurosci Rev*. 2004;3(2):71–100. <https://doi.org/10.1177/1534582304267187>.
26. Smith A. The Empathy Imbalance Hypothesis of Autism: A Theoretical Approach to Cognitive and Emotional Empathy in Autistic Development. *Psychol Rec*. 2009;59(3):489–510. <https://doi.org/10.1007/BF03395675>.
27. Shalev I, Warrier V, Greenberg DM, Smith P, Allison C, Baron-Cohen S, et al. Reexamining empathy in autism: Empathic disequilibrium as a novel predictor of autism diagnosis and autistic traits. *Autism Res*. 2022;15(10):1917–28.
28. Shalev I, Uzevovsky F. Empathic disequilibrium in two different measures of empathy predicts autism traits in neurotypical population. *Mol Autism*. 2020;11(1):59. <https://doi.org/10.1186/s13229-020-00362-1>.
29. Kimber L, Verrier D, Connolly S. Autistic People's Experience of Empathy and the Autistic Empathy Deficit Narrative. *Autism Adulthood*. 2024;6(3):321–30. <https://doi.org/10.1089/aut.2023.0001>.
30. Milton D. On the ontological status of autism: the 'double empathy problem'. *Disabil Soc*. 2012;27(6):883–7. <https://doi.org/10.1080/09687599.2012.710008>.
31. Milton D, Gurbuz E, López B. The 'double empathy problem': Ten years on. *Autism*. 2022;26(8):1901–3. <https://doi.org/10.1177/13623613221129123>.
32. Brewer R, Bioti F, Catmur C, Press C, Happé F, Cook R, et al. Can Neurotypical Individuals Read Autistic Facial Expressions? Atypical Production of Emotional Facial Expressions in Autism Spectrum Disorders. *Autism Res*. 2016;9(2):262–71. <https://doi.org/10.1002/aur.1508>.
33. Sheppard E, Pillai D, Wong GTL, Ropar D, Mitchell P. How easy is it to read the minds of people with autism spectrum disorder? *J Autism Dev Disord*. 2016;46:1247–54.
34. Edey R, Cook J, Brewer R, Johnson MH, Bird G, Press C. Interaction takes two: Typical adults exhibit mind-blindness towards those with autism spectrum disorder. *J Abnorm Psychol*. 2016;125(7):879.
35. Ickes W. Empathic Accuracy. *J Pers*. 1993;61(4):587–610. <https://doi.org/10.1111/j.1467-6494.1993.tb00783.x>.
36. Cheang RT, Skjervling M, Blakemore AI, Kumari V, Puzzo I. Do you feel me? Autism, empathic accuracy and the double empathy problem. *Autism*. 2024;13623613241252320. <https://doi.org/10.1177/13623613241252320>.
37. Sasson NJ, Faso DJ, Nugent J, Lovell S, Kennedy DP, Grossman RB. Neurotypical peers are less willing to interact with those with autism based on thin slice judgments. *Sci Rep*. 2017;7(1):40700.
38. Chen YL, Senande LL, Thorsen M, Patten K. Peer preferences and characteristics of same-group and cross-group social interactions among autistic and non-autistic adolescents. *Autism*. 2021;25(7):1885–900. <https://doi.org/10.1177/13623613211005918>.
39. Crompton CJ, Ropar D, Evans-Williams CV, Flynn EG, Fletcher-Watson S. Autistic peer-to-peer information transfer is highly effective. *Autism*. 2020;24(7):1704–12. <https://doi.org/10.1177/1362361320919286>.
40. Heasman B, Gillespie A. Perspective-taking is two-sided: Misunderstandings between people with Asperger's syndrome and their family members. *Autism*. 2018;22(6):740–50. <https://doi.org/10.1177/1362361317708287>.
41. Black MH, Kuzminski R, Wang J, Ang J, Lee C, Hafidzuddin S, et al. Experiences of Friendships for Individuals on the Autism Spectrum: A Scoping Review. *Rev J Autism Dev Disord*. 2024;11(1):184–209. <https://doi.org/10.1007/s40489-022-00332-8>.
42. Watts G, Crompton C, Grainger C, Long J, Botha M, Somerville M, et al. A certain magic' – autistic adults' experiences of interacting with other autistic people and its relation to Quality of Life: A systematic review and thematic meta-synthesis. *Autism*. 2025;29(9):2239–53. <https://doi.org/10.1177/13623613241255811>.
