Advanced Review

Unraveling the paradox of the autistic self

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Paradoxically, individuals with autism spectrum conditions have been characterized as both impaired in self-referential cognitive processing, yet also egocentric. How can the self in autism be both 'absent' (i.e., impaired self-referential cognition), yet 'all too present' (i.e., egocentric)? In this paper, we first review evidence in support of both claims. Second, we highlight new evidence illustrating atypical function of neural systems underlying self-representation in autism. We suggest that egocentrism and impaired self-referential cognition are not independent phenomena. Instead, both egocentrism and impaired self-referential cognition in autism can be resolved as expressions of one common mechanism linked to the atypical function of neural circuitry coding for self-relevant information. We discuss how autism provides a unique window into the neurodevelopmental mechanisms enabling a critical developmental transition in self-awareness. This transition involves a dual understanding that one is similar to, yet distinct from others. The neural and cognitive basis of this developmental transition is central to understanding the development of social cognition as well as the paradox of the autistic self and its relation to social impairment in autism. © 2010 John Wiley & Sons, Ltd. *WIREs Cogn Sci*

Autism is a heterogeneous neurodevelopmental condition clinically characterized by a triad of impairments in reciprocal social interaction and communication, alongside repetitive stereotyped behaviors and/or unusually restricted interests.[1,2] In cognitive terms, autism is marked by impairments in empathy[3] (also known as 'mindblindness'[4]), central coherence,[5] and executive function,[6] while also showing excellent attention to detail[7] and intact or even superior systemizing.[3] However, the domain of self-referential cognition is one with historical precedent and may provide key insights into the nature of autism.[8–13]

Historically speaking, the 'self' has been at the heart of conceptualizing autism. The first hint of this is seen in the term 'autism'. 'Autism' derives from the Greek word 'autos' and literally translates as 'self'. Swiss psychiatrist Eugene Bleuler was the first to use the term 'autism' to characterize the social withdrawal in schizophrenia. However, in the first documentation of what we now call autism, Austrian-born child psychiatrist Leo Kanner co-opted the term 'autism' to describe children in his clinic who had the fundamental characteristic of being unable to relate to other people. This fundamental feature was what Kanner described as an 'extreme autistic aloneness'.[14] A year later, Austrian pediatrician Hans Asperger almost coincidentally described similar children whom he described as having 'autistic psychopathy' [which literally meant 'self' (autistic) 'personality disorder' (psychopathy)]. Although today autism and Asperger Syndrome are not seen as personality disorders and are certainly not confused with psychopathic (or anti-social) personality disorder, Asperger too was particularly struck by the extreme self-focus and characterized it as 'egocentric in the extreme'.[15] These initial observations by Kanner and Asperger mirror first-person accounts of individuals with autism.[9,10] Thus, from the start, what we now call autism spectrum conditions (ASC) were based on reports of extreme egocentrism. Clinicians refer to this through signs such as the 'far away' gaze of individuals with autism that convey the strong impression of being locked in 'a world of their own', sometimes described as being 'in a glass bubble' and unreachable by other people.

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Despite these characterizations of extreme egocentrism as a description of the autistic self, other accounts make what seems to be the opposite claim. On this alternative view, individuals with ASC are impaired in self-referential cognitive processing. How can individuals with ASC both be impaired in self-referential cognition, yet also show extreme egocentrism? In this article, we consider this apparent paradox and ask if the autistic self is best characterized as an 'absent self'[8] or an 'all too present' egocentric self, or whether both viewpoints are complementary to each other.

In our analysis of this paradox we first provide a broad overview of research that focuses primarily on conceptual aspects of the self in ASC. The focus primarily on conceptual aspects of self-processing is made in order to make a distinction between pre-conceptual aspects of the self such as action-monitoring.[16–19] We then argue that such a paradox need not exist. Finally, we argue that understanding the 'duality of self' (i.e., the realization that one is both similar to yet distinct from others) emerges from the early development of neural circuitry involved in processing self-relevant information. We argue that if this neural circuitry for self-representation is perturbed during early critical periods of development, this may delay the development of the 'duality of self', and trigger the developmental cascade of self-referential and social deficits observed in ASC.

SELF-RECOGNITION

We begin our review of the self in ASC with a focus on impairments in self-referential cognition. Among the first aspects of the self in ASC to be empirically tested was mirror self-recognition ability. The somewhat surprising consensus of these early studies was that rather than failing to recognize themselves, children with autism could reliably recognize themselves in the mirror[20–23] and can do so across a temporally extended period of time (i.e., 'that was me an hour ago').[24] A recent fMRI study of self-face recognition also found no group differences in neural activation to one's own face.[25] However, one caveat to keep in mind is that all studies assessing self-recognition ability test children at much later ages than when such ability typically begins to emerge around 18 months.[26] Added to this caveat are the facts that 18 months is pushing the boundary of the earliest time at which autism can be reliably diagnosed[27] and that most young children with autism are developmentally delayed relative to chronologically age-matched typically developing children. These delays are a significant factor determining whether individuals with autism show self-recognition ability.[23] Perhaps the best test of whether self-recognition ability predicts having a diagnosis of autism would be to prospectively investigate whether infants who later develop autism show early signs of delayed self-recognition development. However, this investigation has yet to be done and should be the focus of future research.

While self-recognition studies suggest that children with autism show intact behavioral and neural markers of low-level physical self-awareness (i.e., visual self-recognition), they also report subtle differences in self-conscious behaviors during such tests. For example, upon recognizing themselves in the mirror, individuals with autism do not show the usual self-conscious reactions (e.g., coyness or embarrassment) that typically developing children show.[20,21] This suggests that something subtle is missing in the self-awareness of individuals with autism and may be related to more abstract representational processes dealing with mental states or emotions rather than representations of a physical self.

