

Animal faux pas: Two legs good four legs bad for theory of mind, but not in the
broad autism spectrum

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ABSTRACT

Research shows that the general population varies with regards to both autistic traits and theory of mind (ToM) ability. Other work has shown that autistic individuals may not under-perform on ToM tests when the agent of evaluation is anthropomorphic rather than typically human. Two studies examined the relation between ToM and autistic trait profiles in over 650 adults using either the standard Faux Pas Recognition Test (FPT) or an anthropomorphised version (FPTa). Results showed that autistic trait profiles were related to faux pas detection ability in the FPT but not the FPTa. Furthermore, while those with the broad autism phenotype scored significantly worse than those who were typically developed on the FPT, scores did not significantly differ on the FPTa. These findings add to a growing body of work suggesting that ToM ability is not at a global deficit in those on the autistic spectrum, but may relate to the mindreading of specifically human agents.

Keywords: broad autism phenotype, autism theory of mind, anthropomorphism, perspective taking, faux pas

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Autistic people are characterized as having certain traits indicative of social and communicative differences, and restricted interests and repetitive behaviours (American Psychiatric Association, 2013). Following the discovery that autistic traits often appear in parents and siblings of autistic people (Piven, Palmer, Jacobi, Childress, & Arndt, 1997) these traits are now understood to be more broadly distributed throughout the general population (Wainer, Ingersoll, & Hopwood, 2011). The Broad Autism Phenotype (BAP) is a term used to describe a section of the population who, despite lacking a formal diagnosis, share many of the same cognitive features as those with a clinical diagnosis of autism (Sucksmith, Roth & Hoekstra, 2011).

One process often found to be altered in both autistic people and those with the BAP is theory of mind (ToM), or the ability to take another's perspective (Fink, Begeer, Peterson, Slaughter, & de Rosnay, 2015; Gökçen, Frederickson & Petrides, 2016). Difficulties with ToM have been linked longitudinally to poorer social outcomes (Peterson, Slaughter, Moore, & Wellman, 2016), and struggles with everyday social skills (Frith, 1994). Determining what underlies these deficits, and how it may be compensated for in the BAP, is less understood. It is hypothesized that impairments seen in clinical groups likely extend to non-clinical groups with a high degree of similar traits (Livingstone & Happe, 2013), and so knowledge about underlying ToM deficits in autistic people will be used to hypothesize about ToM in those with the BAP.

One theory as to why autistic people may struggle with ToM throughout development is that they may have increased motivation to interact with non-social stimuli, such as objects or pictures of objects, which interferes with the automatic processing of social stimuli (Cascio, Foss-Feig, Heacock, Newsom, 2012). As people with the autistic phenotype have been shown

to possess heightened perceptual processing abilities and exhibit restricted interests and expertise within particular domains (Mottron, Dawson, Soulieres, Hubert, & Burack, 2006), it may be that processing stimuli in relation to those interests comes at the detriment of attending to more social stimulus outside of those preferred domains (Sasson, Turner-Brown, Holtzclaw, Lam & Bodfish, 2008).

Others however theorize that social impairments in ASD have less to do with the increased salience of non-social stimulus, and more to do with relative insensitivity and decreased rewards from social interaction (Chevallier, Kohls, Troiani, Brodtkin, & Schultz, 2012). For instance, in TD populations, attending to social stimulus releases neurohormonal rewards (Izuma, Saito & Sadato, 2008). As studies indicate that autistic people have reduced neural reward activation when processing voices (Abrams, Lynch, Cheng, Phillips, Supekar, et al., 2013), and reduced physiological responses towards human facial emotions (Sepeta, Tsuchiya, Davies, Sigman, Bookheimer, et al., 2012), it may be that differences in social sensitivity negatively affects ToM specialization .

