Autistic traits and loneliness in autism are associated with increased tendencies to anthropomorphise

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Abstract

Anthropomorphism – the attribution of human qualities to non-human objects – is believed to be a natural tendency which may serve several adaptive functions. One possibility is that anthropomorphism provides an egocentric heuristic by which we can understand the world. It may also be a strategy for reducing our subjective sense of loneliness. However not all humans exhibit the same propensity to anthropomorphise. Recent findings suggest that autistic individuals may be more likely to anthropomorphise than non-autistic individuals. In Study 1 we conducted a large-scale survey of autistic traits and dispositional anthropomorphism in the general population (n = 870). We found that individuals who reported having more autistic traits had an increased dispositional tendency to anthropomorphise non-human entities. In Study 2 we more closely examined variation in anthropomorphism tendencies in a sample of autistic adults (n = 90) to better understand what might drive increased anthropomorphism in this population. We found that those with greater anthropomorphism tendencies experienced greater levels of self-reported loneliness. We propose that increased anthropomorphism might reflect reduced opportunities for social connection for autistic people and those with more autistic traits.

Anthropomorphism is the tendency to attribute human qualities (including intentions and emotions) to non-human entities (Epley, Waytz, & Cacioppo, 2007).. For example, one might think their computer is being intentionally uncooperative when it stops working. Whilst it is largely accepted that humans have a universal capacity to anthropomorphise (Darwin, 1872; Freud, 1930; Hume, 1957), there are also marked individual differences in the tendency to adopt this attribution style (e.g. Cullen, Kanai, Bahrami, & Rees, 2014; Neave, Jackson, Saxton, & Hönekopp, 2015). There is now growing recognition that this variation is likely driven by a range of psychological determinants, including anxiety, insecurity and the need or desire for 'closeness' (see Kwok, Crone, Ardern, & Norberg, 2018 for a review).

Understanding individual differences is one of the longest-standing empirical pursuits of the psychological sciences – and recent work has begun to investigate how and why anthropomorphism varies. Much of this work has been influenced by Epley and colleagues' (2008) theoretical framework which proposes that there are three psychological factors that influence an individual's tendency to anthropomorphise. These include (1) elicited knowledge, (2) effectance motivation and (3) sociality motivation. These factors are argued to interact in predicting whether an individual is likely to anthroporphise, given their personal disposition, current context and the cultural and developmental influences to which they have been exposed. First, with respect to 'elicited knowledge', the framework suggests that humans are better-equipped to understand how the human mind works than they are at understanding non-human entities and objects (e.g., foreign animals or a new technology). Second, 'effectance motivation' is argued to relate to the human drive to effectively use and interact with both human and non-human entities by predicting their behaviour with reference to human attributions. Of most relevance to the present study, Epley's model also suggests that 'sociality motivation' may further encourage anthropomorphism. Specifically, Epley and colleagues argue that chronic loneliness and social disconnection might motivate the

attribution of human qualities to non-human agents, in order to satisfy the basic human need for belongingness and secure human attachments (Epley, Akalis, Waytz, & Cacioppo, 2008; Epley et al., 2007). This motivation may be strongest when human-human relationships are not available. For instance, lonely individuals might seek comfort and connectedness by establishing social relationships with soft toys or pets (e.g., Tai, Zheng, & Narayanan, 2011). The framework further suggests that people may be differentially influenced by *sociality motivation* depending on their disposition (e.g., chronic loneliness), current situation (e.g., socially isolated), developmental history (e.g., insecure parental attachment) or culture (e.g., individualism versus collectivism; Epley et al., 2007). Indeed, direct links between loneliness and anthropomorphism have been demonstrated. For example, research has shown that lonely people are more likely to anthropomorphise compared to those who are not lonely, and that experimental manipulations of loneliness (e.g., reminding individuals of a close and supportive relationship) is sufficient to reduce anthropomorphism (e.g., Bartz, Tchalova, & Fenerci, 2016; Shin & Kim, 2020).