ORIENTING TO NAME

While delayed self-recognition ability has not yet been tested as a predictor of early autism-risk, other early signs of autism-risk suggest self-referential deficits. One such early risk sign is the absence of orienting to one's name. Retrospective analyses of home videos were the first to highlight such early risk signs.[28] Furthermore, prospective studies of siblings of children with autism also show similar abnormalities in responding to one's own name.[29,30] While absence of responding to one's own name is not an indicator of autism-risk at 6 months of age, it is significantly indicative of autism-risk by 12 months of age. Crucially, the deficits in orienting to one's own name are not driven by deficits in receptive language ability and instead point to social motivational and self-referential difficulties as crucial factors underlying this abnormality.[29,30] This very simple test is in our view deeply important, since it may simultaneously reveal an early communication deficit (i.e., understanding why someone would even be calling your name in the first place), an early social cognition deficit (i.e., understanding that another person is expecting you to respond, e.g., with eye contact), and potentially a self-referential deficit (understanding that this name refers to your 'self'). Although the test itself cannot distinguish between all three of these possible deficits, it is possible that a failure to respond on this test reflects the inherent dependency of all three processes for passing such a test.

FALSE BELIEFS

The concept of an egocentric self in ASC was one of the initial motivations behind testing theory of mind ability in autism.[31] Indeed, the difficulty in attributing false beliefs to others in ASC extends to difficulties in reflecting on their own mind. When individuals with ASC are tested on whether they can remember their own false beliefs, they fail at similar rates to their performance on other-oriented false belief tests.[32] Recent evidence by Williams and Happe[33] demonstrates that when memory demands are eliminated from this task, individuals with ASC show even worse performance when attributing false beliefs to themselves than when attributing a false belief to others.

MONITORING INTENTIONS

As the pronounced deficits in false belief understanding suggest, children with ASC also find it difficult to monitor their own intentions. Phillips and colleagues demonstrated this by having children play a target shooting game. In this game the child starts by declaring which target they are aiming at. Upon shooting a target (where the outcome was surreptitiously manipulated by the experimenter), children with autism were poorer at correctly identifying which targets they intended to hit,[34] claiming that they meant to hit the target that was actually hit. In another study by Williams and Happe, children with ASC were less likely to report that elicited reflexes were unintentional. Furthermore, in a second manipulation, children were asked to complete drawings that were later manipulated by the experimenter. When later asked 'What did you mean to draw?', children with ASC were less able to correctly recognize the drawing that was intended.[35]

Recent neuroimaging work[36] also provides evidence to suggest that individuals with ASC have neural abnormalities linked to monitoring their own intentions in social interactions. While playing an iterative trust game, individuals with ASC did not show the typical robust response in middle cingulate cortex (MCC) when deliberating about their own decision in this game context. The authors interpret the lack of MCC response during self-decisions as an impairment in the capacity of individuals with ASC to represent their own social intent. Corroborating this claim, they also showed that decreases in MCC response during self-decisions predicted increased social and communicative symptom severity.

INTROSPECTION

Deficits in theory of mind and monitoring intentions indicate a possible deficit in introspecting on one's own mental states. While introspection is a difficult topic to test experimentally, some qualitative evidence exists to support that introspection in individuals with ASC is qualitatively different. Hurlburt, Happe, and Frith[37] asked participants to report on randomly sampled moments throughout the day. While most control participants reported a myriad of inner experiences, including descriptions of their own mental states, individuals with ASC mostly reported their physical experiences rather than their mental or emotional states.

ALEXITHYMIA AND SELF-CONSCIOUS EMOTIONS

The qualitative differences in introspective experience suggest that individuals with ASC may also have difficulty in self-referential emotion understanding. This ability is linked to the personality trait 'alexithymia' (which in Ancient Greek literally translates to 'without words for emotion'). Individuals high in alexithymia have difficulty in understanding and describing their own emotions and have an externally (rather than internally) focused style of thinking. Individuals with ASC are significantly more alexithymic.[38] In our work we also found that degree of alexithymia was significantly related to recognizing complex emotions in others.[39] This suggests that ability in self-referential emotion understanding and other-referential emotion understanding are linked. Similarly, individuals with ASC have impairments in both recognizing self-conscious emotions (e.g., pride, embarrassment) in others[11,40] as well as experiencing such emotions.[11,20,21,41] In classic autism, lack of embarrassment might be manifested by an adolescent who undresses in public, oblivious to the reactions of others. In Asperger Syndrome this might be manifested by an adult who outstays his welcome, failing to pick up on the signs of boredom of his host, or who unintentionally insults someone by making a personal remark.[42]

Linked to these inherent self-referential emotional understanding deficits, self-reports of individuals with ASC to emotional/arousing pictures differ from controls even though both groups can show identical physiological responses [indexed by galvanic skin response (GSR)] to such pictures.[43] In the brain there are marked neural differences in ASC when appraising their own emotional responses to arousing pictures. These differences are located in a neural system previously found to be important in

self-referential emotion understanding: the dorsomedial prefrontal cortex (dMPFC).[44] Interestingly, the area of hypoactivation in dMPFC is the same area in which previous studies have observed hypoactivation during other-oriented mentalizing tasks.[45,46] This marked difference exists despite the fact that there are no group differences in the recruitment of neural systems such as the anterior and posterior insula, which are known to co-vary with physiological arousal[47] and interoceptive awareness.[48]

AUTOBIOGRAPHICAL/EPISODIC MEMORY

Discussion of self-referential difficulties in autism so far has centered on mentalizing, introspection, and emotions. Further aspects of the self yet to be discussed are autonoetic consciousness (i.e., awareness of subjective experiences) or autobiographical/episodic memory.[49] Individuals with ASC have specific difficulties with autobiographical/episodic memory, rather than semantic memory.[50] For example, Bowler and colleagues[51] documented that individuals with ASC reported less recollective experience, but more reported familiarity with words that had been previously studied. Thus, participants could not remember specific episodic aspects of the memory task, yet could report more of a 'feeling of knowing'. Similarly, a case study by Klein and colleagues examined an individual with autism (RJ) who had a striking dissociation between intact semantic retrieval for his own personal characteristics (e.g., personality traits), but severe episodic retrieval deficits for personally experienced past events.[52] RJ's episodic retrieval deficits mirrored those of a typical amnesic patient in all respects, except that RJ's deficit was assumed to be developmental rather than acquired. Crane et al.[53,54] and Bruck et al.[55] find similar deficits in episodic memory across children and adults that confirm Klein's early case report claims. Given both the close developmental emergence of episodic memory and theory of mind[56] and evidence that both processes tap similar neural systems,[57] this pattern of results suggests common underlying mechanisms may be at work in both processes.

