Exploring the cognitive foundations of the Shared Attention Mechanism: Evidence for a relationship between self-categorization and shared attention across the autism spectrum

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Abstract

The social difficulties of Autism Spectrum Disorder (ASD) are typically explained as a disruption in the Shared Attention Mechanism (SAM) sub-component of the theory of mind (ToM) system. In the current paper, we explore the hypothesis that SAM's capacity to construct the self-other-object relations necessary for shared-attention arises from a self-categorization process, which is weaker among those with more autistic-like traits. We present participants with self-categorization and shared-attention tasks, and measure their Autism-Spectrum Quotient (AQ). Results reveal a negative relationship between AQ and shared-attention, via self-categorization, suggesting a role for self-categorization in the disruption in SAM seen in ASD. Implications for intervention, and for a ToM model in which weak central coherence plays a role are discussed.

Keywords: shared attention; self-categorization; theory of mind; weak central coherence; categorization

Exploring the cognitive foundations of the Shared Attention Mechanism: Evidence for a relationship between self-categorization and shared attention across the autism spectrum

The social difficulties of Autism Spectrum Disorder (ASD) are typically explained as outcomes of disruption in the ‘theory of mind’ (ToM) system, particularly of the Shared Attention Mechanism (SAM; Baron-Cohen, 2005). Disruption in SAM inhibits individuals from sharing attention with others, which further impairs downstream abilities in other ToM domains, resulting in the social difficulties on which diagnosis is based. Although it is descriptively well-elaborated in Baron-Cohen’s (2005) Empathizing System Model, the cognitive underpinnings of SAM’s representational capacities are not well understood. In the current paper, we hypothesize that SAM relies fundamentally on the cognitive process of self-categorization (Turner, Hogg, Oakes, Reicher & Wetherell, 1987) for its proper functioning, and that disruption of this process explains the difficulties in shared attention seen on the autism spectrum. We further suggest that understanding self-categorization as the cognitive mechanism underlying SAM could lead to a more unified model of ASD, in which weak central coherence (WCC) has a role to play in the ToM difficulties.

The social impairments of ASD have traditionally been understood as a deficit in the ToM system (Baron-Cohen, Leslie & Frith, 1985). Baron-Cohen (2005) suggests that the ToM system is composed of six modules, which develop at different developmental periods. The Intentionality Detector (ID), The Emotion Detector (TED, and the Eye Direction Detector (EDD) develop in early infancy. Maturation of these modules supports the development, in later infancy, of the Shared Attention Mechanism (SAM). The development of SAM further enables the emergence, in early childhood, of The Empathizing SyStem (TESS), and the Theory of Mind Mechanism (ToMM). In a typically developing individual, these modules function as an interconnected system, enabling him or her to represent, feel, infer, and interpret the mental, emotional and behavioral states of others, and thus to function in a socially adaptive manner. However, in people with ASD the functioning of SAM is thought to be disrupted. This prevents shared attention behaviors from arising, and constrains development of the person's ability to represent the mental states of others and to function adaptively in social interactions.

According to Baron-Cohen (2005), SAM's primary contribution to the ToM system is to build triadic representations of self, other, and object. These triadic representations allow a perceiver to determine if his or her attention and that of another perceiver are directed towards the same event or physical object. As a function of this sharing of attention, typically developing children will gradually come to share their experiences with, and learn from, others, through joint attention behaviors such as gaze monitoring (Loveland & Landry, 1986) and proto-declarative pointing (Baron-Cohen, 1989). In children with ASD, on the other hand, these joint attention behaviours appear to be impaired (Mastrogiuseppe, Capirci, Cuva & Venuti, 2015; Mundy, 2016), and this impairment is known to be predictive of later dysfunction in other ToM domains (Mundy, Sigman & Kasari, 1994; Sodian & Kristen-Antonow, 2015), and in social functioning (Brooks & Meltzoff, 2015; Mundy, 1995).

This body of work provides a well-elaborated account of the functions of SAM and the consequences of its functions being diminished. Nevertheless, the precise cognitive mechanism responsible for the emergence and construction of self-other-object representations is not well understood. Typically, models of shared attention focus on understanding the cognitive mechanisms that underpin joint attention *behaviors*, rather than elaborating on the processes involved in producing triadic representations. Edwards, Stephenson, Dalmaso and Bayliss (2015), for example, propose the existence of a cognitive mechanism that allows a perceiver to respond to the gaze-following behavior of others. Similarly, Mundy and Newell (2007) suggest that the joint attention behaviors of *responding* *to joint attention* and *initiating joint attention* rely on the domain-general posterior perceptual and the anterior volitional attention systems, respectively. These are important findings that chart the developmental trajectory of the antecedents of joint attention behaviors, particularly gaze monitoring, gestural communication, and general attention. However, they do not resolve the specific issue of how the cognitive system combines self, other and object into the useable and context-specific triadic representations necessary for shared attention.