In line with Epley's 'sociality motivational' tenet of anthropomorphism, recent research has identified that anthropomorphism tendencies are more common in certain populations who are more likely to experience chronic loneliness such as autistic people (e.g., Causton-Theoharis, Ashby, & Cosier, 2009; Mazurek, 2014; White & Remington, 2018), those who are socially-isolated (e.g., obsessive-compulsive hoarders; Neave et al., 2015; Norberg, Crone, Kwok, & Grisham, 2018) or those who have anxious attachment styles (see Kwok et al., 2018 for review). A recent online survey of the first-hand experiences of anthropomorphism in autistic (n = 87) and non-autistic (n = 263) adults, revealed that anthropomorphism was more common in autistic adults (White & Remington, 2018). These findings initially seem paradoxical, given that autism is believed to be partly characterised by difficulties in representing the mental states and emotions of others (reduced Theory of Mind:

e.g. Baron-Cohen, 1995; Senju, Southgate, White, & Frith, 2009) and in recognising emotional states in the self (alexithymia, Bird & Cook, 2013). There have also been suggestions that metacognition – the understanding of one's own perceptions, feelings, goals, intentions, knowledge and beliefs (Carruthers, 2009) – can be diminished in autism (Carpenter, Williams, & Nicholson, 2019). This further implies that autistic people may be less likely to assign such attributes to other entities. Indeed, in Epley's original account (Epley et al 2007), he proposed that a Theory of Mind is critical for anthropomorphism and, as such, named autistic people as an example of those who would be expected to show *reduced* anthropomorphic tendencies. A deficit in Theory of Mind in autistic people, however, is much contested (see Milton, 2012 for an alternative account). We suggest instead that the over-attribution of human-like mental and emotional states to non-human entities may reflect a compensatory mechanism for lacking human-human social interaction and connectedness in autistic individuals. This is supported by independent findings in which autistic individuals report increased experiences of chronic loneliness, social disconnection and stigmatisation (Causton-Theoharis et al., 2009; Mazurek, 2014; Sasson et al., 2017). One likely explanation is that autistic individuals are lonely due to reduced opportunity for social connection. This may be due to increased stigmatisation (Gelbar, Smith, & Reichow, 2014; Obeid et al., 2015) or a failure of non-autistic individuals to understand or relate to autistic individuals (see Milton, 2012 on the Double Empathy Problem). Indeed, recent evidence shows that non-autistic individuals are less likely to engage in social interactions with autistic individuals, and are prone to rate them less favourably on first impressions than non-autistic individuals (Sasson et al., 2017).

It has been demonstrated, in the general population, that anthropomorphism reduces subjective loneliness, presumably by increasing affiliation with objects that thereby become easier to predict and understand (Epley et al., 2008). Given these findings, and those of

increased loneliness in autism, one potential explanation for the individual differences in anthropomorphism observed across the wider population, may be autistic traits. Autism may present one extreme of a continuous distribution (or multiple distributions) of differences in social and cognitive styles or traits (see Kamp-Becker et al., 2010; Kim et al., 2019 for a discussion of the debate regarding categorical and dimensional approaches to autism). The 'broader autism phenotype' account suggests that these traits may extend to non-autistic relatives and the broader 'neurotypical' population (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001; Landry & Chouinard, 2016). Given that differences in social cognition, information processing and experiences of loneliness and disconnection are characteristics of autism, they are also likely to be represented across the broader autism phenotype. Indeed, autistic traits have been found to positively associate with self-reported loneliness, as well as fewer and/or shorter-lived friendships (Jobe & White, 2007; also see Lamport & Zlomke, 2014). As such, it is possible that individual differences in autistic traits may be associated with differences in anthropomorphism.

The first aim of the current study was to test this directly. Specifically, we asked whether the experience of autistic traits, as measured using the Autism Quotient 10 (AQ10; Allison, Auyeung, & Baron-Cohen, 2012), was associated with individual differences in one's propensity to attribute human qualities to non-human objects and entities as assessed using the Anthropomorphism Quotient (AnthQ; Neave et al., 2015). We anticipated that those who experience more autistic traits would also experience increased tendencies to anthropomorphise.

The second aim of the current study was to address the outstanding question of why the tendency to anthropomorphise is greater in autistic people (White & Remington, 2018) – and perhaps those with more autistic traits. One suggestion is that anthropomorphism in autism may be driven by loneliness; something that is also consistent with previous findings

that loneliness in the general population is positively correlated with anthropomorphism tendencies (Bartz et al., 2016; Epley, Akalis, et al., 2008). A preliminary suggestion regarding this link has been made qualitatively in our previous work (White & Remington, 2018). Here, autistic adults reported that anthropomorphised agents played a role in helping with social disconnectedness. No study, however, has yet directly examined how experiences of loneliness relate to anthropomorphism tendencies in autistic individuals.