43. Crompton CJ, Hallett S, Ropar D, Flynn E, Fletcher-Watson S. I never realised everybody felt as happy as I do when I am around autistic people': A thematic analysis of autistic adults' relationships with autistic and neurotypical friends and family. *Autism*. 2020;24(6):1438–48. <https://doi.org/10.1177/1362361320908976>.
44. DeBrabander KM, Morrison KE, Jones DR, Faso DJ, Chmielewski M, Sasson NJ. Do First Impressions of Autistic Adults Differ Between Autistic and Nonautistic Observers? *Autism Adulthood*. 2019;1(4):250–7. <https://doi.org/10.1089/aut.2019.0018>.
45. Morrison KE, DeBrabander KM, Jones DR, Faso DJ, Ackerman RA, Sasson NJ. Outcomes of real-world social interaction for autistic adults paired with autistic compared to typically developing partners. *Autism*. 2020;24(5):1067–80. <https://doi.org/10.1177/1362361319892701>.
46. Crompton CJ, Foster SJ, Wilks CEH, Dodd M, Efthimiou TN, Ropar D, et al. Information transfer within and between autistic and non-autistic people. *Nat Hum Behav*. 2025;9(7):1488–500. <https://doi.org/10.1038/s41562-025-02163-z>.
47. Efthimiou TN, Lewis S, Foster SJ, Wilks CEH, Dodd M, Jiménez-Sánchez L, et al. Diagnostic status influences rapport and communicative behaviours in dyadic interactions between autistic and non-autistic people. *PLoS ONE*. 2025;20(8):e0330222. <https://doi.org/10.1371/journal.pone.0330222>.
48. Foster SJ, Jones DR, Pinkham AE, Sasson NJ. Facial Affect Differences in Autistic and Non-Autistic Adults Across Contexts and Their Relationship to First-Impression Formation. *Autism Adulthood*. 2025;7(5):581–93. <https://doi.org/10.1089/aut.2023.0199>.
49. Foster SJ, Ackerman RA, Wilks CE, Dodd M, Calderon R, Ropar D, et al. Rapport in same and mixed neurotype groups of autistic and non-autistic adults. *Autism*. 2025;29(7):1700–10. <https://doi.org/10.1177/13623613251320444>.
50. Crompton CJ, Sharp M, Axbey H, Fletcher-Watson S, Flynn EG, Ropar D. Neurotype-matching, but not being autistic, influences self and observer ratings of interpersonal rapport. *Front Psychol*. 2020;11. <https://doi.org/10.3389/fpsyg.2020.586171>.
51. Alexandrovsky M, Ai W, Yu JX, Cunningham WA, Lai MC. Social evaluation of neurotype-dependent media contents in autistic and non-autistic adults. *Autism Adulthood*. 2026;25739581261416455. <https://doi.org/10.1177/25739581261416455>.
52. Komeda H, Kosaka H, Saito DN, Mano Y, Jung M, Fujii T, et al. Autistic empathy toward autistic others. *Soc Cogn Affect Neurosci*. 2015;10(2):145–52. <https://doi.org/10.1093/scan/nsu126>.
53. Komeda H, Kosaka H, Fujioka T, Jung M, Okazawa H. Do individuals with autism spectrum disorders help other people with autism spectrum disorders? An investigation of empathy and helping motivation in adults with autism spectrum disorder. *Front Psychiatry*. 2019;10. <https://doi.org/10.3389/fpsyg.2019.00376>.
54. Baron-Cohen S, Wheelwright S. The Empathy Quotient: An Investigation of Adults with Asperger Syndrome or High Functioning Autism, and Normal Sex Differences. *J Autism Dev Disord*. 2004;34(2):163–75. <https://doi.org/10.1023/B:JADD.0000022607.19833.00>.
55. Davis MH. Measuring individual differences in empathy: evidence for a multi-dimensional approach. *J Pers Soc Psychol*. 1983;44(1):113.
56. Baron-Cohen S, Wheelwright S, Hill J, Raste Y, Plumb I. The Reading the Mind in the Eyes Test Revised Version: A Study with Normal Adults, and Adults with Asperger Syndrome or High-functioning Autism. *J Child Psychol Psychiatry*. 2001;42(2):241–51. <https://doi.org/10.1111/1469-7610.00715>.
57. Neumann DL, Chan RC, Boyle GJ, Wang Y, Westbury HR. Measures of empathy: Self-report, behavioral, and neuroscientific approaches. *Meas Personal Soc Psychol Constr*. 2015;257–89.