However, there is evidence that rather than being insensitive to social stimulus, autistic people may be less sensitive to specifically *human* stimulus. Support for this can be found in studies showing that when TD infants begin to preferentially recognize human faces, infants at risk of ASD do not (Chwarska & Volkmar, 2007), though both populations preferentially attend to face-like shapes throughout early infancy (Elsabbagh & Johnson, 2013). In research on the uncanny valley, a phenomenon in which TD people become increasingly unsettled the more a non-human stimulus appears human (Mori, 1970), autistic individuals may have higher thresholds for human ‘uncanniness’ (Ueyama, 2015). For instance, autistic people rate robots who appear ‘uncanny’ as attractive rather than ‘eerie’ (Destephe, Zecca, Hashimoto, & Takanishi, 2014), and become relaxed rather than uncomfortable the more humanlike a robot behaves (Pioggia, Igliazzi, Ferro, Ahluwalia, Muratori et al., 2005). In sum, it appears that

the sensitivity to human stimuli observed in typical populations does not extend to autistic populations, and instead autistic people may feel more comfortable with the human-like rather than the typically human.

Indeed, research suggests that social processing patterns often found to be atypical in autistic populations may be preserved when the social agent in question is non-human or human like rather than typically human (for a review see Atherton & Cross, 2018). This includes preserved facial processing (Whyte, Behrmann, Minshew, Garcia, & Scherf, 2016), and even improved emotion recognition towards non-human social agents (Brosnan, Johnson, Grawmeyer, Chapman & Benton, 2015). Autistic people also appear to be more socially engaged when interacting with non-human social stimuli. Grandgeorge, Degrez, Alavi & Lemonnier (2016) found that children with ASD showed no particular area of interest when looking at human faces, unlike controls who inordinately direct attention to eye regions, but when presented with animal faces autistic subjects spent a significantly longer time looking at eyes than any other facial area, meaning they may be able to engage with non-human faces in socially typical ways.

Several interventions indicate non-human social engagement can boost ToM and broader social development. For instance, Golan, Ashwin, Granader, McClintock, Day et al., (2010) developed a ToM intervention using anthropomorphic vehicles that was able to improve autistic children's understanding of emotions, while the field of robotics shows promise in increasing social behaviours in autistic people towards androids (Barakova, Bajracharya, Willemsen, Lourens, & Huskens, 2015). Even interventions that allow people with autism to interact with animals has been shown to boost human-led therapeutic interventions (Silva, Correia, Lima, Magalhães, & de Sousa, 2011). These findings, coupled with research showing that autistic people often prefer non-human to human agents in both lab-based assessment (Silva, Da Fonseca, Esteves, Deruelle, 2015) and naturalistic social settings (Celani, 2002),

indicate that autistic people may be more motivated to engage with social agents who are not typically human, which in turn boosts social processing abilities.

As individuals with the BAP have been shown to share the same underlying autistic traits, including dampened neurohormonal social reward responses (Scheele, Kendrick, Khouri, Kretzer, Schläpfer et al., 2014), it is feasible that the processing patterns towards non-human social agents found in clinical groups also extend throughout the wider spectrum. Several studies indicate that they do. For instance, an investigation into sensitivity towards human agency showed that both children diagnosed with ASD, and their parents (used to represent the BAP), gave higher overall impressions of ‘humanness’ for an android than TD families, leading to the conjecture that higher thresholds for ‘uncanniness’ may be indicative of the autism phenotype (Kumazaki, Warren, Swanson, Yoshikawa, Matsumoto et al., 2018).

Collectively, these studies have several implications for social processing differences in the broad autism spectrum. First, they suggest that while both ASD and BAP populations have a somewhat attenuated social sensitivity towards specifically human agency, this sensitivity may be preserved when agents are non-human. Most importantly, it appears that presenting individuals with non-human agents may allow those on the spectrum to achieve commensurate or even enhanced mental state understanding compared to their TD peers (Brosnan et al., 2015). As noted, the majority of studies have shown this pattern of findings in those with a clinical diagnosis of ASD. Whether the same patterns of non-human sensitivity and social understanding can also be found with those with the BAP requires further exploration.

In the majority of the studies used to distinguish human and non-human social understanding, testing methods have relied almost exclusively on visual paradigms (Bottini, 2018). Research has shown that autistic people have distinct perceptual profiles, including

heightened sensitivity to detail and pattern formation (Mottron et al., 2006), and often use rules to decode emotions in faces (Rutherford & McIntosh, 2007). Taking this into account, it may be that the exaggeration of emotional expressions in non-human stimuli such as cartoons allow for atypical processing strategies, such as using explicit rules, to aid emotion decoding (Brosnan et al., 2013). Thus, it can be argued that when autistic and BAP samples pass ToM tasks with non-human agents, they may be relying on atypical strategies that build off their heightened sensory processing abilities.