SELF-REFERENCE EFFECT IN MEMORY

One mechanism underlying the deficits in autobiographical memory may be the enhancing effect that the self plays as an 'elaborational and organizational' encoding/retrieval mechanism.[58] This effect, known as the 'self-reference effect (SRE) in memory', refers to the observation that self-referentially encoded information is typically remembered better than the information encoded via other routes[59] (e.g., semantic manipulations, or thinking about others). In autism, the SRE was first documented as completely absent, since people with ASC showed *equal* recognition memory for both self-referential and non-social semantically encoded personality traits.[60] While this previous study has its drawbacks (e.g., use of a biased measure of recognition memory sensitivity, and no comparison condition for thinking about others), Henderson et al.[61] recently replicated the absence of an SRE in young children without such drawbacks. In adults, rather than observing a completely absent SRE, we found the SRE was significantly attenuated when comparing self to a non-close dissimilar other.[39] In conjunction with Henderson et al., these results suggest a developmental delay in the use of self as an elaborative organizational encoding/retrieval mechanism. Furthermore, we also showed that in adults, individuals with ASC showed worse memory for traits of both self- and close/similar-others. However, there were no differences in memory for traits of a non-close dissimilar other[39] (Figure 1). This result suggests that self-referential cognitive deficits can be observed in the refractory effect it has on performance for social information processing, especially when thinking about others who share significant variability with the self (e.g., similar or close others).

DUALITY OF SELF: RECOGNIZING THAT SELF AND OTHER ARE SIMILAR, YET DIFFERENT

So far, discussion has centered on the array of self-referential impairments in autism. However, this neglects any consideration about the 'duality of self'. By 'duality of self' we mean a *context-dependent* understanding of how one is similar to, yet different from others.[62] Individuals with ASC appear not to employ a typical context-dependent understanding of this dual nature of the self. Two signs of this can be seen in the lack of appropriately distinguishing self from other in instances where self and other are obviously different; and in the lack of anchoring other-representations on self-representations in contexts that require such simulation strategies (e.g., imitation, communication).

VIEWING THE SELF EMBEDDED IN SOCIAL CONTEXTS

First, individuals with ASC often view themselves differently from their typically developing peers. In

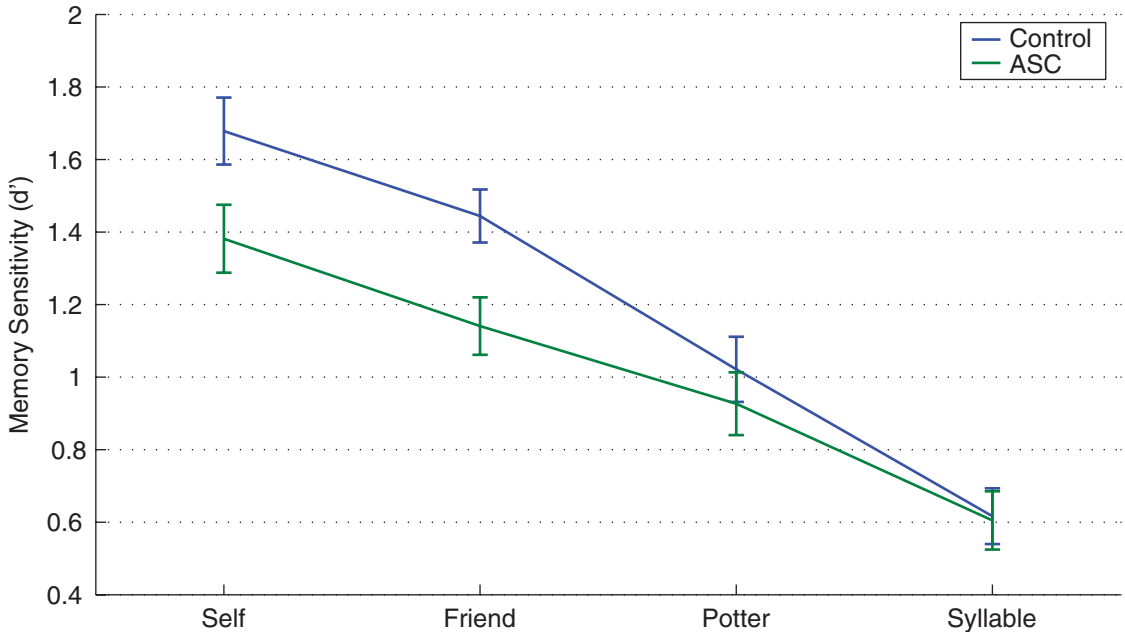

FIGURE 1 | The self-reference effect (SRE) in memory in autism, showing recognition memory performance on the SRE paradigm. In this paradigm, participants judge how descriptive personality trait words are in relation to themselves (Self), a similar/close other such as one's best friend (Friend), or a familiar but dissimilar/non-close other (Harry Potter), or they count how many syllables are in the word. Upon surprise recognition memory test, participants rate whether they remember the word or not. The SRE, calculated as the difference score between Self and Potter (Self-Potter), is attenuated in autism. The reason for this attenuation was due to reduced memory for words processed in relation to self. Deficits in memory also existed for others who were similar/close to oneself (Friend), but were not apparent for the dissimilar/non-close other (Harry Potter) or during a non-social encoding condition such as counting syllables (Syllables). Figure reproduced with permission from Ref. 39 Copyright 2007 *PLoS One*.

particular, individuals with ASC may not automatically view themselves as embedded within social contexts. In an interview study, Lee and Hobson[63] found that while individuals with ASC did not differ from typically developing individuals in the number of statements elicited about the self in physical, active, and psychological contexts, they showed marked reductions specifically in describing themselves in social contexts. This suggests that the self-concepts of individuals with ASC do not naturally include the social world, and may be indicative of the idea that they may not automatically represent themselves in *relation* to others.

