J Autism Dev Disord (2009) 39:1222–1225
DOI 10.1007/s10803-009-0731-6

BRIEF REPORT

Brief Report: Inner Speech Impairment in Children with Autism is Associated with Greater Nonverbal than Verbal Skills

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Published online: 28 March 2009

Abstract We present a new analysis of Whitehouse, Maybery, and Durkin's (2006, Experiment 3) data on inner speech in children with autism (CWA). Because inner speech development is thought to depend on linguistically mediated social interaction, we hypothesized that children with both autism and a nonverbal > verbal (NV > V) skills profile would show the greatest inner speech impairment. CWA and typically developing controls ($n = 23$ in each group) undertook a timed mathematical task-switching test, known to benefit from inner speech use. Participants completed the task with and without articulatory suppression (AS), which disrupts inner speech. The hypothesis was supported: AS interference varied with cognitive profile among CWA but not among controls. Only the NV > V autism group showed no AS interference, indicating an inner speech impairment.

Keywords Autism · Children · Inner speech · Cognitive profile · IQ

Introduction

Perhaps the most common cognitive profile associated with children with autism (CWA) is that characterized by greater nonverbal than verbal ability (NV > V; Joseph et al. 2002). The frequency with which this profile is observed suggests that individuals with a NV > V profile might comprise an etiologically meaningful subgroup of autism. This profile, as defined by significantly superior nonverbal IQ compared to verbal IQ on the Differential Ability Scales (Elliott 1990), has been shown to be associated with greater severity of the social symptoms of autism (Joseph et al. 2002), as well as abnormally large head circumference (Deutsch and Joseph 2003) and brain volume (Tager-Flusberg and Joseph 2003).

This research takes on added interest when it is interpreted within the context of experimental (e.g., Kana et al. 2006) and introspective (Grandin 1995; Hurlburt et al. 1994) reports that visual representation plays a disproportionately prominent role in the way that people with autism process information. This contrasts with studies suggesting that, in normal adults, cognition is more often verbal in nature. Some of these rely on introspective reports (Hurlburt et al. 1994), but most research on this topic employs dual task methodology. Here, the use of internal verbalizing (or inner speech) is measured by analyzing the effect of preventing it, by means of irrelevant articulation (articulatory suppression, AS) during the primary task. The performance of typical adults on executive tasks of strategic planning (Baldo et al. 2005) and task-switching (e.g., Baddeley et al. 2001) has been shown to be compromised with the addition of AS.

According to one prominent view, the development of inner speech depends on the gradual internalization of linguistically mediated social interactions over the course of childhood, resulting in cognitive processes that are mediated by language (Vygotsky 1934/1987). Therefore we would predict that disrupted inner speech development would follow from impoverished experiences of social interaction and/or language difficulties (Fernyhough 1996), both of which characterize CWA. Intriguingly, a recent

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study of CWA by Whitehouse, Maybery, and Durkin (2006, Experiment 3) found a reduced effect of AS on a timed mathematical task-switching test relative to typically developing controls, suggesting that CWA may show limited use of inner speech.

We hypothesized that children who had poor language skills in addition to autism would experience the greatest disruption in inner speech development, especially if they had effective nonverbal skills for achieving goals, i.e., a NV > V profile. To test this hypothesis, we analyzed the data of Whitehouse et al. (2006), Experiment 3, with respect to cognitive profile.

Method

Participants

Participants were 23 boys with high-functioning autism and 23 typically developing boys from Perth, Western Australia. Each CWA had been diagnosed under DSM-IV guidelines, and a random 50% had their diagnosis confirmed with the Autism Diagnostic Interview—Revised (Lord et al. 1994).

Verbal mental age was measured using the Australian standardized version of the Peabody Picture Vocabulary Test—Version IIIA (Dunn and Dunn 1997) and nonverbal mental age was gauged with Raven's Standard Progressive Matrices (Raven et al. 1992).

The autism and control groups were each divided into two groups, based upon a predetermined criterion of having a nonverbal age that exceeded verbal age by at least 2.5 years. Three participants, all with autism, obtained outlying discrepancy scores (10.33, 7.58 and −4.92 years) and were excluded from subsequent analyses.

Mean chronological and mental ages are shown in Table 1. So that the autism and control groups would be equal in nonverbal mental ages, $F(3,39) = 2.31$, ns, the autism groups were older than the control groups, $F(3,39) = 11.78$, $p < .001$. Verbal mental age also differed by group, $F(3,39) = 5.51$, $p < .01$. The verbal mental age of the NV = V autism group was significantly greater than that of the NV > V autism group ($p < .01$), but the NV = V and NV > V control groups did not differ in this way ($p > .50$). The implications of the fact that the NV > V autism group had the lowest language level are tested in the Results section.