In order to control for these possible confounds, this study developed and employed a non-visual ToM test in an effort to explore the ability to decode human versus non-human mental states for those with the BAP. Study 1 first investigated the relationship between ASD traits and ToM when the social agents of interest were human in order to confirm that individuals with the BAP were indeed at a disadvantage when using ToM with human stimuli. We hypothesised that ToM scores in a BAP sample would be lower than their TD counterparts. Study 2 then investigated how those with the BAP would perform compared to TD participants when the social agents were represented as non-humans. We hypothesised that those with the BAP would have equivalent ToM scores to their TD counterparts.

Study 1

Methods

Participants

Students from the University of Houston participated in this study (n=345, 287 females, Mage=21.31, range 18-65). Average level of college attainment was some. There were no exclusion criteria for this study. Participants were recruited from SONA, an online research platform and were given course credit for participation as well as the chance to win one of twenty \$20 Amazon gift cards. The sample size was specified at the design stage based on

power analysis suggesting 35 people were needed in each cell to achieve 80% power to detect small to medium effect size for a between samples t tests. It is estimated that as few as 8% (Maxwell, Parish-Morris, Hsin, Bush & Schultz; 2013), while as many as 30% (Wheelwright, Auyeung, Allison, & Baron-Cohen, 2010) of the general population can be characterized as having the broader autism phenotype. Therefore a total sample range of around 350 was targeted in order to reach an n of 35 individuals who would be considered as displaying the BAP, using a conservative estimate of 10% of our sample would display the BAP. All responses were anonymous, and this research was conducted in line with ethical standards of practice, with ethical approval granted from the University of Houston's Institutional Review Board.

Design & Procedure

The Autism Spectrum Quotient (AQ) (Baron-Cohen et al., 2001) and the Faux Pas Recognition Test (FPT) (Stone, Baron-Cohen & Knight, 1998) were used to measure ASD related traits and advanced ToM ability respectively. Both have been used within the general population to demonstrate the ability to detect individual differences in relation to these traits and abilities (Ahmed & Stephen Miller, 2011; Gökçen, Frederickson & Petrides, 2016). This study employed a between groups design with one subject variable AQ score. Participants were later divided into one of two groups (BAP / TD) based on their AQ scores (see below for details of how these groups were formulated). The dependent variable was faux pas detection as measured by the FPT.

This study was run online using Qualtrics. After providing consent, participants were presented asked their gender, age, and level of educational attainment. Following this, they completed the FPT, where they read the 20 stories (order randomised) presented one at a time, after reading a given story they responded to questions regarding these stories. After

completing this section of the survey, participants then completed the AQ. This order of assessment was employed to control for carryover negative self-appraisals in individuals who endorsed a large frequency of items pertaining to deficits in ASD (as is suggested by Skorich et al., 2016). Participants received the AQ in the original format and were asked to choose the corresponding response which best described their level of agreement in relation to a 4-point scale ranging from strongly disagree and strongly agree. Half of the items are reverse scored. Following completion of both the FPT and the AQ, participants were presented with a debriefing statement in a new screen which explained the aims of the study.

Materials

The AQ is a measure of ASD related traits and is an indicator of a person's quantitative proximity to individuals who are diagnosed with ASD when situated on a continuum of disorder-related traits (Bearden & Freimer, 2006). Research has shown that the AQ measures the same latent traits in both clinical and non-clinical population (Murray, Booth, McKenzie, & Kuenssberg, 2016). The AQ typically uses a binary scoring system (Baron-Cohen et al., 2001), which involves scoring the 50 items by awarding as one point for each item endorsed (items participants marked with the responses "somewhat agree" and "strongly agree"), and 0 points for each item not endorsed (marked with "somewhat disagree" and "strongly disagree") as receiving 0 points. A total score with a maximum score of 50 is then computed by summing the total number of points awarded for each of the questions. A cut-off score of 26 can then be used to identify those in the general population whose scores are elevated in line with clinical samples, as in the Baron-Cohen et al., (2001) original study, where 83% of clinical samples, compared to 8% of those in the general population, scored in this range.