SIMULATING OTHERS THROUGH ONESELF

The lack of automatically viewing oneself in *relation* to the social world may have an impact on employing context-dependent understanding of one side of the dual nature of self; that is, that one is similar to others. In some social contexts, the appropriate strategy is to simulate others through one's own experience and this strategy is most appropriate if another person is similar to oneself.[64] One representative test of this simulative process is in the context of imitation in early development. Decades of research have now documented that individuals with ASC show marked deficits in imitation and its underlying neural basis.[65–67] In communicative contexts, employing the understanding that one is similar to others can also facilitate communication. This context-dependent simulation of others through oneself in communicative contexts is missing in ASC. Hobson and Meyer[13] demonstrated that unlike typically developing children, children with ASC do not use their own bodies to communicate to another person where to place a sticker. In this case, rather than implementing an understanding that another is similar to oneself (e.g., *I* can use my body to communicate to *them* where to place the sticker), individuals with ASC appear to have trouble automatically employing such simulative processing when the context calls for it.

LACK OF SELF–OTHER DISTINCTION

The other way in which the dual nature of self is manifest is in the context-dependent understanding that one is different or distinct from others. Early theory of mind paradigms provide examples where

such an appropriate self–other distinction is lacking. In this case, one must understand that self and other differ in the knowledge each person has about the context.[68] Further evidence that individuals with ASC do not properly distinguish self from other can be seen in a drawing study by Lee and Hobson.[69] These authors observed that children with ASC tend to create drawings of self and other that lack distinguishing characteristics compared to drawings from typically developing children.

PRONOMINAL REVERSAL

In the communicative domain, another example of difficulties in distinguishing self from other is exemplified in the reversal of personal pronouns. Young children with autism frequently reverse first person pronouns to refer to other people (e.g., calling their mother 'I'). Conversely, this pronominal reversal also extends in the other direction. Personal pronouns referring to others are sometimes used to refer to themselves (e.g., 'You want a biscuit').[11,70,71] Even in adulthood there is some abnormality with first person pronoun usage. When primed to make self-references, adults with ASC use first person pronouns less.[39] The misuse of personal pronouns may reflect the equivalence with which individuals with ASC treat self and others. Loveland and Landry[72] found that correct personal pronoun usage was related to the development of joint attention. This relationship highlights that joint attention hinges critically on understanding that self and other are different, yet can share attention in the environment.[73]

PRIVILEGED ACCESS

Another key factor differentiating self from other is the asymmetries in access to informational sources for self and other. We are immersed in our own internal and privileged experiences (sensations, emotions, thoughts), while our experience of others is dominated largely by external observation (e.g., their behavior).[74] Individuals with autism may not perceive themselves as having such privileged access to self-information. In a recent report by Mitchell and O'Keefe[75] children were asked to rate how much they knew about themselves on various topics. In a control condition, they were asked to rate the same topics based on how much they perceived their mother knew about them [e.g., 'How well do (you/your mother) know about what kind of person you are?']. Typically developing children always rated themselves as knowing more about themselves when compared to their mother. However, children with ASC assigned *equal* amounts of knowledge about themselves to their mother as they did for themselves.

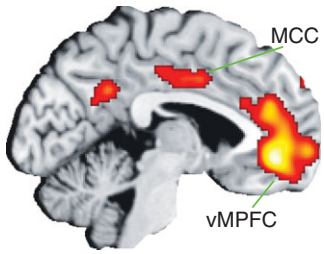

FIGURE 2 | Neural systems involved in self-representation, showing the results of a quantitative meta-analysis of all studies contrasting self-referential processing to other-referential processing (i.e., Self>Other). The ventromedial prefrontal cortex (vMPFC) extending into the anterior cingulate/paracingulate cortex and middle cingulate cortex (MCC) are consistently engaged in the general population during self-referential processing compared to other-referential processing (Self>Other). From data in Lombardo et al.[79]

NEURAL SELF-REPRESENTATION

Finally, we turn to neuroimaging studies of the self in autism that demonstrate that individuals with ASC lack a neural distinction between self and other. First however, we should highlight where neural self-representations occur in the general population. In the general population, the ventromedial prefrontal cortex (vMPFC) and MCC have been shown to respond preferentially to self-relevant information.[76,77] By preferentially coding for self-relevant information, meta-analyses have shown that vMPFC and MCC consistently respond more when reflecting about the self compared to others[78–81] (Figure 2). Even in the absence of explicit self-referencing, these two regions respond more in conditions that are more self-relevant than the comparison condition. One example of this is the increased recruitment of vMPFC and MCC when thinking about others who are similar to oneself compared to dissimilar others.[82–85]

A recent fMRI study by Kennedy and Courchesne[86] probed individuals with ASC for differences in neural self-representation when thinking about one's own personality traits or when thinking about the traits of one's mother (e.g., close other). Individuals with ASC made no Self>Other distinction in the vMPFC. However, this paradigm did not elicit the typical Self>Other effect in the control group either and this may be due to the considerable overlap between the self and close others.