58. Westbury HR, Neumann DL. Empathy-related responses to moving film stimuli depicting human and non-human animal targets in negative circumstances. *Biol Psychol*. 2008;78(1):66–74.
59. Zaki J, Ochsner K. The Need for a Cognitive Neuroscience of Naturalistic Social Cognition. *Ann N Y Acad Sci*. 2009;1167(1):16–30. <https://doi.org/10.1111/j.1749-6632.2009.04601.x>.
60. Zaki J, Bolger N, Ochsner K. It Takes Two: The Interpersonal Nature of Empathic Accuracy. *Psychol Sci*. 2008;19(4):399–404. <https://doi.org/10.1111/j.1467-9280.2008.02099.x>.
61. Jospe K, Genzer S, klein Selle N, Ong D, Zaki J, Perry A. The contribution of linguistic and visual cues to physiological synchrony and empathic accuracy. *Cortex*. 2020;132:296–308.
62. Genzer S, Ong DC, Zaki J, Perry A. Mu rhythm suppression over sensorimotor regions is associated with greater empathic accuracy. *Soc Cogn Affect Neurosci*. 2022;17(9):788–801.
63. Rum Y, Genzer S, Golan O, Allison C, Baron-Cohen S, Perry A. Empathy and interest towards an autistic person and the effect of disclosing the diagnosis. *J Autism Dev Disord*. 2025 Apr;9. <https://doi.org/10.1007/s10803-025-06802-2>.
64. Rum Y, Perry A. Empathic accuracy in clinical populations. *Front Psychiatry*. 2020;11:457.
65. Aan Het Rot M, HogeneIst K. The influence of affective empathy and autism spectrum traits on empathic accuracy. *PLoS ONE*. 2014;9(6):e98436.
66. Adler N, Dvash J, Shamay-Tsoory SG. Empathic Embarrassment Accuracy in Autism Spectrum Disorder. *Autism Res*. 2015;8(3):241–9. <https://doi.org/10.1002/aur.1439>.
67. Bartz JA, Zaki J, Bolger N, Hollander E, Ludwig NN, Kolevzon A, et al. Oxytocin Selectively Improves Empathic Accuracy. *Psychol Sci*. 2010;21(10):1426–8. <https://doi.org/10.1177/0956797610383439>.

68. Demurie E, De Corel M, Roeyers H. Empathic accuracy in adolescents with autism spectrum disorders and adolescents with attention-deficit/hyperactivity disorder. *Res Autism Spectr Disord*. 2011;5(1):126–34.
69. Ponnet K, Buysse A, Roeyers H, De Corte K. Empathic Accuracy in Adults with a Pervasive Developmental Disorder During an Unstructured Conversation with a Typically Developing Stranger. *J Autism Dev Disord*. 2005;35(5):585–600. <https://doi.org/10.1007/s10803-005-0003-z>.
70. Ponnet K, Buysse A, Roeyers H, De Clercq A. Mind-Reading in Young Adults with ASD: Does Structure Matter? *J Autism Dev Disord*. 2008;38(5):905–18. <https://doi.org/10.1007/s10803-007-0462-5>.
71. Ponnet KS, Roeyers H, Buysse A, De Clercq A, Van Der Heyden E. Advanced Mind-Reading in Adults with Asperger Syndrome. *Autism*. 2004;8(3):249–66. <https://doi.org/10.1177/1362361304045214>.
72. Roeyers H, Buysse A, Ponnet K, Pichal B. Advancing Advanced Mind-reading Tests: Empathic Accuracy in Adults with a Pervasive Developmental Disorder. *J Child Psychol Psychiatry*. 2001;42(2):271–8. <https://doi.org/10.1111/1469-7610.00718>.
73. McKenzie K, Russell A, Golm D, Fairchild G. Empathic Accuracy and Cognitive and Affective Empathy in Young Adults With and Without Autism Spectrum Disorder. *J Autism Dev Disord*. 2022;52(5):2004–18. <https://doi.org/10.1007/s10803-021-05093-7>.
74. Zaki J, Ochsner K. The cognitive neuroscience of sharing and understanding others' emotions. Empathy: From bench to bedside. Cambridge, Massachusetts: MIT Press; 2011. pp. 207–26.
75. Tracy JL, Randles D. Four Models of Basic Emotions: A Review of Ekman and Cordaro, Izard, Levenson, and Panksepp and Watt. *Emot Rev*. 2011;3(4):397–405. <https://doi.org/10.1177/1754073911410747>.