Importantly, though, this gap has recently been addressed by theorizing in social psychology. Shteynberg (2015) suggests that shared attention arises from a psychological 'shared-attention state', which he defines as "the perception of in-the-moment attention to an object from a first-person-plural perspective" (pp. 581)[1]. The shared-attention state is therefore a triadic representation of self, other, and object, where self and other have become merged into a psychological "we-mode" (e.g., Searle, 1995). The "we-mode" – also commonly referred to as a *social identity* (Tajfel & Turner, 1979) – itself emerges when a perceiver becomes aware that relationally close or socially equivalent others are synchronously co-attending to a stimulus. Importantly, the extent to which others are perceived to be socially equivalent is a function of the well-elaborated cognitive process of *self-categorization* (Turner, Hogg, Oakes, Reicher & Wetherell, 1987). In short, by recognizing the importance of (1) social identity to shared attention, and (2) self-categorization to social identity, Shteynberg's (2015) shared-attention state model provides a plausible cognitive process to explain how SAM constructs triadic representations.

At the broadest level, self-categorization is the process of using social categories (e.g., age, gender and many more subtle stimulus groupings) to make sense of social stimuli (e.g., persons, traits, behaviors; Skorich & Mavor, 2013) from the perspective of the self. In simple terms, it is the process of coming to understand what some social stimulus is by understanding what other stimuli it is similar to, and different from, in a particular perceptual context (McGarty, 1999). According to self-categorization theory (Turner et al., 1987; Turner, Oakes, Haslam & McGarty, 1994), self-categories – which can include psychological groups as well as aspects of a perceiver's personal identity – become psychologically activated as an interactive function of perceiver, stimulus and situational factors (Oakes, Haslam & Turner, 1994). When a social (i.e., group-based) self-category is activated, the perceiver comes to define him or herself as equivalent to others in that self-category, such that self and other become merged and a social identity (a sense of self and other as "us") emerges. As discussed above, this sense of social identity is hypothesized to lead, *inter alia*, to shared attention (Shteynberg, 2015), and shared attention is hypothesized to give rise to the higher-order ToM processes encapsulated in TESS and ToMM (Baron-Cohen, 2005).

Shteynberg and his colleagues (Shteynberg, 2010; 2014; Shteynberg & Apfelbaum. 2013; Shteynberg & Galinsky, 2011; Shteynberg, Hirsh, Galinsky & Knight, 2014) have amassed a large body of empirical evidence that supports this shared-attention state model. For example, across three studies, Shteynberg (2010) found that inducing a shared social identity in participants (e.g., "we the blue avatar team") increased the salience of stimuli to which they were co-attending relative to participants for whom no shared social identity was induced. Similarly, Shteynberg and Apfelbaum (2013) found that participants who co-attended with similar others to a written exchange were more likely to model the writing style of that exchange than participants who were co-attending with non-similar others. Together, this body of work lends strong support for claims that social identity — and the self-categorization process that makes it possible — is crucial for entering a shared-attention state, which in turn increases the cognitive, emotional and behavioral prominence of co-attended stimuli. Such findings highlight not only the cognitive processes underlying SAM, but also the important consequences that arise from the shared-attention state, and its downstream consequences for ToM and social behavior.

Given its likely role in the construction of triadic representations as part of SAM and SAM's role in the ToM difficulties of ASD, it is plausible that the self-categorization process is implicated in the dysfunction observed in ASD. In the face of dysfunctional self-categorization, SAM would be unable to construct self-other-object representations, and the shared attention observed in typical development would be impaired, resulting in the ToM and social difficulties associated with ASD. Importantly, self-categorization has prior plausibility as a disrupted process in ASD, because the more general process of categorization – of which self-categorization is a special case – is known to be compromised in those with ASD (Klinger & Dawson, 2001; Gastgeb, Dundas, Minshew & Strauss, 2012). Furthermore, like the more general process of categorization, self-categorization is reliant on centrally coherent (more holistic/global) processing, which is also known to be 'weak' in ASD (Happe & Frith, 2006; Frith & Happe, 1994).

Recent research on the relationship between autistic-like traits, self-categorization, and mental state inference also provides evidence for the role of self-categorization in ASD. Skorich et al. (2016) presented participants with social information about a variety of target people who were members of one of four local categories embedded within one of two global categories. This hierarchical social category structure allowed participants to extract a categorization pattern at either a more global level or a more local level. Participants were then asked to infer the mental states of novel category members, and to complete the Autism-Spectrum Quotient (AQ; Baron-Cohen, Wheelwright, Skinner, Martin & Clubley, 2001). Results revealed that a higher AQ was associated with more local social categorization, which in turn predicted more mental state inferences based on the local social categories. These results provided the first direct evidence that the degree of autistic-like traits might be predictive of differences in the self-categorization process, which in turn appear to produce differences in the pattern of mental state inferences.

