

Title:

A lack of self-consciousness in Asperger's disorder but not in PDDNOS: implication for the clinical importance of ASD subtypes

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Abstract

Self-consciousness plays an important role in a person's social life. Assuming that self-consciousness is a key to understanding social impairments in high-functioning autism spectrum disorder (ASD), we examined self-consciousness in individuals with Asperger's disorder, pervasive developmental disorder not otherwise specified (PDDNOS) and their controls using an episodic memory task. The PDDNOS group consisted of individuals in a milder subgroup of PDDNOS, with less autistic features than Asperger's disorder. In the learning phase, one of three types of questions (phonological, semantic, self-referential) was asked about each following target word. The target words were all personality trait adjectives. Next, a recognition test was conducted. The PDDNOS group, like the control, showed the most superior performance in self-referential processing (i.e. the self-reference effect) while the Asperger's group did not; however, both the ASD groups revealed an atypical pattern of relationship between memory performance and IQ. Individuals with PDDNOS, unlike those with Asperger's disorder, may be self-conscious to the same degree as typically developing individuals, but the cognitive process leading them to self-consciousness seems atypical, causing social impairments similar to those seen in individuals with Asperger's disorder who lack self-consciousness.

Key words

Autism spectrum disorder (ASD); subtyping; self-consciousness; self-information processing; memory

Highlights

- We examined self-consciousness in Asperger's disorder and PDDNOS using an episodic memory task.
- The PDDNOS and control groups showed the self-reference effect (i.e. the most superior performance in recognition for self-referential processing), while the Asperger's group did not.
- However, both the ASD groups showed the same atypical pattern of relationship between the task performance and IQ.
- PDDNOS individuals may be self-conscious to the same degree as typically developing individuals, but the underlying cognitive process seems atypical, just as in Asperger's disorder.

1. Introduction

Impairments in social interaction are the core feature of autism spectrum disorder (ASD). While maladaptation in social situations is a common problem in individuals with ASD, they show multiple clinical manifestations and their difficulties differ greatly among individuals, and accordingly, their needs vary from person to person. For example, while some show little interest in other people, others show intense interest. Some approach others excessively, other show social avoidance such as mutism and withdrawal from people, even if they have the potential ability to maintain social activities. One of the important points for providing effective support to individuals with ASD is the degree of impairment of social interaction, which differs between subtypes of ASD, which are comprised in pervasive developmental disorder in the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, text revision (DSM-IV-TR).

Subtyping is an important factor related to various clinical manifestation of ASD. Based on the major diagnostic criteria, such as DSM-IV-TR and the 10th edition of the International Classification of Disease (ICD-10), ASD comprises autistic disorder (autism), Asperger's disorder (Asperger's syndrome) (AS) and pervasive developmental disorder, not otherwise specified (pervasive developmental disorder, unspecified) (PDDNOS). Epidemiological studies have reported that PDDNOS is the most common ASD (Baird et al., 2006; Chakrabarti & Fombonne, 2001). PDDNOS is used as a residual category containing heterogeneous subgroups with varying degrees of autistic symptoms such as an autism-like subgroup with late onset (i.e. atypical autism in ICD-10), an Asperger-like subgroup with low intellectual ability and a subgroup whose symptoms are milder than Asperger's disorder.

In individuals with ASD, having mild symptomatology does not always mean that their difficulties are mild. For example, in individuals in the milder-symptom subgroup of PDDNOS, their diagnosis is frequently overlooked and they receive little support, although they have the same difficulties in interpersonal relationship as individuals with other ASD, often suffering from an overwhelming stress and psychiatric problems such as anxiety and depression. The above clinical observations raise the following questions: why the difficulties seen in the milder subgroup of PDDNOS were not less severe (sometimes even more severe) than other ASD despite the milder symptoms, and why they frequently show comorbid stress-related psychiatric conditions. Considering that, anxiety/depression is generally related to the degree of the development of self-awareness, it is suspected that people in the above subgroup of PDDNOS might be more able to be aware of their own maladaptation in daily life than those with autism or Asperger's disorder, leading to psychiatric problems such as anxiety.