The FPT is a measure of advanced ToM ability, and it specifically measures one's understanding of social norm violations (Stone et al., 1998). This measure was selected due to

its non-visual nature and its ability to reveal ToM variation in adults within the general population (Ahmed & Miller, 2011). Research on the FPT has been shown to correspond to teacher ratings of children's social functioning (Banerjee & Henderson, 2001), and rates of peer rejection (Banerjee & Watling, 2005). Several studies have shown that the FPT is able to distinguish between adults with ASD and controls (Thiébaud, White, Walsh, Klargaard, Wu, Rees, & Burgess, 2016).

The FPT is composed of 20 stories. The FPT stories describe social situations, ten of which contain a faux pas, and ten that do not. Faux pas stories test two separable aspects of ToM: cognitive ToM, in which one must represent the knowledge state of a character, and affective ToM, in which one must represent the emotional state of another character (Shamay-Tsoory, & Aharon-Peretz, 2007). For example, in one narrative a woman invites her cousin over for dinner, and during the evening the cousin *doesn't realize* (cognitive ToM) that when he states that he doesn't like apple pie, he has *hurt his cousin's feelings* (affective ToM), as this was the kind of pie she had baked. A non-faux pas story consists of situations in which one character may behave thoughtlessly (cognitive ToM), such as forgetting a library card, or where a character may experience hurt emotions (affective ToM), such as losing a part in a play. However, non-faux pas stories do not contain both elements, in which one character thoughtlessly or unintentionally causes harm to another emotionally.

After reading each story, participants are asked to identify whether anything awkward took place. Answer choices were either "yes" or "no." Each response is scored a 1 if correct or a 0 if incorrect and a total score is then computed (0-20) by summing each of the questions. In the original FPT manual by Stone, Baron-Cohen and Knight (1998), participants are given the FPT orally and after first identifying whether a faux pas occurred, engage in 5 additional free response questions that further probe ToM understanding. While effective at probing different aspects of ToM reasoning, using this traditional testing method prohibits a large-scale study of

this magnitude. However, findings from Thiébaud et al., (2016) suggest that testing participants on the first yes/no question in the original FPT alone can differentiate between ASD and TD samples. Therefore, this study also used this shortened FPT protocol in order to test a suitably large sample.

Results and Discussion

Both the AQ and the FPT data failed to meet the assumptions of normality (p 's $<.001$). Data were examined for outliers using box plots in line with recommendations by Field (2015), however excluding outliers did not allow the data to meet the assumptions of normality. Therefore no outliers were excluded and non-parametric statistics were used. A non-parametric correlation was performed to establish whether the expected relationship between the AQ and ToM scores of the entire sample was present. Analysis revealed a significant negative correlation between the FPT and AQ Scores ($r_s = -.128$, $n=345$, $p=.018$) suggesting that lower scores on the AQ correlated with higher scores on the FPT.

BAP and TD groups were then formulated based on individuals AQ scores in line with recommendations by Baron-Cohen et al., (2001) and previous studies assessing autistic traits in the general population (Eriksson, 2013). Specifically, the BAP group included every participant who scored 26 and above on the AQ, which included 59 participants (17% of the total n). A matched TD group was then formulated comprising of the 59 participants with the lowest AQ scores. The use of a low AQ control group was formulated based on previous research excluding the middle group of AQ scorers (e.g. Bayliss, & Tipper, 2005). An independent samples Mann Whitney U test was performed to explore whether there was a significant difference in FPT scores between those who possess the BAP versus low AQ scorers (those with TD). Those with the BAP scored significantly worse on the FPT than those who were TD ($U = 2,200$, $Z = 2.53$, $p = .011$, $r = 0.23$). See table 1 for all descriptive statistics.