In the context of the current paper, the results reported by Skorich and colleagues (2016) can be interpreted as support for the notion that differences in self-categorization across the autism spectrum could be predictive of differences in shared attention tendencies, and related to, or causative of, dysfunction in SAM. To investigate this possibility directly, in the present study we (1) examine the relationship between self-categorization and shared attention, and (2) explore how this relationship manifests itself across a sample of the general population who differ in the degree to which they possess autistic-like traits. We employ a commonly used social categorization task (Taylor, Fiske, Etcoff & Ruderman, 1978) in order to measure the degree to which participants self-categorize in terms of a particular social group and come to view themselves in terms of the corresponding social identity. We also manipulate the degree of covariation between the social categories and the social information presented in the categorization task to test the exploratory hypothesis that the specific self-categorization difficulty experienced by those with a high degree of autistic-like traits is one of pattern detection (Almeida, Dickinson, Maybery, Badcock, & Badcock, 2010; Frith & Happe, 1994). We then present participants with an adapted version of Shteynberg's (2010) shared attention word memory task to measure the degree to which participants' self-categorization predicts the degree to which they share attention with similar others. We also measured the degree of participants' autistic-like traits in order to explore its relationship to self-categorization and shared attention.

Consistent with the argument that self-categorization is disrupted in ASD, we hypothesize that:

H1. the degree of a person's autistic-like traits will be negatively related to the degree of self-categorization that they show in the categorization task (captured by a self-categorization index, SCI, where a positive score indicates typical self-categorization, and a score of zero or below indicates no or atypical self-categorization).

More specifically, we anticipate that:

H1a. participants with a low AQ will have an SCI significantly greater than zero, but that participants with a high AQ will not have an SCI significantly different from zero.

H1b: the effect of AQ will be moderated by the degree of covariation across the covariation conditions, such that AQ will be more strongly negatively related to self-categorization in a moderate covariation condition (where the pattern is difficult to detect), relative to both high and no covariation conditions (where the pattern is easy to detect or there is no pattern to detect).

In line with the suggestion that ASD is characterized by decreased shared attention, we also hypothesize that:

H2. the degree of a person's autistic-like traits will be negatively related to the degree of shared attention with members of their own social category (ingroup), but will not be related to the degree of shared attention with members of the social category to which they did not belong (outgroup).

More specifically, we anticipate that:

H2a. there will be a difference between ingroup and outgroup shared attention for participants with a low AQ, but no difference for those with a high AQ, because low-AQ participants will show a bias towards words co-attended by ingroup members, whereas high-AQ participants will show no such bias.

Given that self-categorization is known to be a causal antecedent of shared attention with ingroup members, we also hypothesize that:

H3: the SCI will be positively related to ingroup shared attention, but not to outgroup shared attention.

Finally, we hypothesize that:

H4. the relationship between autistic-like traits and ingroup shared attention will disappear, or be attenuated, when participants' SCI is added to the model, thus demonstrating that self-categorization mediates the relationship between autistic-like traits and ingroup shared attention (see Figure 1 for a graphical representation of hypotheses).

INSERT FIGURE 1 HERE

Method

Participants

One hundred and seventy-seven participants were recruited via online crowdsourcing tool Crowdflower. One hundred and forty-five participants generated a valid Autism-Quotient score, having provided a response to all 50 items, and were thus retained for all subsequent analyses. Of the final sample, 74 participants were female, 65 were male, and 6 did not indicate their gender. The mean age was 35.52 years with a range from 18 to 72. The research was approved by the Australian National University Human Research Ethics Committee.

Design

The study employed a three-condition (covariation: zero/moderate/high) between-participants design, with participants' AQ included as a continuous predictor. The dependent variables were self-categorization score in the categorization task, and ingroup and outgroup word memory in the shared attention task.

Procedure

The entire study was conducted online, employing Qualtrics survey software to present all stimuli and collect all data.

Phase 1: Avatar Selection. Participants were informed that they would be completing a series of cognitive tasks at the same time as five other participants. They were told that each participant, including themselves, would be selecting an avatar to represent them throughout the study. Unbeknownst to participants, they were in fact completing the study on their own.

Participants were then given the choice of three avatars, presented on-screen in random order, one above the other. Participants were told that these avatars were the three avatars remaining after other participants had selected their avatars. The avatars were androgynous in appearance, and differed in terms of facial characteristics, hair length and hair style. Each avatar wore a black t-shirt, with the word "Smedd" written prominently on the front. Participants selected their avatar by clicking on the avatar of their choice.

Following avatar selection, participants were asked to provide their name or a pseudonym, which, they were told, would be displayed alongside their avatar in all subsequent tasks. They were told that other participants would similarly be providing a name or pseudonym, which would also be displayed alongside their avatar.