Previous studies suggested that self-consciousness, which is a type of self-awareness requiring a representation of self and others, is impaired in ASD; for example, a lack of self-conscious reactions in a mirror-rouge test (Neuman & hill, 1978; Dawson & McKissick, 1984), impaired autonoetic (self-knowing) consciousness (Bowler, Gardiner, & Grice, 2000; Bowler, Gardiner, & Gaigg, 2007; Tanweer, Rathbone, & Souchay, 2010), failure to distinguish themselves from others (Jordan, 1989; Lee, Hobson, & Chiat, 1994), poorer memory for self- versus peer-performed events (Millward, Powell, Messer, & Jordan, 2000), lack of viewing themselves as embedded within social contexts (Lee & Hobson, 1998) and identifying their own emotional states (Silani et al., 2008). Some theorists propose that impaired

self-consciousness may be fundamental to social impairments in ASD (Frith & Happé, 1999). The notion that ASD is characterized by impairments in Theory of Mind (ToM) drew considerable attention of researchers and clinicians. Frith and Happé (1999) argued that people with autistic disorder might have as little awareness of their own mental state as awareness of the mental states of other people (i.e. ToM). It is well known that many individuals with high-functioning ASD pass the ToM tasks. Therefore, it is of interest whether such individuals develop self-consciousness or not.

Self-consciousness is generally difficult to quantify; however, there is a paradigm in memory research that seems more suitable for the quantitative evaluation of self-consciousness than other methodologies, which is called the self-reference effect (SRE). SRE is a phenomenon in which self-related encoding enhances episodic memory better than encoding in other ways (e.g. phonological encoding, general semantic encoding, other-related encoding) (Rogers, Kuiper, & Kirker, 1977; Symons & Johnson, 1997 for review). When a person exhibits SRE, this means that the individual has a highly organized self-concept (leading them to use the self as an effective memory organizational system). It is acknowledged that healthy adults show SRE robustly (Symons & Johnson, 1997) with emergence in at least middle childhood (Pullyblank, Bisanz, Scott, & Champion, 1985). The typical self-reference task was developed as an extension of the levels-of-processing task (Rogers, Kuiper, & Kirker, 1977). This task generates the levels-of-processing effect (Craik & Tulving, 1975), a phenomenon that semantic encoding results in superior memory performance to “shallow”(phonological and graphic) encoding. The levels-of-processing effect is also robust in typically developing individuals (Geis & Hall, 1976; Geis & Hall, 1978; Owings & Baumeister, 1979). The first study that examined the levels-of-processing

effect in ASD (Toichi & Kamio, 2002) found a lack of the effect in individuals with autistic disorder with/without mild intellectual disability (but see Toichi et al., 2002). While absence of the SRE in ASD has also been reported in previous studies (Toichi et al., 2002; Henderson et al., 2009), one study reported that adults with ASD showed SRE to some extent (Lombardo, Barnes, Wheelwright, & Baron-Cohen, 2007). Thus it remained inconclusive whether ASD individuals show impaired self-consciousness or not.

Considering the possibility that the development of self-consciousness might differ between ASD subtypes with varying severity of autistic symptoms, we examined self-consciousness in AS and the mildest subgroup of PDDNOS using the SRE paradigm. We predicted that the PDDNOS group, like typically developing individuals, would show SRE, which may partly account for the development of secondary psychiatric symptoms seen in ASD with the mildest autistic features.

2. Methods

2.1. Participants

Ethics approval for this study was obtained from the Ethics Committee of Kyoto University Graduate School and Faculty of Medicine. Written informed consent was obtained from all participants.