Our own recent study on neural self-representation in autism was similar to the Kennedy and Courchesne study[86] except that we chose a familiar non-close other (the British Queen) as the

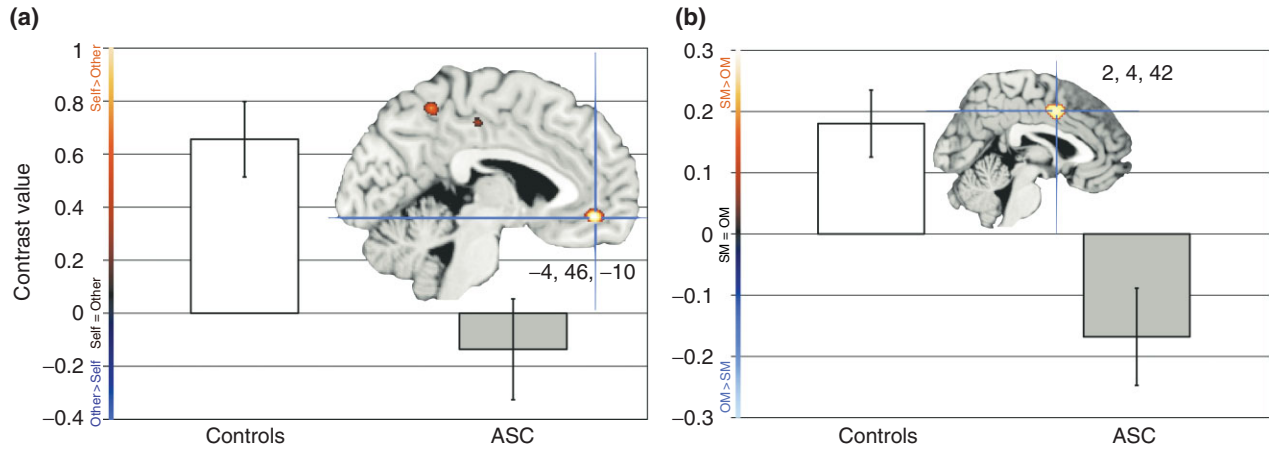

FIGURE 3 | Atypical in neural self-representation in ASC, depicting the lack of preferential vMPFC and MCC response to self-referential cognitive processing. (a) In controls, vMPFC robustly responds more to self-referential processing compared to other-referential processing (Self>Other). However, in autism, vMPFC response is equivalent for both self- and other-referential processing (Self = Other). (b) The MCC responds more to mentalizing about self than other (SM>OM) in controls. However, in ASC, the MCC responds in the opposite fashion; more for mentalizing about others than self. From data in Lombardo et al. [79]

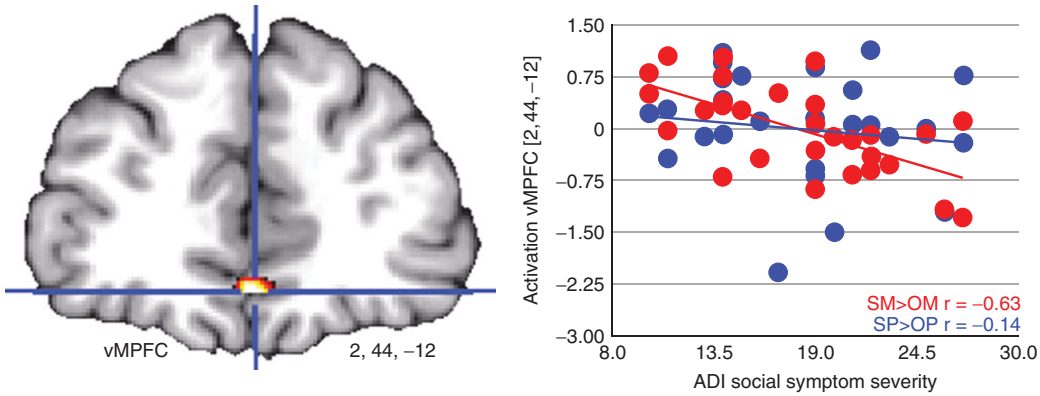

FIGURE 4 | Early childhood social impairment and vMPFC Self–Other distinction, showing that the magnitude of vMPFC Self>Other response is correlated with the magnitude of early childhood social impairments in autism. This correlation was specific to judgments in the mentalizing domain (red dots) and did not generalize to judgments about the physical characteristics (blue dots) of self and other. Those individuals who showed the largest self–other mentalizing distinction in vMPFC (i.e., SM>OM; values highest on the y-axis) were least socially impaired in early childhood (values lowest on the x-axis). However, those individuals who made little to no self–other mentalizing distinction (i.e., SM = OM or OM>SM; decreasing values on the y-axis) were the most socially impaired in early childhood. Figure reproduced with permission from Ref. 79 Copyright 2009 Guarantors of *Brain*.

person for the other condition. Unlike the Kennedy and Courchesne study, we were able to elicit a large Self>Other distinction in the vMPFC of control participants.[87] MCC responded more to mentalizing about the self versus mentalizing about others. In contrast, individuals with ASC recruited vMPFC equally for both self and other and recruited MCC more from mentalizing about others than mentalizing about self (Figure 3).[79] Regions that made the self–other distinction in the other direction (i.e., coding for Other>Self) showed identical responses for both controls and ASC. In other words, individuals with ASC show atypical patterns of neural self-representation in regions that specifically code for self-information. In addition to the deficit in vMPFC, we also found a relationship between the vMPFC Self>Other effect and early childhood social impairments. Individuals with the largest Self>Other effect in vMPFC were the least socially impaired in early childhood, while those with little to no Self>Other effect (i.e., Self = Other) were the most socially impaired in early childhood. This relationship was only apparent in a mentalizing context and was not apparent when making physical judgments (Figure 4). These

results demonstrate that the neural circuitry typically involved in coding self-relevant information is atypical in autism and that the magnitude of deficit may be an underlying mechanism behind the early social deficits in autism.