Participants were then asked to wait until other participants had (supposedly) selected their avatars. Participants waited seven seconds before they were told that all participants had selected their avatars.

Phase 2: Categorization Task. Next, participants were given instructions for an adapted version of a commonly-used categorization task (Taylor et al., 1978), originally developed to explore the extent to which participants use social categories to organise social information. Participants were informed that they would be presented with a number of statements on-screen, one-by-one, displayed below the avatar of the participant to whom that statement was attributed. They were told that each of the participants, including themselves, was a member of either group Smedd or group Plibb, and that their group membership would be represented by the colour of the t-shirt worn by the avatar – black for Smedd and grey for Plibb – and by the word "Smedd" or "Plibb" written prominently across the front of the t-shirt. Participants were then told that their task was to remember as many of the statements as they could, with particular reference to who performed the behavior. Participants were told that the statements would be of the form “[Name], a member of group [Smedd/Plibb], [behavior]” for statements attributed to other participants, and “You, a member of group Smedd, [behavior]” for statements attributed to themselves. The five names used for the ostensible other participants (heretofore referred to as “targets”) were Louise, Holly, Sarah, Laura, and Alice. Louise, Holly and the participant were always members of group Smedd, and Sarah, Laura and Alice were always members of group Plibb, such that group Smedd and group Plibb had three members each.

Each of the behaviors described in the statements was constructed so as to capture one of the Big-Five personality factors of agreeableness, conscientiousness, extraversion, or neuroticism (Goldberg, 1990; see Figure 2 for an example agreeableness statement as it appeared to participants). Constructing the statements so as to capture these personality factors allowed us to test the notion that autistic-like traits would be predictive of decreased pattern detection (e.g., Almeida et al., 2010), because we were then able to manipulate the covariation between the groups and the personality traits. In the zero-covariation condition, the agreeableness, conscientiousness, extraversion, and neuroticism statements were equally divided between Smedd and Plibb, and between targets. In the moderate-covariation condition, 50% of Smedd statements were agreeableness statements, and 50 % of Plibb statements were conscientiousness statements, with the remaining statements consisting of an equal combination of the remaining trait dimensions. In the high-covariation condition, 75% of Smedd statements were agreeableness statements, and 75% of Plibb were concientiousness statements, with the remaining statements mapping onto the opposite trait dimension for each group.

In all three conditions, each of the targets, including the participant themselves, was attributed with 6 statements. The 36 statements thus created were displayed to participants, one-by-one, in random order, below the appropriate avatar. Each statement stayed on-screen for 11 seconds, with a 500ms inter-statement interval.

INSERT FIGURE 2 HERE

Phase 3: Attribution Task. Following initial statement presentation, participants were re-presented with the 36 behavioral statements from the previous task, along with a further 24 filler statements, with the avatar, name, and group membership removed. Participants were asked to indicate, for each statement, if it was one they had seen before, by clicking on “seen before” or “not seen before” displayed on-screen below the statement. If participants indicated that they had not seen the statement before, the next statement was displayed. If they indicated that they had seen the statement before, they were asked to attribute it to the person with whom it had been associated in the previous task, by clicking on the appropriate avatar from the six possible avatars displayed below the statement. The avatars, with their names below, were presented in three columns below each statement, in a different random order for each statement. The 60 statements were randomized and presented on-screen one-by-one, until participants made a response.

Phase 4: Shared Attention Task. Participants were next asked to complete a shared attention word memory task (Shteynberg, 2010). The task was divided into two almost identical parts, each of which consisted of the presentation of two lists of 9 words side-by-side, followed by a recognition memory task. For each pair of word lists, participants were told that they would be paired with two other participants, who were said to be simultaneously completing the task. One of these ostensible other participants was said to be simultaneously viewing one of the lists of words that the participant was viewing, and the other participant was said to be simultaneously viewing the other list. Participants were told that the other participants' avatars would appear on screen above the list that they were both being presented with. Participants were then told that the participants with whom they would be paired were members of groups Smedd or Plibb, and that participants' group membership would be indicated by their avatar's t-shirt.

Participants were then presented with the first two word lists. The list on the left-hand side of the screen was displayed below the avatar of a member of group Smedd, and the list on the right-hand side was displayed below the avatar of a member of group Plibb (see Figure 3 for shared attention task as it appeared to participants). Participants were given 30 seconds to view the two lists. There was then a 20-second delay before participants were presented with the longer list of 18 target words and 18 filler words, from which they were asked to click on all those words they could remember from the lists previously presented. Participants were given as much time as they needed to complete this word recognition task.

After completing the first word memory task, participants were presented with the second pair of word lists, in which the left/right position of group Smedd and group Plibb avatars was swapped relative to the first pair of word lists. In all other respects this second word memory task was identical to the first.