[Insert table 1 here]

In line with past research, these results indicate that ToM performance is impaired as a function of ASD related traits in the general population (Gökçen, Frederickson, & Petrides, 2016). This provides further evidence validating the use of the FPT as a ToM measure in the general population (Ahmed & Miller, 2011) as it can reveal meaningful differences that map to ASD traits, as it has been shown to do in clinical populations (Thiébaud et al., 2016). Furthermore, while the FPT was originally developed to be scored along a number of dimensions, this study indicates that, similarly to Thiébaud et al., (2016), faux pas recognition alone can discriminate between individuals with high and low autistic traits. This is the first work however to show that this shortened version of the FPT can discriminate even between members of the general population with different degrees of autistic traits. Like previous studies, it has been shown that those on the BAP struggle to perform ToM tasks when the object of evaluation is human. We then investigated whether the same relation between AQ and FPT scores held when agents of evaluation in the FPT were non-human, and whether differences between BAP and TD groups remained significant.

Study 2

Methods

Students from the University of Houston participated in this study (n=330, 264 females, Mage=22.14, range 18-45). The average level of educational attainment was some college experience. Anybody who had previously took part in study 1 was automatically excluded from this study (hence the slightly lower sample size). The design, procedure and materials were identical to study 1, except the FPT was replaced with a modified anthropomorphic version (FPTa). All stories were changed from typical human situations to closely matched stories that had an animal context. One example was story 1, where a boy overhears a classmate talking

about him in a bathroom stall. For the FPTa this story was changed to a story about a horse who overhears another horse talking about him in a stable stall. All details were kept as close possible to the original while the characters and environment of the story was anthropomorphised. An example of the original and anthropomorphised version of story 1 can be found below, and a copy of all original and anthropomorphised stories can be found in appendix 1.

Original Story 1 - Mike had just started at a new school. He was in one of the stalls in the bathroom at school. Joe and Peter, two of his classmates, came in and were standing at the sinks talking.

Joe said, "You know that new guy in the class? His name's Mike. Doesn't he look weird? And he's so short!"

Mike came out of the stall and Joe and Peter saw him.

Peter said, "Oh hi, Mike! Are you going out to play football now?"

Animal Story 1 - Bronco had just started racing at a new track. He was in one of the stalls in the barn of the track. Mare and Stallion, two of the other racehorses, trotted in and stood by the feeders talking.

Mare said, "You know that new horse at the track? His name's Bronco. Doesn't he look weird? And he's so short!"

Bronco came out of the stall and Mare and Stallion saw him.

Stallion said, "Oh hi, Bronco! Are you going out to race now?"

Multiple anthropomorphised versions of the FPT stories were first produced by the two researchers. Both the researchers and multiple faculty members at the University of Houston then compared the new stories to their original counterparts and agreed upon a final set of the most representative versions. These were then piloted, twenty participants were presented with the original FPT stories and the FPTa stories and asked to pair each human story with the animal story that most closely matched it's narrative. This pilot produced a 100% match rate.

Results and Discussion

Data for both the AQ and the FPTa failed to meet the assumptions of normality (p 's $<.001$). Removing outliers (using the same procedure as in study 1) did not allow the data to meet the assumptions of normality, therefore no outliers were excluded. A non-parametric correlation was performed to establish whether a relationship between ASD predictor and ToM scores of the entire sample was still present when the object of evaluations were no longer human. There was not a significant correlation between the FPTa and AQ ($r_s = -.073$, $n=330$, $p=.148$) suggesting that AQ no longer correlated with the anthropomorphised version of the FPT. BAP and TD groups were then formulated based on individuals AQ scores in exactly the same way as study 1. The BAP group included 46 participants (14% of the total n) as did the matched TD group. An independent samples Mann Whitney U test was then performed to explore whether there was a significant difference in FPTa scores between BAP and TD groups. The BAP group did not score significantly worse on the FPTa than the TD group ($U = 1216$, $Z = 1.247$, $p = .213$, $r = 0.13$). See table 2 for descriptive statistics.

[insert table 2 here]

General Discussion

This work highlights several important findings. First, in line with previous work into the BAP, it appears that ToM performance on the original FPT is lower when autistic traits are elevated in individuals within the general population (Gökçen, Frederickson, & Petrides, 2016). This indicates that, in line with Livingston and Happe (2017), while the trait expression of those with the BAP may not warrant a clinical diagnosis, they do differ with regards to ToM relative to those with a lower frequency of such traits. Research such as this is further proof that there is more individual difference with regards to adult ToM ability than is generally understood. Secondly, study 2 indicates that ToM differences between high and low AQ scorers

did not persist when the target of mental state evaluation was non-human, in line with results from clinical samples (Brosnan et al., 2015).