The participants were 18 individuals with AS, 19 individuals with PDDNOS and 19 typically developing controls. The ASD group had been referred to Kyoto University for cognitive assessments by affiliated hospitals, the National Employment Center for the Handicapped, or public consultation offices. The control subjects were recruited from high school through graduate university students. We confirmed that the

individuals in the control group did not have ASD based on the interview by a child psychiatrist. The three groups were matched for age, verbal IQ (VIQ) and performance IQ (PIQ) on the Japanese version of the Wechsler Adult Intelligence Scale or the Wechsler Intelligence Scale for Children. There was no significant difference in gender ratio between groups. The characteristics of the subjects are presented in Table 1. All participants were free from physical diseases or psychiatric problems other than those related to ASD, and none was medicated.

TABLE 1. Characteristics of Participants

Characteristics	PDDNOS (N=19)		Asperger's Disorder (N=18)		Control (N=19)		P value
	Mean	SD	Mean	SD	Mean	SD	
Age (years)	20.74	6.53	20.78	9.02	22.16	5.36	0.78 ^a
VIQ	106.55	15.80	106.94	3.72	105.84	21.42	0.89 ^a
PIQ	100.63	18.71	98.72	16.08	96.68	19.45	0.80 ^a
Gender Ratio (male : female)	13:6		15:3		15:4		0.54 ^b
^a One-way ANOVA		^b χ^2 test					

The diagnosis of AS and PDDNOS was made by two experienced child psychiatrists (the authors) according to the DSM-IV-TR, based on an interview with the subjects, information from their parents, professionals who have helped them and a clinical record of childhood, when available. The diagnostic criteria of AS (DSM-IV-TR) consist of two major components: the criteria for qualitative impairment in social interaction, which include four items, and the criteria for obsessive traits (restricted repetitive and stereotyped patterns of behavior, interests, and activities), which include four items. The participants diagnosed with AS had symptoms that met two or more items of the social impairment criteria, which caused clinically significant impairment in social functioning. Individuals who met only one item of the

social impairment criteria at a clinical level took part in this study as a milder subgroup of ASD (PDDNOS group). Thus, social impairment in the PDDNOS group was generally milder than in the AS group. Regarding the criteria for obsessive traits, all participants with ASD met one or more items of the criteria. No participants satisfied the criteria of “autistic disorder” for qualitative impairment in communication.

2.2. Materials

A word list was developed from verbal materials collected from spontaneous language used by high-functioning adolescents with and without autism who did not participate in the main part of this study. Ninety adjectives for personality traits were chosen, 30 of which were used as targets to be learned, with the remaining 60 used as distractors in a recognition test. The adjectives were all common words among Japanese children and adolescents. There were no significant differences in word frequency between the targets and distractors. There were three 'levels' of question for each target: phonological, semantic and self-referential. The phonological questions in this study were all of the form “Does the word rhyme with xxx?”. The semantic and self-referential questions were all of the form “Is the meaning of the word similar to xxx?” and “Does the word describe you?”, respectively. There were two types of answer (yes/no) at each level of questioning, leading to six (three levels \times two answer types) different questions for each target (Table 2). Six lists, each consisting of 30 questions, were developed by pairing each of the 30 targets, adopting one question from each of the six alternative questions. Of the 30 questions about the targets to be studied, 10 questions were of phonological type, 10 of semantic type (half were yes

type, and half were no type), and the remaining 10 were the self-referential type. Moreover, three word lists were prepared for the recognition test, with each consisting of the same 30 targets and 60 distracters; however, their arrangement differed.

TABLE 2. Examples of Questions Used in the Self-Reference Task

Level	Target: 'shin-setsu' (kind)
Phonological	
Yes	Does the word rhyme with 'men-setsu' (interview)?
No	Does the word rhyme with 'kei-kaku' (plan)?
Semantic	
Yes	Is the meaning of the word similar to 'yasashii' (tender)?
No	Is the meaning of the word similar to 'tsumetai' (cold)?
Self-referential	
Yes or No	Does the word describe you?