INSERT FIGURE 3 HERE

Phase 5: Autism-Spectrum Quotient and Demographic Information. Participants were next asked to complete the Autism-Spectrum Quotient (AQ; Baron-Cohen et al., 2001), which captures variability in autistic-like traits across the general population. Participants were asked to indicate their agreement with each of the 50 items by clicking on one of the four scale-points from "Disagree Strongly" to "Agree Strongly". Finally, participants were asked to indicate their gender, their age, and whether English was their first language.

Results

Calculation of Measures

An AQ score was calculated for each participant in two steps. First, a score of 1 was given for responses of "Disagree Strongly" or "Disagree" to reverse-coded items, and for responses of “Agree Strongly” or “Agree” for forward-coded items. These scores were then summed to create a final AQ score. A higher score on this measure indicates more autistic-like traits. The mean AQ in our sample was 21.72, with a range from 2 to 41.

A self-categorization index (SCI) was calculated by subtracting the number of between-category errors (incorrect person, incorrect group) that participants made in the attribution task from the number of within-category errors (incorrect person, correct group) that they made. A higher SCI score indicates more self-categorization. The mean SCI score in our sample was 1.12 with a range from -13 to +18.5.

A measure of ingroup shared attention was created by counting the number of words correctly remembered from the two lists viewed by members of group Smedd. The mean ingroup shared attention score was 5.64, with a range from 0 to 9. A measure of outgroup shared attention was created by counting the number of words correctly remembered from the two lists viewed by members of group Plibb. The mean outgroup shared attention score was 5.57, with a range from 0 to 9.

H1: AQ and self-categorization

A between-participants covariation condition by AQ ANCOVA was conducted on the SCI. Consistent with H1, this revealed a main effect of AQ, $F(1, 139) = 4.88$, $p = .029$, $\eta^2 = .032$, such that the relationship between AQ and self-categorization was negative, $r(145) = -.184$. The main effect of covariation condition was non-significant, $F(1, 139) = .196$, $p = .822$, $\eta^2 = .003$, as was the interaction of AQ and covariation condition, $F(1, 139) = .808$, $p = .448$, $\eta^2 = .011$. The absence of the interaction indicates no support for H1b.

Two further analyses were conducted to explore the relationship between AQ and self-categorization. Participants with an AQ score below the median score of 22 were classified as low-AQ, while those with an AQ score above 22 were classified as high-AQ. Supporting H1a, the mean SCI score of low-AQ participants was significantly greater than 0 ($M = 2.41$, *SD* = 4.7), *t*(74) = 4.41, $p < .001$, indicating that these participants self-categorized in terms of group Smedd. Also in line with H1a, the mean SCI score of the high-AQ group was not significantly different from 0 (*M* = –.22, *SD* = 4.22), *t*(71) = .436, *p* = .664, indicating that these participants did not self-categorize in terms of group Smedd.

H2: AQ and ingroup and outgroup shared attention

A between-participants covariation condition by AQ ANCOVA was conducted on the ingroup shared attention measure. Supporting H2, this revealed a main effect of AQ, *F*(1, 139) = 4.37, *p* = .038, $\eta^2 = .03$, such that the relationship between AQ and ingroup shared attention was negative, *r*(145) = -.177. The main effect of covariation condition was non-significant, *F*(1, 139) = 1.163, *p* = .315, $\eta^2 = .016$, as was the interaction of AQ and covariation condition, *F*(1, 139) = 1.627, *p* = .200, $\eta^2 = .023$.

A between-participants covariation condition by AQ ANCOVA was conducted on the outgroup shared attention measure. Consistent with H2, this revealed no main effect of AQ, *F*(1, 139) = 1.804, *p* = 1.81, $\eta^2 = .013$, no main effect of covariation condition, *F*(1, 139) = .251, *p* = .778, $\eta^2 = .004$, and no interaction of AQ and covariation condition, *F*(1, 139) = .577, *p* = .563, $\eta^2 = .008$.

Two further analyses were conducted to explore the difference between ingroup and outgroup shared attention for those with a higher AQ and for those with a lower AQ. Supporting H2a, low-AQ (<22) participants showed significantly more ingroup shared attention (*M* = 6.27, *SD* = 1.74) than outgroup shared attention (*M* = 5.93, *SD* = 1.99), *t*(74) = 1.99, *p* = .05, indicating a tendency to share attention more with ingroup members than outgroup members. Also in line with H2a, in high-AQ (>22) participants, this difference between ingroup (*M* = 4.99, *SD* = 2.40) and outgroup (*M* = 5.19, *SD* = 2.53) shared attention was non-significant, *t*(71) = -1.02, *p* = .311, indicating no clear tendency to share attention more with ingroup members than outgroup members.