To this end, Study 2 examined a subset of the autistic participants from Study 1 to determine whether those diagnosed with autism are more likely to anthropomorphise when they experience greater self-reported loneliness. We anticipated that in autism, anthropomorphism tendencies would be positively associated with subjective loneliness. This would be consistent with the idea that anthropomorphism is driven by similar factors for autistic and non-autistic individuals, such as reduced social connections with others.

Study 1

Method

Participants. The study used data from 870 participants who were independently recruited to participate in six separate research studies conducted in the United Kingdom (UK; n = 760) and Australia (n = 110). The majority of respondents (n=592, 68%) identified as female, 261 as male; 2 preferred not to answer and 15 identified as non-binary. All participants provided informed written consent before participating, and the protocol for this study was reviewed and approved by the Human Ethics Committee at either the University College London (UK) or Macquarie University (Australia). Demographic and questionnaire data for all participants are summarised in Table 1. A subset of the sample had a formal diagnosis of autism (n = 281). Of the remaining participants, 105 had a diagnosis of a neurological (e.g. ADHD, schizophrenia) or mental health condition (e.g., anxiety, depression). Thus the data were analysed with three delineations: full sample (n = 870), no

diagnosis (n = 484), autistic (n = 281).

Table 1. Demographic information for all respondents.

	Full Sample (n = 870)	**No Diagnosis** (n = 484)	**Autistic** (n = 281)
Demographic data - Frequency (%)			
Age in years			
16-17	10 (1.15)	3 (0.62)	6 (2.10)
18-24	146 (16.78)	100 (20.66)	37 (13.20)
25-34	210 (24.14)	113 (23.35)	74 (26.30)
35-44	181 (20.80)	96 (19.83)	62 (22.10)
45-54	156 (17.93)	70 (14.46)	58 (20.60)
55-64	115 (13.22)	65 (13.43)	35 (12.50)
65-74	48 (5.52)	34 (7.025)	9 (3.20)
75 +	4 (0.50)	3 (0.62)	0 (0.00)
Gender			
Male	261 (30.00)	111 (22.93)	122 (43.40)
Female	592 (68.05)	372 (76.86)	147 (52.30)
Other	15 (1.72)	1 (0.21)	10 (3.60)
Prefer not to say	2 (0.23)	-	2 (0.70)
Native English Speaking			
Yes	847 (97.36)	471 (97.31)	274 (97.50)
No	25 (2.87)	13 (2.69)	7 (2.50)
Questionnaire data – M (SD)			
AQ10	4.68 (3.00)	2.68 (1.55)	8.05 (1.74)
AnthQ			
Childhood	36.0 (28.00)	27.70 (21.90)	48.2 (30.90)
Adult	21.20 (16.40)	17.10 (13.80)	26.8 (17.80)
Total	17.91 (16.06)	14.89 (15.17)	21.7 (15.6)

Note. AQ10: Autism Quotient 10; AnthQ: Anthropomorphism Quotient; M: Mean; SD: Standard Deviation.

Measures. Across both studies, participants provided basic demographic information and completed both the AQ10 and AnthQ. The UK-based data collection was conducted via online surveys, whilst the Australian-based data collection was conducted by administering

these questionnaires in person in a paper-based format.

Autism Quotient 10 (AQ10). The AQ10 is a brief self-report measure of traits associated with autism and can be used as an effective screening tool for autism (Allison et al., 2012). The items enquire about everyday behaviours and preferences (e.g., "*I find it difficult to work out people's intentions*") which participants respond to on a 4-point Likert scale (1 = Definitely Agree, 4 = Definitely Disagree). The highest possible AQ10 score is 10, and the lowest possible score is zero. Higher AQ10 scores indicate the possession of more autistic traits (Baron-Cohen et al., 2001). Like the 50-item full scale Autism Quotient questionnaire (see Baron-Cohen et al., 2001), the AQ10 has been shown to validly distinguish autistic and non-autistic individuals and has demonstrated substantial internal consistency (Cronbach's alpha = .85; Allison et al., 2012).