In addition to the materials to be learned, six further target-question pairs were prepared for the purpose of presentation before (three pairs) and after (three pairs) the 30 pairs on which the participants would be tested. The target words used in these additional target-question pairs did not appear in the recognition test, eliminating possible primacy and recency effects in recognition performance.

2.3. Procedure

The participants were tested individually. The task consisted of a learning phase and a recognition phase. One of the 18 (six learning \times three recognition) task conditions was assigned to each participant, so that the task conditions for participants differed in each group. In the learning phase, participants first saw a question presented on a computer display for eight seconds, followed by the presentation of a

target word for two seconds. Participants were then asked to answer 'yes' or 'no' within five seconds following target presentation. The same procedure was repeated until the last item without a break. During this phase, participants did not know that a recognition task would follow. Immediately after the learning phase, a word recognition list was given to participants, and they were asked to choose 30 words that they judged as 'old' within a five-minute period.

3. Results

In the learning phase, subjects in the three groups answered most of the phonological and semantic questions correctly. Mean error rates for phonological and semantic questions were 5.6%, 1.1% in the AS group, 5.8%, 1.1% in the PDDNOS group, and 1.1%, 0.5% in the control group. One-way ANOVA revealed that there was no significant difference in error rates among groups for the phonological ($F(2,53) = 1.13, p > .10$) and semantic ($F(2,53) = 0.16, p > .10$) questions, respectively. The proportion of Yes responses to the self-referential questions was 59.4%, 48.4% and 47.4% in the AS, PDDNOS and control groups, respectively. One-way ANOVA revealed that there was no significant difference among groups for the average proportions of "yes" responses to the self-referential questions ($F(2,53) = 2.25, p > .10$).

In the recognition phase, each subject chose exactly 30 words, as instructed. Mean rates of correct recognition resulting from phonological, semantic, and self-referential processing were 37.2% (SD = 22.2%), 79.4% (SD = 20.7%), 83.89% (SD = 10.9%) in the AS group, 33.7% (SD = 25.0%), 73.2% (SD = 14.2%), 86.3% (SD = 13.4%) in the PDDNOS group and 42.6% (SD = 20.5%), 77.9% (15.8%), 89.5% (SD = 12.7%) in

the control group (Figure 1).

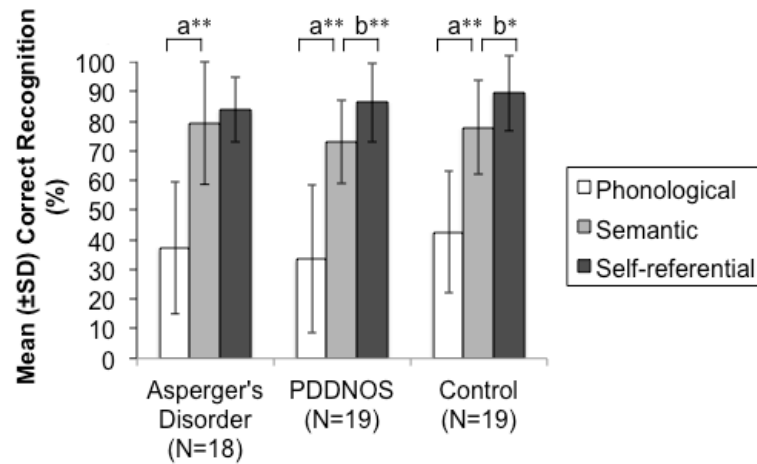


Fig. 1. Recognition performance of Asperger's disorder, PDDNOS and control group in the self-reference task.