In addition to localized vMPFC dysfunction, we observed that the lack of a Self>Other distinction extended into the neural circuit functionally connected with vMPFC during self-judgments. The vMPFC circuit engaged during self-referential processing typically evokes strong functional connectivity with embodied sensorimotor regions such as the ventral premotor cortex and somatosensory cortex. In autism, this connectivity between vMPFC and embodied sensorimotor systems was absent. Therefore, in addition to localized vMPFC dysfunction, this result also highlights that neural self-representation in autism is atypical across a whole neural circuit crucial for coding self-referential information.[79]

CONCLUSION

As we have highlighted, individuals with autism are paradoxically both egocentric and impaired in self-referential cognitive processing. However, this paradox may arise simply from the common sense assumption that extreme egocentrism implies enhanced self-referential cognitive processing. This assumption is questionable since egocentrism can also arise simply if self and other are treated with equivalence. In autism, it is even more apparent why this assumption may not apply. 'Egocentrism' may simply be a label to define instances where individuals do not properly distinguish between self and other. The neural evidence provides a key clue that an 'egocentric' response in the brain (i.e., Self = Other) is actually the result of an impairment in self-referential coding of information. Thus, both the impairments in self-referential cognitive processing and extreme egocentrism revolve around one common mechanism that can be parsimoniously attributed to the failure of neural circuitry coding for self-representations.

It is interesting to note that the self–other equivalence which characterizes some of the behavioral and neural evidence for self-representation in autism is very similar to the ideas in developmental psychology that posit such self–other equivalence as the starting point for social cognitive development.[88] It is also interesting that some of the earliest social cognitive deficits in autism, such as orienting to name,[28–30] joint attention,[89] imitation,[65] and theory of mind[4] all lie at the interface of relating oneself to others and occur soon after infants begin to pass the mirror self-recognition test.[26] We suggest that this developmental time period is critical for the emergence of understanding the 'duality of self' in a social context. It is during this time that infants transition from the early 'like-me' stage into a developing understanding that oneself is similar to, yet simultaneously different and distinct from, other individuals. The challenge for future research will be to explore such duality in the early development of autism and to relate such work back to neurobiological abnormalities occurring in brain regions supporting neural self-representation.

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REFERENCES

1. American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders*. Washington, DC: American Psychiatric Association; 1994.
2. ICD-10. *International Classification of Diseases*. Geneva, Switzerland: World Heath Organization; 1994.
3. Baron-Cohen S. The extreme male brain theory of autism. *Trends Cogn Sci* 2002, 6:248–254.
4. Baron-Cohen S. *Mindblindness: An Essay on Autism and Theory of Mind*. Cambridge, MA: MIT Press; 1995.
5. Happe F, Frith U. The weak coherence account: detail-focused cognitive style in autism spectrum disorders. *J Autism Dev Disord* 2006, 36:5–25.
6. Ozonoff S, Pennington BF, Rogers SJ. Executive function deficits in high-functioning autistic individuals: relationship to theory of mind. *J Child Psychol Psychiatry* 1991, 32:1081–1105.
7. Mottron L, Dawson M, Soulieres I, Hubert B, Burack J. Enhanced perceptual functioning in autism: an update, and eight principles of autistic perception. *J Autism Dev Disord* 2006, 36:27–43.

8. Frith U. *Autism: Explaining the Enigma*. Malden, MA: Blackwell, 2003.
9. Frith U, de Vignemont F. Egocentrism, allocentrism, and Asperger syndrome. *Conscious Cogn* 2005, 14:719–738.
10. Frith U, Happe F. Theory of mind and self-consciousness: what it is like to be autistic. *Mind and Language* 1999, 14:1–22.
11. Hobson PR, Chidambi G, Lee A, Meyer J. Foundations for self-awareness: an exploration through autism. *Monogr Soc Res Child Dev* 2006, 71:vii–166.
12. Hobson RP. On the origins of self and the case of autism. *Dev Psychopathol* 1990, 2:163–181.
13. Hobson RP, Meyer JA. Foundations for self and other: a study in autism. *Dev Sci* 2005, 8:481–491.
14. Kanner L. Autistic disturbance of affective contact. *Nerv Child* 1943, 2:217–250.
15. Asperger H. Die autistischen Psychopathen im Kindesalter. *Arch Psychiatr Nervenkr* 1944, 117:76–136.
16. David N, Gawronski A, Santos NS, Huff W, Lehnhardt FG, et al. Dissociation between key processes of social cognition in autism: impaired mentalizing but intact sense of agency. *J Autism Dev Disord* 2008, 38:593–605.
17. Lind SE, Bowler DM. Recognition memory, self-other source memory, and theory-of-mind in children with autism spectrum disorder. *J Autism Dev Disord* 2009, 39:1231–1239.
18. Millward C, Powell S, Messer D, Jordan R. Recall for self and other in autism: children's memory for events experienced by themselves and their peers. *J Autism Dev Disord* 2000, 30:15–28.
19. Williams D, Happe F. Pre-conceptual aspects of self-awareness in autism spectrum disorder: the case of action-monitoring. *J Autism Dev Disord* 2009, 39:251–259.
20. Neuman CJ, Hill SD. Self-recognition and stimulus preference in autistic children. *Dev Psychobiol* 1978, 11:571–578.
21. Dawson G, McKissick FC. Self-recognition in autistic children. *J Autism Dev Disord* 1984, 14:383–394.
22. Spiker D, Ricks M. Visual self-recognition in autistic children: developmental relationships. *Child Dev* 1984, 55:214–225.
23. Ferrari M, Matthews WS. Self-recognition deficits in autism: syndrome-specific or general developmental delay?. *J Autism Dev Disord* 1983, 13:317–324.
24. Lind SE, Bowler DM. Delayed self-recognition in children with autism spectrum disorder. *J Autism Dev Disord* 2009, 39:643–650.
25. Uddin LQ, Davies MS, Scott AA, Zaidel E, Susan Y, et al. Neural basis of self and other representation in autism: an FMRI study of self-face recognition. *PLoS One* 2008, 3:e3526.
26. Amsterdam B. Mirror self-image reactions before age two. *Dev Psychobiol* 1972, 5:297–305.
27. Cox A, Klein K, Charman T, Baird G, Baron-Cohen S, et al. Autism spectrum disorders at 20 and 42 months of age: stability of clinical and ADI-R diagnosis. *J Child Psychol Psychiatry* 1999, 40:719–732.
28. Osterling J, Dawson G. Early recognition of children with autism: a study of first birthday home videotapes. *J Autism Dev Disord* 1994, 24:247–257.
29. Nadig AS, Ozonoff S, Young GS, Rozga A, Sigman M, et al. A prospective study of response to name in infants at risk for autism. *Arch Pediatr Adolesc Med* 2007, 161:378–383.
30. Zwaigenbaum L, Bryson S, Rogers T, Roberts W, Brian J, et al. Behavioral manifestations of autism in the first year of life. *Int J Dev Neurosci* 2005, 23:143–152.
31. Baron-Cohen S, Leslie AM, Frith U. Does the autistic child have a "theory of mind"?. *Cognition* 1985, 21:37–46.
32. Perner J, Frith U, Leslie AM, Leekam SR. Exploration of the autistic child's theory of mind: knowledge, belief, and communication. *Child Dev* 1989, 60:688–700.
33. Williams DM, Happe F. What did I say? Versus what did I think? Attributing false beliefs to self amongst children with and without autism. *J Autism Dev Disord* 2009, 39:865–873.
34. Phillips W, Baron-Cohen S, Rutter M. Understanding intention in normal development and in autism. *Br J Dev Psychol* 1998, 16:337–348.
35. Williams D, Happe F. Representing intentions in self and other: studies of autism and typical development. *Dev Sci*. DOI: 10.1111/j.1467-7687.2009.00885.x.
36. Chiu PH, et al. Self responses along cingulate cortex reveal quantitative neural phenotype for high-functioning autism. *Neuron* 2008, 57:463–473.
37. Hurlburt RT, Happe F, Frith U. Sampling the form of inner experience in three adults with Asperger Syndrome. *Psychol Med* 1994, 24:385–395.
38. Hill E, Berthoz S, Frith U. Brief report: cognitive processing of own emotions in individuals with autistic spectrum disorder and in their relatives. *J Autism Dev Disord* 2004, 34:229–235.
39. Lombardo MV, Barnes JL, Wheelwright SJ, Baron-Cohen S. Self-referential cognition and empathy in autism. *PLoS One* 2007, 2:e883.
40. Heerey EA, Keltner D, Capps LM. Making sense of self-conscious emotion: linking theory of mind and emotion in children with autism. *Emotion* 2003, 3:394–400.
41. Kasari C, Sigman MD, Baumgartner P, Stipek DJ. Pride and mastery in children with autism. *J Child Psychol Psychiatry* 1993, 34:353–362.
42. Baron-Cohen S. *Autism and Asperger Syndrome: The facts*. Oxford: Oxford University Press; 2008.