Anthropomorphism Quotient (AnthQ). The AnthQ is a 20-item self-report scale which measures individual differences in dispositional anthropomorphism – the tendency to attribute human-like characteristics to a non-human entity or object (Neave et al., 2015). Participants report their level of agreement with statements that suggest non-human objects have thoughts, feelings or motivations (e.g., *"I sometimes wonder if my computer deliberately runs more slowly after I have shouted at it"*) using a 7-point Likert scale (0 = Not at All, 6 = Very Much So). Half of the items can be used to create a score for childhood anthropomorphism tendencies and the other half for current adult tendencies. The total score is derived from all 20 items, with possible scores ranging from zero to 120. Higher scores indicate stronger dispositional tendencies to anthropomorphise. The measure also gives a score for each of two subscales: (1) Child subscale, based on items regarding childhood experiences of anthropomorphism and, (2) 'General' (or Adult) subscale, based on items related to current experiences. Whilst caution should be exercised when interpreting the Child subscale results, as they rely on retrospective memory, the subscales can offer an insight into

situational versus dispositional factors.

Results

To determine whether individual differences in dispositional anthropomorphism were related to individual differences in autistic traits, we calculated Spearman Rho (ρ) correlation coefficients using each individual's AQ10 and AnthQ scores. Unlike Pearson correlation analyses, Spearman correlations use ranked scores making the test robust to non-normal data. The data in the current study on the AQ10 and all AnthQ scales significantly deviated from a normal distribution as confirmed using the Shapiro-Wilk Test (all ps < .001). Indeed, this was also true when assessing the full sample, no diagnosis and autism subgroups separately. Close inspection of the data revealed that this was due to a high concentration of low scores on these measures. This analysis method is also more appropriate for ordinal data, which is relevant to the current study since scores on the AQ10 and AnthQ cannot strictly be considered continuous variables. Further, the datasets were not normally distributed.

First, we conducted this analysis on the full sample (n = 870). Then, to confirm that any observed effects were not driven by psychiatric or neurodevelopmental diagnoses we excluded participants who reported any such history, resulting in a much smaller sample (n = 484). Autistic traits were significantly and positively correlated with anthropomorphism tendencies in the full sample: the possession of more autistic traits was associated with increased self-reported tendencies to anthropomorphise non-human entities and objects using the Total AnthQ score (Spearman ρ = .278, p < .001, n = 870), as well as the Child (Spearman ρ = .298, p < .001, n = 870) and Adult (Spearman ρ = .241, p < .001, n = 870) subscales. This was also the case for Total score on the AnthQ when re-running the analysis excluding participants who reported having a psychiatric or neurodevelopmental condition (Spearman ρ = .197, p < .001, n = 484). However, in this group, neither the Child (Spearman ρ = .053, p = .242, n = 484) nor the Adult subscale scores (Spearman ρ = .025, p = .588, n =

484) significantly correlated with AQ10 scores. Given that this resulted in the exclusion of 281 autistic participants, this likely reflects a significant reduction of the variability of AQ10 scores in our dataset.

Finally, 2.64% of the full sample were not native English-speakers. Given that speaking a native language which comprises gendered nouns (e.g., Spanish) could influence the way in which individuals anthropomorphise objects, we repeated the above analyses excluding non-native English speakers (also see Sagiv, Sobczak-Edmans, & Williams, 2017 for a discussion on higher rates of grapheme personification in French than English-speaking populations). Again, the same effects were observed for both the full sample (n = 845; **Total:** Spearman ρ = .276, p < .001; **Child:** Spearman ρ = .296, p < .001; **Adult:** Spearman ρ = .239, p < .001) and the 'no diagnosis' sample (n = 471; **Total:** Spearman ρ = .197, p < .001; **Child:** Spearman ρ = .049, p = .292; **Adult:** Spearman ρ = .018, p = .692).