All the groups showed the levels-of-processing effect. Although the Asperger group did not show the self-reference effect, the PDDNOS group, like the control group, did show the effect. Bars indicate the standard deviation of the mean. ^a Levels-of-processing effect. ^b Self-reference effect. * $p < .05$. ** $p < .01$

A preliminary analysis using three-way ANOVA (Group x Level x Answer Type) revealed that there were no significant main effects of Answer Type ($F(1,53) = 2.19$, $p > .10$) and that Answer Type did not interact with Group ($F(2,53) = 2.05$, $p > .10$), Level ($F(2,53) = 1.14$, $p > .10$) or Group and Level ($F(4,106) = 0.87$, $p > .10$);

therefore, this factor was neglected in the following analyses. Another preliminary analysis using Group x Level repeated-measures ANOVA confirmed a significant main effect of Level ($F(2,106) = 169.53, p < .001$), with no significant main effect of Group ($F(2,53) = 0.870, p > .10$), which indicates that overall memory performance in the three groups was similar.

Since the levels-of-processing effect and SRE were defined in principle as a significant *within-group* difference in memory performance between levels, post-hoc comparisons were conducted in each group. Bonferroni-corrected pairwise t-tests revealed a significant difference in recognition performance between phonological and semantic levels in all groups (AS group: $p < .001$, PDDNOS group: $p < .001$, control group: $p < .001$). This indicates that all groups showed the levels-of-processing effect. A significant difference in recognition performance between semantic and self-referential levels was also found in the PDDNOS group ($p < .01$) and the control group ($p < .05$), but not in the AS group ($p > .10$). This indicates that the PDDNOS group and the control group showed SRE but the AS group did not. Furthermore, between-group comparisons showed no significant difference in performance between the AS group and the PDDNOS group at phonological ($p > .10$), semantic ($p > .10$) and self-referential ($p > .10$) levels, between the AS group and the control group at phonological ($p > .10$), semantic ($p > .10$) and self-referential ($p > .10$) levels, or between the PDDNOS group and the control group at phonological ($p > .10$), semantic ($p > .10$) and self-referential ($p > .10$) levels, respectively.

Next, Spearman's correlation analyses were conducted in the two ASD groups regarding the associations between the amplitude of SRE and the number of criteria for social impairment and obsessive traits in the DSM-IV-TR they met. The amplitude

of SRE was calculated by subtracting the performance of the semantic level from that of self-referential level. There was no significant correlation between the number of obsessive trait criteria and the degree of self-reference ($p > .1$). However, there was a statistical trend toward a weak correlation between the numbers of the social impairment criteria and the amplitude of SRE ($\rho = -.30, p = .084$).

Following the example of the previous study (Toichi & Kamio, 2002), in which the autistic group and the control group showed a difference in the pattern of correlation between their performance in the levels-of-processing task and other cognitive measures, subsidiary analyses using Spearman's correlations were conducted regarding the associations between the recognition performance at each level and age, VIQ and PIQ. There were moderate correlations between the self-referential level and VIQ ($\rho = .57, p < .05$) and between the semantic level and VIQ ($\rho = .57, p < .05$) and PIQ ($\rho = .65, p < .01$) in the control group, with no significant correlation between the recognition performance at each level and age ($p > .10$). There was no significant correlation in the two ASD groups ($p > .10$). Furthermore, to explore the associations between the amplitude of SRE and age, VIQ and PIQ, Spearman's correlations analyses were conducted. In all groups, there was no significant correlation between the amplitude of SRE and age, VIQ, PIQ, respectively ($p > .10$).

4. Discussion

The control group in the present study showed the levels-of-processing effect and SRE. The results are consistent with previous findings, which confirmed that healthy adults robustly showed the levels-of-processing effect and SRE (c.f., Craik & Tulving, 1975; Symons & Johnson, 1997).