Procedure

Participants were given mathematical problems, with function and equal signs omitted (e.g., 4 1 ______). The first digit for each problem was selected at random, whilst ensuring that the solution would be a single digit. The digit to be added or subtracted was always "1". Each participant completed two sets of problems with AS, and two sets in the control condition. In both conditions, participants were asked to complete the problems as if there were alternating plus and minus signs, while a metronome sounded one beat per second. In the control condition, participants were given no instructions other than to complete the problems as quickly and accurately as possible. In the AS condition, participants were also asked to repeat the word "Monday" in time with the metronome. There were 20 problems in each set. One set was completed for each condition in each of two sessions, conducted roughly 14 days apart. The order of presentation, which was the same for all participants, was counterbalanced across sessions.

Mean time taken to complete the lists and total number of errors (out of 20) were recorded. For errors that could be interpreted as alternation errors, 'consequential marking' was employed to avoid unfair penalties: If a child had subtracted when they should have added, or vice versa, but then resumed alternating, only one error was recorded.

Results

As shown in Table 1, performance in the control condition did not vary by group in terms of response times, $F(3,39) = 0.88$, ns, or errors, $F(3,39) = 0.22$, ns.

Table 1 Descriptive statistics

	Autism		Control	
	NV = V ($n = 12$)	NV > V ($n = 8$)	NV = V ($n = 15$)	NV > V ($n = 8$)
Chronological age[a]	11;4 $(2;2)_a$	10;5 $(1;7)_a$	8;4 $(1;0)_b$	8;4 $(0;8)_b$
Nonverbal age[a]	11;3 $(2;0)_a$	12;3 $(2;0)_a$	10;7 $(1;2)_a$	11;9 $(1;1)_a$
Verbal age[a]	10;11 $(2;11)_a$	7;9 $(1;4)_b$	9;8 $(1;4)_{a,b}$	8;5 $(0;9)_b$
Time taken in the control condition (seconds)	75.3 $(45.3)_a$	72.5 $(36.8)_a$	73.0 $(20.4)_a$	94.8 $(28.3)_a$
Number of errors in the control condition (out of 20)	1.3 $(1.5)_a$	1.1 $(1.1)_a$	1.3 $(1.0)_a$	0.9 $(0.8)_a$

Notes: All figures are mean (SD). Means in the same row that do not share subscripts differ at $p < .05$ on the Scheffé test

[a] In years; months

The effect of AS on response times (AS interference) was calculated as the mean time taken in the AS condition minus the mean time taken in the control condition, so that a more positive number denoted greater AS interference.

A 2(diagnostic group) × 2(cognitive profile) ANCOVA, with chronological age, verbal age, and nonverbal age as covariates, revealed no effect of cognitive profile on AS interference, $F(1,36) = 2.30$, ns, $\eta_p^2 = .06$. There was, however, a main effect of diagnostic group, $F(1,36) = 4.75$, $p = .04$, $\eta_p^2 = .12$, which was qualified by a significant interaction with profile type, $F(1,36) = 5.14$, $p = .03$, $\eta_p^2 = .13$. Adjusted means are shown in Fig. 1.

Two further ANCOVAs explored the effect of cognitive profile on AS interference within each diagnostic group (with the covariates as above). There was an effect of cognitive profile in the autism group, $F(1,15) = 11.33$, $p < .01$, $\eta_p^2 = .43$, but not in the control group, $F(1,18) = 1.01$, $p = .33$, $\eta_p^2 = .05$. Thus, amongst the CWA, AS interference was lower for participants with a NV > V profile than those with a more even cognitive profile.

One-sample *t*-tests comparing AS interference to zero showed that the only group to show no significant AS interference was the autism group with the NV > V profile, $t(7) = 0.19$, $p = .86$ (for all other groups, $p < .05$).

Next, we investigated the possibility that these results could be explained in terms of group differences in the effect of speed of performance on accuracy. AS interference was calculated in terms of errors, as the mean number of errors in the AS condition minus the mean number of errors in the control condition. A 2(diagnostic group) × 2(cognitive profile) ANCOVA (covariates as above) revealed no main effect of diagnostic group, $F(1,39) = 0.33$, ns, or profile type, $F(1,39) = 0.66$, ns, and no interaction, $F(1,39) = 0.33$, ns. Therefore the group differences in the response time AS interference effect (described above) cannot be explained in terms of speed-accuracy trade-off.