43. Ben Shalom D, Mostofsky SH, Hazlett RL, Goldberg MC, Landa RJ, et al. Normal physiological emotions but differences in expression of conscious feelings in children with high-functioning autism. *J Autism Dev Disord* 2006, 36:395–400.
44. Silani G, Bird G, Brindley R, Singer T, Frith C, et al. Levels of emotional awareness and autism: an fMRI study. *Soc Neurosci* 2008, 3:97–110.
45. Castelli F, Frith C, Happe F, Frith U. Autism, Asperger syndrome and brain mechanisms for the attribution of mental states to animated shapes. *Brain* 2002, 125:1839–1849.
46. Happe F, Ehlers S, Fletcher P, Frith U, Johansson M, et al. 'Theory of mind' in the brain. Evidence from a PET scan study of Asperger syndrome. *Neuroreport* 1996, 8:197–201.
47. Critchley HD, Elliott R, Mathias CJ, Dolan RJ. Neural activity relating to generation and representation of galvanic skin conductance responses: a functional magnetic resonance imaging study. *J Neurosci* 2000, 20:3033–3040.
48. Critchley HD, Wiens S, Rotshtein P, Ohman A, Dolan RJ. Neural systems supporting interoceptive awareness. *Nat Neurosci* 2004, 7:189–195.
49. Lind S, Bowler D. Episodic memory and autonoetic consciousness in autism spectrum disorders: the roles of self-awareness, representational abilities, and temporal cognition. In: Boucher JM, Bowler DM, eds. *Memory in Autism: Theory and Evidence*. Cambridge, UK: Cambridge University Press; 2008, 166–187.
50. Ben Shalom D. Memory in autism: review and synthesis. *Cortex* 2003, 39:1129–1138.
51. Bowler DM, Gardiner JM, Grice SJ. Episodic memory and remembering in adults with Asperger syndrome. *J Autism Dev Disord* 2000, 30:295–304.
52. Klein SB, Chan RL, Loftus J. Independence of episodic and semantic self knowledge: the case of autism. *Soc Cogn* 1999, 17:413–436.
53. Crane L, Goddard L. Episodic and semantic autobiographical memory in adults with autism spectrum disorders. *J Autism Dev Disord* 2008, 38:498–506.
54. Crane L, Goddard L, Pring L. Specific and general autobiographical knowledge in adults with autism spectrum disorders: the role of personal goals. *Memory* 2009, 17:557–576.
55. Bruck M, London K, Landa R, Goodman J. Autobiographical memory and suggestibility in children with autism spectrum disorder. *Dev Psychopathol* 2007, 19:73–95.
56. Perner J, Ruffman T. Episodic memory and autonoetic consciousness: developmental evidence and a theory of childhood amnesia. *J Exp Child Psychol* 1995, 59:516–548.
57. Buckner RL, Carroll DC. Self-projection and the brain. *Trends Cogn Sci* 2006, 11:49–57.
58. Klein SB, Loftus J. The nature of self-referent encoding: the contributions of elaborative and organizational processes. *J Pers Soc Psychol* 1988, 55:5–11.
59. Rogers TB, Kuiper NA, Kirker WS. Self-reference and the encoding of personal information. *J Pers Soc Psychol* 1977, 35:677–688.
60. Toichi M, Kamio Y, Okada T, Sakihama M, Eric A. A lack of self-consciousness in autism. *Am J Psychiatry* 2002, 159:1422–1424.
61. Henderson HA, Zahka NE, Kojkowski NM, Inge AP, Schwartz CB, et al. Self-referenced memory, social cognition, and symptom presentation in autism. *J Child Psychol Psychiatry* 2009, 50:853–861.
62. Brewer MB. The social self: on being the same and different at the same time. *Pers Soc Psychol Bull* 1991, 17:475–482.
63. Lee A, Hobson RP. On developing self-concepts: a controlled study of children and adolescents with autism. *J Child Psychol Psychiatry* 1998, 39:1131–1144.
64. Ames DR. Inside the mind reader's tool kit: projection and stereotyping in mental state inference. *J Pers Soc Psychol* 2004, 87:340–353.
65. Rogers SJ, Pennington BF. A theoretical approach to deficits in infantile autism. *Dev Psychopathol* 1991, 3:137–162.
66. Williams JH. Self-other relations in social development and autism: multiple roles for mirror neurons and other brain bases. *Autism Res* 2008, 1:73–90.
67. Dapretto M, Davies MS, Pfeifer JH, Scott AA, Sigman M. Understanding emotions in others: mirror neuron dysfunction in children with autism spectrum disorders. *Nat Neurosci* 2006, 9:28–30.
68. Birch SA, Bloom P. Children are cursed: an asymmetric bias in mental-state attribution. *Psychol Sci* 2003, 14:283–286.
69. Lee A, Hobson PR. Drawing self and others: how do children with autism differ from those with learning difficulties. *Br J Dev Psychol* 2006, 24:547–565.
70. Jordan RR. An experimental comparison of the understanding and use of speaker addresse personal pronouns in autistic children. *Br J Disord Commun* 1989, 24:169–179.
71. Lee A, Hobson RP, Chiat S. I, you, me, and autism: an experimental study. *J Autism Dev Disord* 1994, 24:155–176.
72. Loveland KA, Landry SH. Joint attention and language in autism and developmental language delay. *J Autism Dev Disord* 1986, 16:335–349.
73. Mundy P, Sullivan L, Mastergeorge AM. A parallel and distributed-processing model of joint attention, social cognition and autism. *Autism Res* 2009, 2:2–21.
74. Pronin E. How we see ourselves and how we see others. *Science* 2008, 320:1177–1180.