Both AS and PDDNOS groups in the current study showed the levels-of-processing effect. Previous studies assessing the levels-of-processing effect in ASD reported inconsistent findings (Toichi & Kamio, 2002; Toichi et al., 2002). Toichi et al. (2002) found that individuals with autistic disorder showed the effect, as in the present study, while Toichi and Kamio (2002) found that individuals with autistic disorder did not show the effect. These inconsistent findings seem to be attributable to the difference in the settings about target words. Adjectives were used as target words in the current study and Toichi et al. (2002) while nouns were used in Toichi and Kamio (2002). The chance of coincidence in endings differs widely between adjectives and nouns in Japanese. Since Japanese adjectives generally have similar endings, like -ful, -ic and -able in English, phonological processing for adjectives is less elaborative (i.e. the depth of processing at the phonological level is shallower) than that for nouns, eliciting more easily the levels-of-processing effect (vs. semantic processing). Actually, mean rates of correct recognition at the phonological level were around 65 % (autistic group) and 50% (control group) in Toichi and Kamio (2002) and 37.2% (AS group), 33.7% (PDDNOS group) and 38.8% (control group) in the current study, while mean rates of correct recognition at the semantic level in the ASD group and control group were almost identical (between 70% and 80 %) in both studies (the results in Toichi et al., 2002, also showed the same tendency as the present study). These findings indicate that the depth of processing at the phonological level was different among the studies. Thus, the inconsistent findings on the levels-of-processing effect among the studies are explicable from the difference in the depth of phonological processing. As far as we know, the current study is the first to report that individuals with AS and PDDNOS have an intact levels-of-processing effect.

More importantly, the PDDNOS group showed SRE as well as the control group in the current study, while the AS group did not. Because all three groups showed the levels-of-processing effect, the absence of SRE in the AS group was not attributable to a general lack of the levels-of-processing effect. Since the difference between the two ASD groups lies in the degree of impairment in social interaction (as described in the 'Participants' section), we considered that the result was closely related to the degree of impairment in social interaction. A weak negative correlation between the number of satisfied social impairment criteria and the degree of self-consciousness (i.e. the amplitude of SRE), although it did not reach a significant level, suggests that the severity of impairment in social interaction in ASD was related to the degree of self-consciousness. Individuals with PDDNOS who are more self-conscious than AS may develop a highly organized concept of self, as well as typically developing individuals, resulting in effective encoding of self-referential information. There might be a possibility that a lack of SRE in the AS group may be attributable to a developmental delay of self-consciousness. Although typically developing children usually show SRE by ten years old (Pullyblank, Bisanz, Scott, & Champion, 1985), it might well be that the participants with AS, who were adolescents or in early adulthood, were in the course of developing self-consciousness. In this study, however, there was no correlation between age and the amplitude of SRE in the AS group. Thus, it seems difficult to explain the lack of SRE in the AS group in terms of the factor of age.

Previous studies examining SRE in ASD have reported inconsistent findings. Lombardo et al. (2007) reported that adults with high-functioning autistic disorder and AS showed SRE, while adults (Toichi et al., 2002) and children (Henderson et al.,

2009) with high-functioning autistic disorder did not. It seems likely that the inconsistency of these results could be explained by the differences in the methodology and ASD subtypes. First, these studies did not use the same task; Lombardo et al. (2007) and Henderson et al. (2009) used the self-reference task, which used self-other comparisons, whereas Toichi et al. (2002) used the original paradigm (Rogers et al., 1977) of self-semantic comparisons, as did the current study. Because the depth of processing of other-related encoding is not always equal to that of semantic encoding, the results of Lombardo et al. (2007) and Henderson et al. (2009) cannot be directly compared with the results of Toichi et al. (2002) and the current study. Second, given that the ASD groups in this study showed a difference in self-consciousness (i.e. the presence or absence of SRE) depending on the severity of autistic features, the finding that the participants with autistic disorder, which is a severer subtype of ASD, did not show SRE in Toichi et al. (2002) is in accordance with our results. Also the difference in the results between Lombardo et al. (2007) and Henderson et al. (2009) may be explicable in terms of the difference in ASD subtypes.