In the autistic group, there were no significant correlations between AQ10 and AnthQ scores on any of the AnthQ subscales, irrespective of whether we included (n = 281) or excluded (n = 274) non-native English speakers from the analyses (all ps > .268). This is likely due to the fact that autistic participants, by definition, have scores clustered between six and ten on the AQ10. The autistic group did, however, differ significantly from the no diagnosis group on both measures: autistic participants showed higher anthropomorphism tendencies on all subscales (**Total:** Mann-Whitney U = 48685, p <.001, *Cohen's d* = -0.442; **Child:** Mann-Whitney U = 40959, p <.001, *Cohen's d* = -0.800*;* **Adult:** Mann-Whitney U = 46336, p <.001, *Cohen's d* = -0.627) and also, unsurprisingly on autistic traits (Mann-Whitney U = 3555, p <.001, *Cohen's d* = -3.311) compared to the participants with no neurological diagnoses. To best characterise the data, we have plotted the raw data from the full sample, including a linear regression line which best fits the data (Figure 1A). We have

also plotted the average AnthQ ranks for each of the possible AQ10 scores to more closely reflect the monotonic trend assessed by the Spearman correlation analyses (Figure 1B).

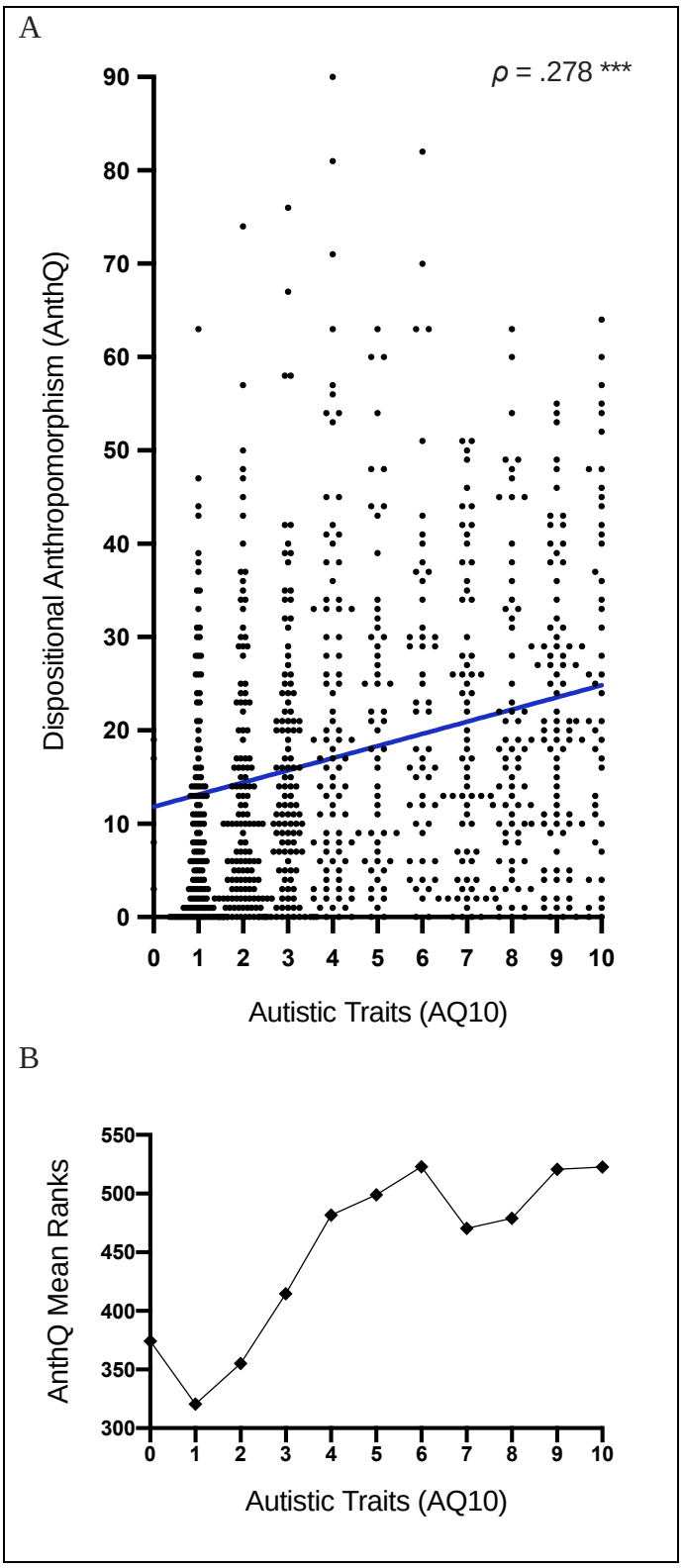

Figure 1. (A) Scatter plot of autistic traits (AQ10) and dispositional anthropomorphism tendencies using total scale scores (AnthQ). Slope depicts the best fitting linear regression line. *** denotes p <.001. (B) Mean AnthQ ranks are plotted for each possible AQ10 score to more closely characterise the monotonic relationship between AQ10 and AnthQ scores. Data depicted in both plots are derived from the full sample (n = 870).