H3: Self-categorization and ingroup and outgroup shared attention

Next, the relationship between SCI and ingroup and outgroup shared attention was explored. Supporting H3, this revealed a positive relationship with ingroup shared attention, $r(145) = .173$, $p = .037$, but no significant relationship with outgroup shared attention, $r(145) = .136$, $p = .104$.

H4: Self-categorization as a mediator of the relationship between AQ and ingroup shared attention

Finally, the mediating role of self-categorization in the relationship between AQ and ingroup shared attention was tested by way of a between-participants covaration condition by AQ ANCOVA, in which the SCI was entered as a covariate. Supporting H4, this revealed that the previously significant relationship between AQ and ingroup shared attention became non-significant, $F(1, 139) = 3.16$, $p = .077$, $\eta^2 = .020$. This suggests that the relationship between AQ and ingroup shared attention is fully mediated by self-categorization (Baron & Kenny, 1986; see Figure 4).

INSERT FIGURE 4 HERE

Discussion

The current study was designed to explore whether the cognitive process of self-categorization lies at the heart of the representational capacities of SAM, and whether disrupted self-categorization across the autism-spectrum is predictive of differences in shared attention tendencies. We hypothesized that the degree of autistic-like traits would negatively predict self-categorization (H1). Our results provided support for this hypothesis, and also for the more specific prediction (H1a) that low-AQ participants would show self-categorization (having an SCI significantly greater than zero), but that high-AQ would not. We also expected that this relationship might be moderated by the degree of manipulated covariation (H1b), but we found no support for this hypothesis.

We further hypothesized that the degree of autistic-like traits would negatively predict ingroup shared attention, but not outgroup shared attention (H2). Again, results provided support for this hypothesis, and for the more specific prediction (H2a) that low-AQ participants would share attention more with ingroup than outgroup members, but that high-AQ participants would not.

We also hypothesized that the degree of self-categorization would positively predict ingroup shared attention but not outgroup shared attention (H3), and that self-categorization would mediate the relationship between autistic-like traits and ingroup shared attention (H4). Both of these hypotheses were supported, providing evidence that self-categorization is the mechanism that underpins the relationship between AQ and ingroup shared attention. The null relationship between self-categorization and outgroup shared attention also acts as a comparison control, suggesting that shared attention might be evident only when shared (ingroup) social identity has been made salient to the perceiver. However, further work including an experimentally manipulated control condition needs to be conducted, in order to explore more rigorously whether shared self-categorization is a pre-requisite for shared attention.

Taken together these results provide the first empirical support for the novel theoretical propositions that: (1) self-categorization may underlie the representational capacities of SAM; and (2) decreased self-categorization related to the degree of a person's autistic-like traits is predictive of decreased shared attention tendencies. These results have at least four important implications for ongoing research.

First, these results have implications for our understanding of the cognitive differences of individuals at the higher end of the autism-spectrum. More specifically, evidence that autistic-like traits are predictive of decreased self-categorization, and therefore of a decreased tendency to construct relevant social identities, provides support for the suggestion that dysfunction in self-categorization might be at the heart of the social difficulties of ASD (Skorich et al., 2016). In the absence of these social identities, a person with more autistic-like traits, and perhaps those diagnosed with ASD, would be less able to enter a shared-attention state, would be less likely to engage in joint attention behaviors, and would therefore be delayed in developing the higher-order ToM skills of affective and cognitive empathizing. Without these higher-order representational capacities, a person would then show all the difficulties in social functioning associated with ASD (Baron-Cohen et al., 1985).

Second, by placing self-categorization at the heart of shared attention, the current results provide novel avenues for exploring joint attention behaviors, and for developing interventions based around expanded understanding of these domains. In a recent meta-analytic review, Murza, Schwartz, Hahs-Vaughn and Nye (2016) found that joint attention interventions for children with ASD are generally effective in increasing positive outcomes in social functioning and communication, but the specific intervention factors responsible for these positive outcomes was unclear. By enhancing our understanding of the cognitive underpinnings of shared attention, the present results provide opportunities to pinpoint these factors more precisely, and hence to design more focused interventions. If self-categorization is fundamental to shared attention, then inducing self-categorization in joint attention interventions should increase their efficacy, which could be achieved by behavioral means, or via more cognitive-based strategies. In the former (behavioral) category, selective imitation could be used, as recent evidence suggests that selective imitation of play behavior by parents – which plausibly increases the child's sense of shared self-categorization with their parents (Lakens, 2010) – is effective in fostering the development of shared attention in children with ASD (Gulsrud, Helleman, Shire & Kasari, 2015; Ingersoll, 2012). In the latter (cognitive) category, more focused interventions could be created by adapting computational models of category learning (e.g., Love, Medin & Gureckis, 2004) for shared attention situations. Attentional focus, background knowledge, situational goals, the accessibility of particular self-categories in working memory, the categorical relations between self, other and object – all of which are important factors in computational models of categorization and self-categorization – could all be explicitly manipulated in joint attention interventions. These joint attention interventions could then also feed into evidence-based social skills programs (e.g., the Secret Agent Society; Beaumont, Rotolone & Sofronoff, 2015, or the PEERS program, Mandelberg et al., 2014), thus also enhancing their efficacy. As well as the more positive outcomes we predict from such enhanced interventions, the increased understanding of the cognitive processes underlying shared attention should also lead to greater understanding of the shared attention phenomenon itself, and of the behaviors that arise from it.