75. Mitchell P, O'Keefe K. Brief report: do individuals with autism spectrum disorder think they know their own minds?. *J Autism Dev Disord* 2008, 38:1591–1597.
76. Moran JM, Heatherton TF, Kelley WM. Modulation of cortical midline structures by implicit and explicit self-relevance evaluation. *Soc Neurosci* 2009, 4:197–211.
77. Moran JM, Macrae CN, Heatherton TF, Wyland CL, Kelley WM. Neuroanatomical evidence for distinct cognitive and affective components of self. *J Cogn Neurosci* 2006, 18:1586–1594.
78. Kelley WM, Macrae CL, Wyland CL, et al. Finding the self? An event-related fMRI study. *J Cogn Neurosci* 2002, 14:785–794.
79. Lombardo MV, et al. Atypical neural self-representation in autism. *Brain*. DOI: 10.1093/brain/awp306.
80. Northoff G, Heinzel A, de Greck M, Bermpohl F, Dobrowolny H, et al. Self-referential processing in our brain–a meta-analysis of imaging studies on the self. *Neuroimage* 2006, 31:440–457.
81. van Overwalle F. Social cognition and the brain: a meta-analysis. *Hum Brain Mapp* 2009, 30:829–858.
82. Jenkins AC, Macrae CN, Mitchell JP. Repetition suppression of ventromedial prefrontal activity during judgments of self and others. *Proc Natl Acad Sci U S A* 2008, 105:4507–4512.
83. Mitchell JP, Macrae CN, Banaji MR. Dissociable medial prefrontal contributions to judgments of similar and dissimilar others. *Neuron* 2006, 50:655–663.
84. Mobbs D, Yu R, Meyer M, Passamonti L, Seymour B, et al. A key role for similarity in vicarious reward. *Science* 2009, 324:900.
85. Lamm C, Meltzoff AN, Decety J. How do we empathize with someone who is not like us? A functional magnetic resonance imaging study. *J Cogn Neurosci*. DOI: 10.1162/jocn.2009.21186.
86. Kennedy DP, Courchesne E. Functional abnormalities of the default network during self- and other-reflection in autism. *Soc Cogn Affect Neurosci* 2008, 3:177–190.
87. Lombardo MV, Chakrabarti B, Bullmore ET, Wheelwright SJ, Sadek SA, et al. Shared neural circuits for mentalizing about the self and others. *J Cogn Neurosci*. DOI: 10.1162/jocn.2009.21287.
88. Meltzoff AN. 'Like me': a foundation for social cognition. *Dev Sci* 2007, 10:126–134.
89. Landa RJ, Holman KC, Garrett-Mayer E. Social and communication development in toddlers with early and later diagnosis of autism spectrum disorders. *Arch Gen Psychiatry* 2007, 64:853–864.

FURTHER READING

Amodio DM, Frith CD. Meeting of minds: the medial frontal cortex and social cognition. *Nat Rev Neurosci* 2006, 7:268–277.
Banaji MR, Prentice DA. The self in social contexts. *Annu Rev Psychol* 1994, 45:297–332.
Epley N, Keysar B, Van Boven L, Gilovich T. Perspective taking as egocentric anchoring and adjustment. *J Pers Soc Psychol* 2004, 87:327–339.
Goldman AI. *Simulating Minds: The Philosophy, Psychology, and Neuroscience of Mind Reading*. New York: Oxford University Press; 2006.
Kagan J. *The Second year: The Emergence of Self-awareness*. Cambridge, MA: Harvard University Press; 1981.