Study 2

Method

Participants. To recruit participants for Study 2, an email was sent to all autistic individuals who had previously taken part in the UK-based research studies contributing data to Study 1. In total, 90 people agreed to take part in Study 2 and completed the questionnaire. The majority of participants (n = 75, 83%) reported having a professional diagnosis of autism, one was in the process of obtaining a diagnosis and 14 were self-diagnosed. A score of six or above on the AQ10 is considered an indication of autism. One of the self-diagnosed individuals had a score lower than this cut off on the AQ10 and was therefore excluded from further analyses. The mean AQ10 score of the participants who scored above threshold was 8.1 (*SD* = 1.8).

All participants were native English speakers. The majority of respondents (n = 51, 57%) identified as female, 29 as male; 4 preferred not to answer and 5 identified as non-binary. The majority of the respondents were from the UK (80%), and 36 (41%) reported having other neurological conditions (see Table 2 for full demographics).

Table 2. Demographic information for all respondents.

Demographic data - Frequency (%)	
Age in years	
16-24	10 (11.2)
25-34	26 (29.2)
35-44	25 (28.1)
45-54	12 (13.5)
55-64	12 (13.5)
65-74	4 (4.5)
Gender	
Male	29 (32.6)
Female	51 (57.3)

Other	5 (5.6)
Prefer not to say	4 (4.5)
Autism Diagnosis	
Clinical diagnosis	75 (84.3)
In process of diagnosis	1 (1.1)
Self-diagnosed	13 (14.6)
Other Conditions (n=87)	
Yes	36 (41.4)
Depression	14
Anxiety	12
Post-Traumatic Stress Disorder	6
Obsessive Compulsive Disorder	4
Bipolar Disorder	4
Dyslexia	2
Attention Deficit Hyperactivity Disorder	2
Dyspraxia	1
Other	6
No	42 (48.3)
Prefer not to say	9 (10.3)

Questionnaire data – M (SD)

AQ10	8.1 (1.8)
AnthQ	
Childhood (n = 86)	40.0 (18.8)
Adult (n = 89)	30.5 (15.5)
Total (n = 86)	67.6 (31.5)
Loneliness Scale	
Total score (n = 86)	54.7 (11.7)
Frequency of anthropomorphism (n = 88)	**Frequency (%)**
Never	17 (19.3)
Rarely	11 (12.5)
Monthly	8 (9.1)
Weekly	21 (23.9)
Daily	31 (35.2)

Note. AQ10: Autism Quotient 10; AnthQ: Anthropomorphism Quotient; M: Mean; SD: Standard Deviation.

Measures. Participants completed all measures in an online survey. This included the AnthQ and AQ10 measures used in Study 1, as well as two additional measures to assess participant's subjective loneliness and frequency of anthropomorphism tendencies.

The UCLA Loneliness Scale – Revised. The Loneliness Scale comprises 20-items which assess subjective feelings of loneliness and social connection by asking participants to endorse statements on a scale of 1 (never) to 4 (often; Russell, Peplau, & Cutrona, 1980). Higher scores correspond to higher levels of loneliness.

Frequency of Anthropomorphism. This question was used to assess whether, and how frequently, an individual experienced anthropomorphism (as in White and Remington, 2018). The scale ranged from 1 (Never) to 5 (Daily). Higher scores corresponded to greater frequency of anthropomorphism.

Results

The average scores for all measures (AQ10, AnthQ, UCLA Loneliness Scale, and Frequency of Anthropomorphism) were calculated for each participant (see Table 2). Non-parametric correlations were run between AnthQ and subjective loneliness scores. The Adult subscale of the AnthQ, which measures the level of anthropomorphism experienced as an adult, was significantly associated with reported levels of loneliness (Spearman $\rho = .242$, $p = .024$). The total AnthQ score ($p = .092$) and Child Subscale ($p = .278$) were not significantly associated with loneliness