Our results showed differences between the two ASD groups and the control group in the pattern of correlation between the cognitive measures and the performance of the recognition task. Performance at the semantic level correlated with both VIQ and PIQ in the control group, whereas there was no correlation in the two ASD groups. Also, while the performance at the self-referential level correlated with VIQ in the controls, it did not correlate with any cognitive measures in the ASD groups. These results suggest a possibility that the mental operations used in the ASD groups at semantic and self-referential processing were different from those used in the control group. Interestingly, the PDDNOS group, despite showing SRE, revealed the same

relationship between IQs and the recognition performance as the AS group who did not show SRE, suggestive of a possible difference in the way of being self-conscious between the control and PDDNOS groups.

The results of the current study seem to have some clinical implications. One is about the relationship between psychiatric problems and self-consciousness in ASD. It is generally recognized that anxiety/depression is related to the degree of the development of self-awareness. Mazurek and Kanne (2010) claimed that individuals with ASD who have more insight and self-awareness would show higher rates of anxiety, from the results that more symptoms of anxiety/depression were associated with higher IQ and milder ASD severity in those with ASD. If so, being self-conscious might not necessarily exert a favorable influence on individuals with ASD who belong to a milder-symptom subgroup of PDDNOS. Actually, patients with mild ASD severity who visit a psychiatrist are often conscious of how others view them. However, they tend to misread situations and become confused and nervous. Symptoms of anxiety/depression frequently observed in such individuals with PDDNOS seem to derive from their being self-conscious.

Misreading or misunderstanding social situation about self is one of the characteristics seen not only in mild ASD having self-consciousness but also in other ASD subtypes. These clinical findings suggest that atypical or deviant processing of self-related information may exist widely in ASD regardless of its severity. Considering such clinical observation as well as the finding of the current study, a cognitive behavioral approach seems to be suitable for such people in whom misperception of self-related situations causes internalizing problems such as a depressive state. Modifying their interpretation of self-related situations and reducing

their inappropriate responses, by learning how to properly analyze them and how to behave in confusing situations, could be useful for alleviating their difficulties.

Another clinical implication of our results is about the issue of ASD subtypes. In DSM-5, the diagnostic boundaries of ASD subtypes have been abolished, and they are integrated into the single diagnosis of ASD. With the transition to DSM-5, there is a possibility that some individuals with PDDNOS will lose the diagnosis of ASD. However, as already described, individuals with PDDNOS, despite their mild symptomatology, have essentially the same problems as those with other ASD. Therefore, their difficulties in everyday life should not be overlooked and appropriate support according to their varying needs will continue to be necessary.

A limitation of this study is that we targeted subjects in adolescence and early adulthood. While age was not found to be a factor influencing SRE in this study, further research on SRE in older adults is needed to clarify the relationship between age and the development of self-consciousness in ASD.

In summary, the current study demonstrated that individuals with PDDNOS show self-consciousness like typically developing individuals but the individuals with AS do not. Meanwhile, our findings suggested that the way of being self-conscious in those with PDDNOS might be atypical, possibly using the unique cognitive style common in ASD. Investigating self-consciousness using an objective and quantitative methodology such as SRE may shed light on the nature of social impairment in ASD.

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References

- Baird, G., Simonoff, E., Pickles, A., Chandler, S., Loucas, T., Meldrum, D., & Charman, T. (2006). Prevalence of disorders of the autism spectrum in a population cohort of children in South Thames: the Special Needs and Autism Project (SNAP). *Lancet*, 368, 210-215.
- Bowler, D. M., Gardiner, J. M., & Gaigg, S. B. (2007). Factors affecting conscious awareness in the recollective experience of adults with Asperger's syndrome. *Consciousness and Cognition*, 16, 124-143.
- Bowler, D. M., Gardiner, J. M., & Grice, S. J. (2000). Episodic memory and remembering in adults with Asperger syndrome. *Journal of Autism and Developmental Disorders*, 30, 295-304.
- Chakrabarti, S., & Fombonne, E. (2001). Pervasive developmental disorders in preschool children. *JAMA*, 285, 3093-3099.
- Craik, F. I. M., & Tulving, E. (1975). Depth of processing and the retention of words in episodic memory. *Journal of Experimental Psychology: General*, 104, 268-294.
- Dawson, G., & McKissick F. C. (1984). Self-Recognition in Autistic Children. *Journal of Autism and Developmental Disorders*, 14, 383-394.