76. Ekman P, Cordaro D. What is Meant by Calling Emotions Basic. *Emot Rev*. 2011;3(4):364–70. <https://doi.org/10.1177/1754073911410740>.
77. Izard CE. Forms and Functions of Emotions: Matters of Emotion–Cognition Interactions. *Emot Rev*. 2011;3(4):371–8. <https://doi.org/10.1177/1754073911410737>.
78. Levenson RW. Basic emotion questions. *Emot Rev*. 2011;3379–86. <https://doi.org/10.1177/1754073911410743>.
79. Panksepp J, Watt D. Panksepp: What is basic about basic emotions? Lasting lessons from affective neuroscience. *Emot Rev*. 2011;387–96. <https://doi.org/10.1177/175407391141074>.
80. Posner J, Russell JA, Peterson BS. The circumplex model of affect: An integrative approach to affective neuroscience, cognitive development, and psychopathology. *Dev Psychopathol*. 2005;17(3):715–34.
81. Creswell JW, Clark VP. Mixed methods research. Thousand Oaks CA [Internet]. 2007 [cited 2026 Mar 29]. Available from: <https://www.cambridgeenglish.org/Images/735110-studies-in-language-testing-volume-43.pdf#page=53>.
82. Creswell JW, Clark VLP. Designing and conducting mixed methods research. Sage; 2017.
83. Bölte S. The power of words: Is qualitative research as important as quantitative research in the study of autism? *Autism*. 2014;18(2):67–8. <https://doi.org/10.1177/1362361313517367>.
84. Bervoets J, Milton D, de Cruys SV. Autism and intolerance of uncertainty: an ill-fitting pair. *Trends Cogn Sci*. 2021;25(12):1009–10. <https://doi.org/10.1016/j.tics.2021.08.006> PubMed PMID: 34686441.
85. Jaswal VK, Akhtar N. Being versus appearing socially uninterested: Challenging assumptions about social motivation in autism. *Behav Brain Sci*. 2019;42:e82.
86. Genzer S, Ong DC, Zaki J, Perry A. Mu rhythm suppression over sensorimotor regions is associated with greater empathic accuracy. *Soc Cogn Affect Neurosci*. 2022;(February):1–14. <https://doi.org/10.1093/scan/nsac011>.
87. Israelashvili J, Sauter D, Fischer A. How well can we assess our ability to understand others' feelings? Beliefs about taking others' perspectives and actual understanding of others' emotions. *Front Psychol*. 2019;10:2475.
88. Bates D, Mächler M, Bolker B, Walker S. Fitting linear mixed-effects models using lme4. *J Stat Softw*. 2015;67:1–48.
89. Birks M, Mills J. Grounded theory: a practical guide [Internet]. 2022 [cited 2026 Mar 29]. Available from: <https://www.torrossa.com/gs/resourceProxy?an=5409511&publisher=FZ7200>.
90. Birks M, Mills J. Grounded theory: a practical guide. 2022;1–100.
91. Ayalon Y, Sabar Ben-Yehoshua N. The process of content analysis according to grounded theory. *Qual Data Anal*. 2010;359–82.
92. Foster SJ, Dunn D, Patel S, Pinkham AE, Ackerman RA, Sasson NJ. Discrepancies between feeling and expressing: Perceptions of autistic and non-autistic emotional expressions by non-autistic observers. *Autism*. 2026;30(4):914–30. <https://doi.org/10.1177/13623613251415129>.
93. Beck KB, MacKenzie KT, Kumar T, Breitenfeldt KE, Chang JC, Conner CM, et al. The World's Really Not Set Up for the Neurodivergent Person: Understanding Emotion Dysregulation from the Perspective of Autistic Adults. *Autism Adult-hood*. 2026;8(1):68–78. <https://doi.org/10.1089/aut.2023.0214>.
94. Carpenter KL, Williams DM. A meta-analysis and critical review of metacognitive accuracy in autism. *Autism*. 2023;27(2):512–25. <https://doi.org/10.1177/13623613221106004>.
95. American Psychiatric Association D. Diagnostic and statistical manual of mental disorders: DSM-5 [Internet]. Vol. 5. American psychiatric association Washington, DC. 2013 [cited 2024 Oct 26]. Available from: https://www.academia.edu/download/38718268/csl6820_21.pdf.
96. Sher MA, Oliver C. Assessment of self-report response bias in high functioning autistic people. *Psychiatry Psychol Law*. 2023;30(3):229–48. <https://doi.org/10.1080/13218719.2021.2006097>.

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