We also explored whether the *frequency* with which individuals anthropomorphised revealed a similar relationship with loneliness experiences. We created two groups: those who reported never or rarely experiencing anthropomorphism on the Frequency of Anthropomorphism measure (n = 29) and those who did so frequently (weekly/daily, n = 52). Unsurprisingly, AnthQ scores were significantly larger in those who frequently anthropomorphised when using the Child subscale (Mann-Whitney $U = 1282.0$, $p < .001$,

Cohen's d = 2.34), the Adult subscale (Mann-Whitney U = 1305.0, p < .001, Cohen's d = 1.71) and the total AnthQ score (Mann-Whitney U = 1282.5, p < .001, Cohen's d = 2.34). More importantly, subjective loneliness scores were also significantly higher in the group who frequently anthropomorphised compared to the group who did not (Mann-Whitney U = 900, p = .037, Cohen's d = 0.49).

Discussion

Using a large, cross-continental sample, Study 1 provides substantial evidence that individual differences in dispositional anthropomorphism are positively associated with the self-reported experience of autistic traits (as measured by the AQ10). That is, individuals in our sample who had more autistic traits were more likely to have stronger anthropomorphism tendencies. These data are consistent with previous findings which reveal that autistic adults are more likely to anthropomorphise than others in the general population (White & Remington, 2018). One explanation for this association – and for the greater propensity to anthropomorphise in autism – is that these individuals may be more socially-disconnected, and are thus more motivated to anthropomorphise in order to cultivate a sense 'social' affiliation and belonging (White & Remington, 2018).

In line with this account, a different stream of research have revealed that autistic individuals are more likely to experience social isolation than non-autistic individuals (Causton-Theoharis et al., 2009). In the general population, the anthropomorphism of non-human objects has also been shown to reduce subjective experiences of loneliness (Epley et al., 2008). More recent work has also revealed that both autistic and non-autistic individuals engage in anthropomorphism as a compensatory strategy to seek social 'connectedness', safety, comfort and friendship in the absence of meaningful human-human relationships (Negri, White, & Remington, 2019). Considering these previous findings together, it is therefore possible that social disconnection may co-vary with subclinical autistic traits,

resulting in the association with anthropomorphism across the broader autism phenotype.

Whilst items on the AQ10 do demonstrate face validity for measuring social constructs (e.g., the respondent's self-reported capacity to understand and interact with others; e.g., *"I know how to tell if someone listening to me is getting bored"*), these constructs are based on neurotypical social norms. For example, it has been argued that autistic social behaviours may appear different from non-autistic social constructs, but that this does not mean there is a lack of social motivation or behaviour (Jaswal & Akhtar, 2019). As such, the scale does not account for how autistic individuals view their level of social connectedness or whether they experience loneliness. To this end. Study 2 addressed this question explicitly, and provides further confirmation for the relationship between loneliness and anthropomorphism in autism. In this large sample of autistic adults, we show compelling evidence for increased anthropomorphism tendencies in individuals who report experiencing higher levels of subjective loneliness. Interestingly, however, this was only true when using the adult subscale of the AnthQ, which is sensitive to an individual's *current* context, rather than the child subscale which asks participants to respond retrospectively about their childhood experiences. This is consistent with the fact that the loneliness measure also focussed on current feelings, and suggests that the social disconnectedness experienced by the autistic participants may have been less salient earlier in life. Alternatively, it may be the case that, rather than being less salient in early life, childhood anthropomorphism was not recalled in adults with autism, due to difficulties with long-term autobiographical memory. Consistent with this latter interpretation, research suggests that an autobiographical memory deficit may be a characteristic of autism (Crane & Goddard, 2008; Goddard, Howlin, Dritschel, & Patel, 2007). Future research could perhaps aim directly to test and tease apart these different interpretations. It must be noted, however, that while an association – between loneliness and anthropomorphism – was evident in the present study, no conclusions

regarding causation can be drawn. It remains possible that other tenets of Epley's original framework play an equivalent, or greater, role in the increased level of anthropomorphism for those with higher levels of autistic traits. For example, autism is associated with a preference for routine and an intolerance of uncertainty (American Psychiatric Association, 2013). This may result in a desire to increase the predictability of one's surroundings – a process that is key to Epley's suggestion of 'effectance motivation' as a pathway to anthropomorphism. It would be interesting to explore these various hypotheses directly in future research.