A number of ToM measures have been found to discriminate between adults in the general population in relation to their ASD related traits. However, the FPT is somewhat unique in that it uses a non-visual, non-auditory testing paradigm as a measure of ToM. Furthermore, while many assessments of adult ToM rely on increasingly higher order ToM representations, requiring adults to place significant load on executive functioning and working memory abilities, the FPT relies on the ability to contextualize social interaction. Thus, while it can be argued that its written presentation limits its generalizability to dynamic social encounters, it equally has strengths as a generalizable assessment in that it tests how an individual would apply ToM skills in familiar, everyday situations. Importantly for the current research design, the written form of the FPT presents the opportunity to eliminate the sensory aspects of ToM situations that may unequally affect those with and without a high number of ASD traits. Thus, by using a non-visual, non-auditory measure in the present study, it was possible to reduce ToM to a measure of social cognitive ability independent of sensory processing differences.

Our results indicate that when individuals with the BAP take the FPT with the original, human characters as the social agents of interest, they perform significantly worse than TD individuals. While this is not the first study to show that the FPT can reveal ToM differences within the general population (Ahmed & Miller, 2011), it is the first to show that it can discriminate between BAP and TD individuals, and do so through the use of a shortened, online version of the task.

Notably, when the FPT was presented in the context of animal rather than typically human agents and settings, there was no longer an overall relation between FPT scores and ASD traits of the full sample, nor was there a significant difference between the ToM

performance of BAP and TD participants. This is significant for several reasons. Firstly, it shows that when an object of social evaluation is non-human rather than human, people with the BAP perform equally to those who are TD. More importantly, this finding indicates that people with the BAP do not have a global ToM deficit. Indeed, they can perform equally to TD populations when social agents are non-human rather than human.

Due to the fact that this study employed a ToM testing paradigm that was devoid of sensory detail, it becomes easier to rule out previous hypotheses linking perceptual sensitivities to enhanced interest and ability with regards to non-human stimuli. For instance, interest and efficacy in anthropomorphic stimuli in autistic people has also been explained as the product of the heightened availability of visual clues that can help decode ToM, such as the exaggeration often present in cartoon (Rhodes, Brennan & Carey, 1987) and animal expressions (Borgi & Cirulli, 2016), and the heightened motion in animal movement that can be used to decode mental states (Tami & Gallagher, 2009). As the animal version of the FPT did not provide any additional sensory cues dependent upon agent type, it is unlikely that this is what drove improved ToM ability in this task. However, it remains a possibility that the animal FPT stories contained more imaginative contextual detail, which may have cued the interest of participants in the BAP group more than the human FPT stories (Atherton, Lummis, Day & Cross, 2018).

Another possible explanation for these findings is that perhaps autistic people do not find human stimuli more difficult to decode, but find them less interesting. While not directly assessed, it is possible that this is what accounts for our findings. For instance, both stories used the same narrative construction to relay the appearance or absence of a faux pas, and were identical in complexity. The animal characters in the second study were essentially the human characters; they simply resided in different habitats and were referred to by their species rather than their names. People on the BAP did not show relative deficits in decoding these stories

relative to TD participants, indicating that ToM ability was intact. However, their weakened performance on the human version indicated that something other than ability may be influencing their performance. As research shows that individuals engage in tasks that they find rewarding, and that this has a significant impact on performance (Chevallier et al., 2012), understanding motivation to engage with ToM rather than pure ability may be of particular interest in conceptualizing differences in the BAP.

Together, these results suggest two important things. First, results show that people on the BAP do not have global ToM deficits in all contexts, they specifically have deficits in human contexts, as shown in study 1. This cannot be explained by global ToM deficits, as study 2 shows intact ability. Therefore, it may be that individuals on the BAP were not as engaged when completing the human ToM tasks as compared to those with lower autistic traits. In contrast, as ToM deficits were ameliorated with the use of anthropomorphic stimuli, it may be that differences in motivation become equalized between groups when mentalizing about non-humans. Perhaps an ability to perform at level with NT individuals may alone makes non-human social engagement particularly attractive to this population, as has been suggested by work examining social preference patterns in clinical samples (Celani, 2002).