Finally, we considered the implications of the fact that the NV > V autism group had the lowest language level of the four groups, by investigating the possibility that AS interference (in terms of response times) could be predicted by language level alone. The correlation between verbal mental age and AS interference was not significant in either the autism group, $r(19) = .17$, $p = .48$, or the whole sample, $r(42) = -.08$, ns. These correlations did not increase in size when chronological age was partialled out, $r_p(17) = .16$ and $r_p(40) = .07$ respectively, both ns. Therefore the lack of AS interference in the NV > V autism group cannot be explained in terms of language level alone: Both verbal and nonverbal IQ are needed to explain variation in susceptibility to AS.

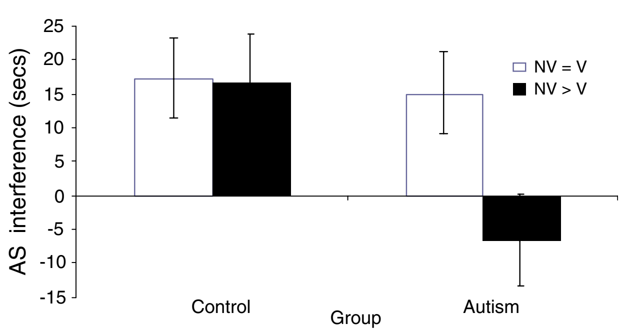

Fig. 1 Articulatory suppression (AS) interference by group (adjusted means)

Discussion

The analyses reported here show reduced AS interference on a mathematical task-switching test for the autism groups compared to the control groups, consistent with the original report of the data (Whitehouse et al. 2006, Experiment 3). However, further analysis showed that this effect was driven solely by the CWA with a NV > V profile, who showed no interference on task-switching with the addition of AS.

The significant main effect of diagnostic group suggests that the CWA were, on average, less reliant on inner speech in the task-switching paradigm. The presence of the diagnostic group × cognitive profile interaction, however, points to the need to refine the view of a simple association between autism and inner speech impairment. Specifically, a NV > V profile appears to interact with autism to produce an inner speech impairment. Poor verbal skills relative to nonverbal skills, combined with the presence of autism, might therefore represent a double blow to inner speech development.

From a Vygotskian perspective, relatively weak verbal skills and the social-interactional atypicalities that characterize autism can both be seen as factors preventing participation in the type of linguistically mediated social interactions on which inner speech development is thought to depend. The present findings are therefore in line with evidence from studies on typically developing children that relatively impoverished social interaction and verbal abilities can affect the development of verbal mediation (e.g., Al-Namlah et al. 2006).

It may be that the children in question both experience barriers to inner speech development and have at their disposal efficient nonverbal cognitive strategies, of the sort described in the qualitative accounts of Grandin (1995) and Hurlburt et al. (1994). A notable result here is that the children with both autism and a NV > V profile, although appearing not to use inner speech, performed just as well as the other three groups in the control condition. It is unclear how this was achieved, but one possible non-verbal strategy for task-switching is to 'label' the two tasks with spatial representations or motor movements rather than words. Although this task-switching test seemed to be amenable to non-verbal strategies for the participants with both autism and a NV > V skills profile, we would expect a tendency not to use inner speech to have deleterious effects on functioning in the real world, most notably for executive functioning (Baddeley et al. 2001; Baldo et al. 2005) and social understanding (Fernyhough 2008). The extent to which inner speech abnormalities could explain such impairments in NV > V autism is a matter for future research.

Although we interpret the results in terms of the possible effect of cognitive profile on inner speech development, an alternative possibility is that NV > V profile and reduced inner speech use are not directly functionally related but, rather, have a common cause. Whatever the explanation for the relation, these findings are consistent with previous research suggesting individuals with a NV > V profile comprise an etiologically meaningful subgroup of autism (Tager-Flusberg and Joseph 2003), and add reduced inner speech use to the list of what is known about this subgroup.

That inner speech impairment was found for only a subgroup of CWA might account for previous contradictory findings on inner speech in autism. For example, the two other experiments in Whitehouse et al. (2006) indicated that CWA are less likely than controls to use inner speech to remember pictures, whereas Williams et al. (2008) report a study in which no such difference was found. Another study looked at the overt speech of CWA while performing two executive tasks (the 'building sticks' task and the Wisconsin Card Sorting Test), and found that they were just as likely as typically developing controls to talk to themselves in task-relevant ways (Winsler et al. 2007). The present results suggest that contradictory findings might be explained by differences in the composition of the autism samples. Although all the papers contain information on the participants' verbal ability scores, their IQ profiles are unreported. We suggest that future studies of inner speech in autism consider NV > V profile as a moderating variable.

Finally, it should be noted that this is a relatively small study, in which we relied upon single measures of verbal and nonverbal mental age. Nevertheless the clear findings indicate that associations between cognitive profile and inner speech development in autism deserve further research.

Acknowledgments The authors thank two anonymous reviewers for their helpful comments.

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