Independent of the role that loneliness might play in motivating anthropomorphism in autism – and across the broader autism phenotype – is the finding that autistic traits are associated with the increased tendency to mentalise, empathise and relate to non-human entities (Study 1). These processes are all implicitly engaged during the anthropomorphism of non-human entities (Epley, Waytz, Akalis, & Cacioppo, 2008) and therefore call into question the original suggestion that autistic people show reduced Theory of Mind (Baron-Cohen, 1995) and will therefore not show anthropomorphic tendencies (Epley et al 2007). Further, our findings are significant in that they contrast with the – traditionally-dominant – view that the autism phenotype is characterised by a reduced motivation to understand and interact with others (c.f. Chevallier, Kohls, Troiani, Brodkin, & Schultz, 2012). This is in keeping with recent work which suggests that the theory of reduced social motivation may be based on an erroneous presumption that social behaviour in autistic people looks identical to that of neurotypical people (Jaswal & Akhtar, 2019). This means that the social overtures and responses made by autistic people may be overlooked or dismissed.

Considering the results of the present study, we suggest that whilst the ability and drive for social interaction may be intact in autism, the autism phenotype is better characterised by difficulties maintaining relationships with others because of a mismatch or 'misattunement' in the communication and social-cognitive processing styles engaged by

autistic and non-autistic individuals (Bolis, Balsters, Wenderoth, Becchio, & Schilbach, 2017; Milton, 2012). Such a claim is consistent with recent evidence that non-autistic individuals are less inclined to interact with autistic individuals on the basis of their appearance and behaviour – even when they are not explicitly aware of their autism diagnosis (Sasson et al., 2017). This suggests that individuals on the autism spectrum may have fewer opportunities to establish relationships with others, irrespective of their social-cognitive ability (e.g., empathising).

Indeed, it is possible that anthropomorphism – in autism and typical development – can lead to the engagement of genuine mentalising and empathising processes. Qualitative data from autistic and non-autistic adults has shown that experiencing empathy towards anthropomorphised items can result in distress when the item is damaged or 'harmed' (Negri et al., 2019). That is, the object is related to in much the same way one might feel about an unwell friend. This again highlights that the increased tendency to anthropomorphise across the broader autism phenotype unlikely reflects a deficit in the *drive* or *ability* to relate to others – but perhaps a dearth of *opportunity*. These findings also highlight the paradoxical positive (e.g., connectedness, safety) and negative (e.g., distress and worry about the wellbeing of the anthropomorphised agents) outcomes that may be experienced in tandem by those with strong anthropomorphism tendencies. Further work is needed to examine both the positive and negative outcomes of anthropomorphism – and how they manifest in autism and across the broader autism phenotype. Work on the latter may also benefit from implementing other more comprehensive measures of autistic traits, including the full-scale Autism Quotient (Baron-Cohen et al., 2001) and the Subthreshold Autistic Traits Questionnaire (SATQ; Kanne, Wang, & Christ, 2011). In the present study, the AQ10 was used for pragmatic reasons to ensure the survey length was manageable. Using a more substantial scale in future research would provide the opportunity to examine which aspects of autistic

traits – as categorised by the full-scale AQ's subscales (e.g., the communication or social subscales vs imagination, local detail or attention switching subscales) – best predict anthropomorphism tendencies. Further, the SATQ, like the AQ questionnaire was designed to measure autistic traits in the general population but measures the presentation of a much broader range of autistic traits (Kanne et al., 2011; Nishiyama et al., 2014), particularly given that the AQ is argued to better capture traits typically observed in the male, rather than female, autism phenotype (Murray et al., 2017; Ruzich et al., 2015). Therefore, validating the current findings from Study 1 with the SATQ would provide evidence for their generalisability.

Conclusion

In line with recent work showing that autistic individuals have greater propensities to anthropomorphise non-human entities (White & Remington, 2018), the current study provides evidence that this phenomenon extends to the broader autism phenotype (Study 1). In order to understand what might drive increased anthropomorphism amongst those with autistic traits, we more closely examined variation in anthropomorphism tendencies in a large sample of autistic adults (Study 2). We found that those with greater anthropomorphism tendencies also experienced greater levels of self-reported loneliness. Our findings are consistent with the idea that the increased tendency to anthropomorphise amongst many autistic individuals – and those with autistic traits – unlikely reflects a reduced motivation or drive to connect with others, but perhaps reduced opportunities to do so.

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