Frith, U., & Happe, F. (1999). Theory of Mind and Self-Consciousness: What Is It Like to Be Autistic? *Mind and Language*, 14, 82-89.

Geis, M. F. & Hall, D. M. (1976). Encoding and incidental memory in children. *Journal of Experimental Child Psychology*, 22, 58–66.

Geis, M. F. & Hall, D. M. (1978). Encoding and congruity in children's incidental memory. *Child Development*, 49, 857–861.

Henderson, H. A., Zahka, N. E., Kojkowski, N. M., Inge, A. P., Schwartz, C. B., Hileman, C. M., Coman, D. C., & Mundy, P. C. (2009). Self-referenced memory, social cognition, and symptom presentation in autism. *Journal of Child Psychology and Psychiatry*, 50, 853-861.

Jordan, R. R. (1989). An experimental comparison of the understanding and use of speaker-addressee personal pronouns in autistic children. *The British Journal of Disorders of Communication*, 24, 169-179.

Lee, A., & Hobson, R. P. (1998). On developing self-concepts: a controlled study of children and adolescents with autism. *Journal of Child Psychology and Psychiatry*, 39, 1131-1144.

- Lee, A., Hobson, R. P., & Chiat, S. (1994). I, you, me, and autism: an experimental study. *Journal of Autism and Developmental Disorders*, 24, 155-176.
- Lombardo, M. V., Barnes, J. L., Wheelwright, S. J., & Baron-Cohen, S. (2007). Self-referential cognition and empathy in autism. *PloS one*, 2, e883.
- Mazurek, M. O., & Kanne, S. M. (2010). Friendship and internalizing symptoms among children and adolescents with ASD. *Journal of Autism and Developmental Disorders*, 40, 1512-1520.
- Millward, C., Powell, S., Messer, D., & Jordan, R. (2000) Recall for self and other in autism: children's memory for events experienced by themselves and their peers. *Journal of Autism and Developmental Disorders*, 30, 15-28.
- Neuman, C. J., & Hill, S. D. (1978). Self-recognition and stimulus preference in autistic children. *Developmental Psychobiology*, 11, 571-578.
- Owings, R. A., & Baumeister, A. A. (1979). Levels of processing, encoding strategies, and memory development. *Journal of Experimental Child Psychology*, 28, 100–118.
- Pullyblank, J., Bisanz, J., Scott, C., & Champion, M. A. (1985). Developmental invariance in the effects of functional self-knowledge on memory. *Child Development*, 56, 1447-1454.

- Rogers, T. B., Kuiper, N. A., & Kirker, W. S. (1977). Self-reference and the encoding of personal information. *Journal of Personality and Social Psychology*, 35, 677-688.
- Silani, G., Bird, G., Brindley, R., Tania, S., Frith, C., & Frith, U. (2008). Levels of emotional awareness and autism: an fMRI study. *Social Neuroscience*, 3, 97-112.
- Symons, C. S., & Johnson, B. T. (1997). The self-reference effect in memory: a meta-analysis. *Psychological Bulletin*, 121, 371- 394.
- Tanweer, T., Rathbone, C. J., & Souchay, C. (2010). Autobiographical memory, autoeic consciousness, and identity in Asperger syndrome. *Neuropsychologia*, 48, 900-908.
- Toichi, M., & Kamio, Y. (2002). Long-term memory and levels-of-processing in autism. *Neuropsychologia*, 40, 964--969.
- Toichi, M., Kamio, Y., Okada, T., Sakihama, M., Youngstrom, E. A., Findling, R. L., & Yamamoto, K. (2002). A lack of self-consciousness in autism. *The American Journal of Psychiatry*, 159, 1422--1424.