It remains unclear why the animal agents in the second version of the FPT would be able to reduce differences between those with and without the BAP, particularly as it is conjectured that how one reasons about human mental states should serve as the model for how one thinks about non-human mental states (Epley, Waytz & Cacioppo, 2007). As seen in studies on autism and the Social Attribution Task, in which ToM is measured through recognising human agency in moving shapes (Abell, Happe & Frith, 2000), it would be presumed that people with high BAP traits would decline in ToM when decoding animal agents relative to human agents, in line with the TD group. The fact that our study revealed an ability on par with non-BAP samples when thinking about the non-human suggests that while people

without the BAP use a human proxy to understand non-human characters, reflecting their human-specific expertise, it may be that people with a high degree of autistic traits use a different process less reliant on human comparisons. This may reflect the type of atypical processes that Livingstone & Happe (2013) suggest people with a high degree of autistic traits use to compensate for implicit deficits. Improving an understanding of how this compensatory process occurs, and why it occurs with the non-human rather than the human, is of future interest.

This study has several limitations worth noting. First, this study explored autistic traits and anthropomorphic ToM engagement in a non-clinical sample. Future research should extend this work to include clinical populations. This study also employed a ToM task that relied upon high verbal ability. Such work is not easily replicated to include those on the spectrum who experience lower verbal abilities. When replicating with clinical samples, it will be of interest to test ToM in ways that allow for wider participation regardless of verbal ability. This study's reliance on an online presentation also meant that we inevitably lost an element of control. As with any online work, despite requesting participants completed the survey, alone, in private and in a quiet place this cannot be guaranteed. This study also used a measure that, while revealing differences between the samples of interest, also saw ceiling effects in FPT test scores. Further testing should determine whether anthropomorphized versus human ToM abilities differ using measures with greater variability in scores.

Finally, this study had a largely female sample, which is not typical of studies of autism. However, research suggests that the conceptualization of autism as a largely male condition is slowly changing, in line with the recognition of a bias with regards to classification of males and females, as research shows women generally require more severe symptoms to warrant an autism diagnosis (Russell, Ford, Steer, & Golding, 2010). Indeed, recent work indicates that both males and females with a clinical diagnosis score at the high end of the AQ with no

significant sex differences (Ruzich, Allison, Smith, Watson, Auyeung et al., 2015) and a recent large-scale ToM assessment found an absence of typical sex differences (typically a female advantage) when assessing autistic samples of both genders (Baron-Cohen, Bowen, Holt, Allison, Auyeung et al., 2015). This indicates that while females with high autistic traits may present differently than males in everyday life, and may correspondingly be treated differently, they likely share the same cognitive markers as their male counterparts, making research such as this, despite a heavily female sample, generalizable to the wider spectrum.

In conclusion, in line with our hypotheses, these studies revealed that mentalizing impairments in BAP populations can be ameliorated when social agents are depicted as non-human rather than human. These findings have been shown using a non-visual task, eliminating the possibility that sensory differences underlie this finding. As the stories were identical in complexity and structure, it is unlikely that people with the BAP are universally impaired in ToM relative to TD populations. Instead, they are likely less expert in their understanding of human agents, while also displaying intact expertise when decoding animal stories relative to controls. Further research should attempt to replicate this pattern using a variety of ToM paradigms, investigate the type of strategies autistic people traits utilize when assessing the mental states of human versus non-human agents, and explore whether non-human ToM can be used to build expertise in human ToM.

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Table 1.

Descriptive statistics for the AQ & FPT measures for Study 1.

Group	AQ Total				FPT Total			
	M	SD	Mdn	Range	M	SD	Mdn	Range
BAP	28.31	2.12	28.04	26-36	17.23	2.36	17.86	12-20
TD	11.41	2.39	11.73	3-14	18.41	1.9	19.03	10-20

Table 2.

Descriptive statistics for the AQ & FPTa measures for Study 2.

Group	AQ Total				FPTa Total			
	M	SD	Mdn	Range	M	SD	Mdn	Range
BAP	28.15	2.55	27.47	26-36	16.22	3.2	17.43	9-20
TD	11.24	1.48	11.5	6-13	17.15	2.5	17.77	10-20