Third, by conceptualizing ASD explicitly as a disorder of self-categorization, we also see particular prospects for developing interventions based around social identity approaches to health and well-being (e.g., along lines suggested by Haslam, Jetten, Postmes & Haslam, 2009; Jetten, Haslam & Haslam, 2012). In this regard it is notable that people with ASD suffer from significantly higher levels of depression (Ghaziuddin, Ghaziuddin & Greden, 2002) and anxiety (White, Oswald, Ollendick & Scahill, 2009) than the neurotypical population. Importantly, though, recent research has pointed to the critical role played by social identities in these phenomena (e.g., Cruwys, Dingle, Haslam, Haslam, Jetten & Morton, 2013). If, as these results suggest, ASD is a disorder of self-categorization in which difficulties in constructing social identities are evident, then it is quite likely that the decreased well-being seen in people with ASD could be a direct result of a social identity deficit. Accordingly, interventions that create the opportunity for people to develop, maintain and enhance social identities – which have shown great promise in decreasing depression and anxiety in neurotypicals (Haslam, Cruwys, Haslam, Dingle & Chang, 2016) – might be adapted specifically for an ASD population, with the goal of developing social identities in those for whom this process is otherwise challenging.

Finally, the current results speak to the possibility of developing a more integrated understanding of ASD. As things stand, ASD is typically understood to be a ‘fractionated’ disorder, characterized by a number of distinct but co-occurring clusters of features (Brunsdon & Happe, 2014). As discussed above, ToM dysfunction is understood to be at the heart of the social difficulties of ASD, but people with ASD also show a number of other cognitive-perceptual differences, many of which have been attributed to a tendency towards weak central coherence (WCC; Frith & Happe, 1994), or some variant thereof, such as enhanced perceptual processing (Mottron, Dawson, Soulieres, Hubert & Burack, 2006). Importantly, the present results speak to the possibility of integrating these WCC features with the ToM difficulties. Categorization, including self-categorization, is known to be affected in ASD (Klinger & Dawson, 2001; Skorich et al., 2016), a general impairment which has been attributed to a tendency towards WCC. Yet if self-categorization is at the heart of shared attention, and it is weak at the higher ends of the autism spectrum, as these results suggest, then it is plausible that the ToM difficulties of ASD are outcomes of WCC via a dysfunctional self-categorization process. Importantly, neurological and developmental evidence also appears to support this account, as self-categorization and ToM processes – including shared attention – activate overlapping neural substrates in the medial pre-frontal cortex (Molenberghs & Morrison, 2014; Mundy, Gwaltney & Henderson, 2010; Redcay, Kleiner & Saxe, 2012; Telzer, Ichien & Qu, 2015), and it also appears that the self-categorization system develops at the same age as, or perhaps earlier than, early joint attention (Elison et al., 2013; Grossman & Johnson, 2010; Quinn, Yahr, Kuhn, Slater & Pascalis, 2002; Sanefuji, Ohgami & Hashiya, 2006), at somewhere between 3 and 9 months.

This suggests that an integrated understanding of ASD informed by our analysis and this convergent evidence has the potential to lead to a better understanding of the cognitive processes affected in the disorder, the neurological systems that underpin those processes, and the genetic and environmental bases of dysfunction in those systems. Importantly too, by integrating insights from multiple sub-disciplines in psychology (cognitive, clinical and social), this approach offers the prospect of a properly bio-psycho-social model of the condition in which all of these dimensions are taken equally seriously.

Limitations

Despite the promise of developing this more unified cognitive account of ASD, it is important to note the limitations of the current research. First, the sample is drawn from the general population, rather than from an ASD clinical population, and therefore the results speak most directly to the ‘broader autism phenotype’ (Piven, Palmer, Jacobi, Childress & Arndt, (1997) rather than to ASD per se. Second, the cross-sectional nature of the study, in conjunction with the adult sample, makes it difficult to draw inferences about the developmental dynamics associated with SAM – which are known to be particularly important with regard to the downstream consequences for social functioning (Baron-Cohen, 2005) – and how these might relate to differences in self-categorization. Most importantly, however, the methodology of the study reported in this paper does not allow for strong causal claims to be made. On the basis of Shteynberg’s (2010) shared-attention model, we discuss our results predominantly in the context of the theoretically plausible hypothesis that self-categorization might underlie shared attention. Our results could, however, be interpreted as revealing at least three alternative causal relationships.

Specifically, research has shown that better recognition memory can arise as a function of joint attention, in the absence of an explicit manipulation of self-categorization. For example, Striano, Chen, Cleveland and Bradshaw (2006) have shown that 9-month old infants looked at a novel toy longer when an experimenter alternated their gaze between the toy and the infant – in a joint attention condition – compared to a condition in which the experimenter alternated their gaze between the toy and a spot on the ceiling – in an object only condition. This suggests that, in very early development, gaze cues to joint attention may lead to enhanced processing of objects in the absence of self-categorization (see also, Böckler, Knoblich & Sebanz, 2011; Boothby, Clark & Bargh, 2014; Frischen & Tipper, 2004; Lindemann, Nuku, Rueschemeyer & Bekkering, 2011). In this context, our results could be interpreted as showing that self-categorization is *sufficient* for shared attention, but that it is perhaps not *necessary*.

Relatedly, the research of Striano and colleagues (2006) could be interpreted as demonstrating that joint attention *precedes* self-categorization. Indeed, Pellicano and Macrae (2009) found that mutual eye gaze facilitated sex categorization of faces over and above an averted gaze condition. Further, their results revealed that this effect only emerged for typically developing children, but not for children with ASD. These results suggest that mutual eye gaze – and thus joint attention – can in fact be a determinant of categorization, and that this process is disrupted in children with ASD. With this in mind, our results could be interpreted as revealing that shared attention brings about self-categorization of self and relevant ingroup members, rather than the reverse.

Finally, as with all experimental research, it is also possible that a third, unidentified process is a causal antecedent of both joint attention and self-categorization, such that neither of these processes precedes or produces the other. We maintain, however, that the hypothesis that self-categorization is fundamental to shared-attention remains particularly plausible, as its constituent assumptions are well supported both theoretically (Shteynberg, 2015; Turner et al., 1987; 1994) and empirically (Skorich et al., 2016; Shteynberg, 2010; Shteynberg & Apfelbaum, 2013; Shteynberg & Galinsky, 2011; Shteynberg et al., 2014). Furthermore, categorization – and its social equivalent self-categorization – is a ubiquitous process (Bruner, 1957; Oakes, Haslam & Turner, 1994), necessary for all perceptual sense-making operations in which the stimulus field is partitioned into meaningful entities, such as the process of determining self-other-object relations in shared attention situations[2]. Nevertheless, future research in which self-categorization is manipulated experimentally is essential in order to more robustly establish the causal paths underlying the relationship between self-categorization and shared-attention observed in the current study.

Conclusion

In the current paper, we sought to test the idea, derived from Shteynberg's (2015) shared-attention state model, that SAM might be reliant on self-categorization for its proper functioning, and that weaker self-categorization could explain the decreased shared attention seen in those with more autistic-like traits. Our results provide support for this account, which we suggest could lead to a more unified model of ASD. However, a number of avenues remain to be explored in future research. These include more rigorously exploring the causal relationships between self-categorization and shared attention, specifying the precise self-categorization sub-processes that might be affected in ASD, and investigating their significance both for the neurological and genetic basis of the condition, and for intervention. Our hope is that the present research convinces researchers of the value of such exploration and encourages them to participate in what will, of necessity, be a collaborative endeavour.

Footnotes

1. Superficially, the triadic representations described by Baron-Cohen (2005) and the shared-attention state described by Shteynberg (2010) appear to be distinct forms of cognitive representation. Multidimensional models of self-categorization (e.g., see McGarty, 1999, pp. 34-35, 119-120), however, suggest that self, other, and object can simultaneously be viewed in terms of their triadic relations and in terms of a first-person plural representation.
2. There is good reason to believe that categorization – and its social corollary self-categorization – is a basic cognitive process, because its primary function of dividing sensory information into units of meaning is necessary for any adaptive response to the external environment. Nonetheless, it is possible that categorization and self-categorization can only arise following particular, specific inputs from the environment (consistent with a neuroconstructivist approach; Mareschal, 2011), such that the causals paths underlying a complex process such as shared attention would be dynamic and multi-directional. Mapping out this interplay in future research is crucial to understanding the causal antecedents of shared attention and social perception more generally.

Figure Captions

Figure 1. Graphical representation of the research hypotheses

Figure 2. Example statement and associated avatar from the self-categorization task.

Figure 3. Example word lists and associated avatars from the shared attention task.

Figure 4. The relationship between autism quotient and ingroup shared attention, via self-categorization. $^*p < .05$

Compliance with Ethical Standards

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Ethical Approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards**.**

Informed Consent: Informed consent was obtained from all individual participants included in the study reported in this manuscript.

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