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Brief report: Effect of verbalization to other individuals on cognitive planning in children with autism spectrum disorders

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ABSTRACT

This study investigated 21 children with ASD to ascertain the effects of verbalization to others on cognitive planning in children with ASD. The Tower of Hanoi (ToH) test was administered in two conditions: solo and duo. Participants performed the ToH test using the normal method in the solo condition. In the duo condition, a participant was not allowed to touch the ToH apparatus, but was allowed to communicate about the procedure verbally to complete the ToH test. In children with ASD in this study, performance of the duo condition was not different from the solo condition. However, individual differences in the performance of the duo condition were observed. Participants were classifiable into three groups based on their performance. The results show that the roles of verbalization on cognitive planning in children with ASD are not homogeneous.

Introduction

Autism spectrum disorders (ASD) appear to be biologically-based conditions with an early onset and a lifelong course. Previously, they included several autistic disorders such as autism, Asperger's syndrome (AS), and pervasive developmental disorders not otherwise specified (PDD-NOS) in the Diagnostic and Statistical Manual of Mental Disorders Fourth Edition text revision (DSM-IV-TR) [1]. The core features of these disorders are communication and social deficits, along with stereotyped behaviors [2]. Many empirical studies have also revealed the existence of cognitive control impairments in children with ASD [3, 4]. Cognitive control, executive control, and executive functions are umbrella terms that represent a series of higher-order cognitive processes such as planning, shifting, monitoring, and response inhibition. Tasks of many kinds have been used to evaluate levels of cognitive control, such as the Tower of Hanoi (ToH) test, the Wisconsin Card Sorting Test (WCST), and the Stroop test. It has become clear that children with ASD show lower performance with the series of tower tests such as ToH test and Tower of London (ToL) test, indicating that their cognitive planning ability is impaired [4]. Pennington and Ozonoff

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reported that the cognitive control task that best discriminated between children with ASD and the control group was the ToH test [3].

In recent years, several researchers have reported a relation between cognitive control and language or inner speech. According to an influential theory of Soviet psychology presented by LS Vygotsky, children's self-regulating skills originate in linguistic interactions with others early in life [5]. Such interpersonal dialog gradually becomes internalized language: inner speech. Inner speech is regarded as a tool for various voluntary mental activities such as attention, thinking, and planning. These concepts are supported by current developmental psychology and experimental psychology [6, 7]. In current cognitive neuroscience, it is thought that the function of inner speech is based on the phonological loop of the working memory [8]. Some studies have revealed that the performance of several cognitive control tasks was specifically interrupted under the articulatory suppression condition, which is the experimental condition to load the capacity of the phonological loop [9]. Probably, articulatory suppression interferes with inner speech in cognitive control tasks [6].

For children with ASD, some studies have indicated the possibility that efficient use of inner speech on cognitive control is impaired, on the grounds that articulatory suppression does not affect the performance of cognitive control tasks in those children (for a brief review see Williams et al. [10]). With respect to cognitive planning ability, Wallace et al. [11] reported that articulatory suppression did not diminish the performance of the ToL test significantly in children with ASD, unlike the typical comparison group. Holland and Low [12] also reported that performances of the ToH test in children with ASD were unaffected by articulatory suppression, but that visuospatial suppression affected their ToH performance. Holland and Low [12] claimed that children with ASD were able to use visuospatial working memory resources but not inner speech to serve cognitive control. Williams et al. [10] reported that articulatory suppression did not significantly diminish the performance of the ToL test in the manner reported by Wallace et al. [11], and that the degree to which articulatory suppression affected ToL test performance was highly correlated with the severity of communication difficulties among children with ASD. However, children with ASD reportedly have an intact mechanism for use of inner speech to serve cognitive control [13, 14]. Consequently, the possibility exists that the role of inner speech on cognitive control in children with ASD is not homogeneous.

Noguchi and Matsuno [15] reported several important results related to intervention strategies for children with cognitive control difficulties. Their study investigated the planning ability of children with intellectual developmental disabilities (IDD) using the ToH test. They tested the effects that modification of the test procedure exerted on ToH test performance. One modification was verbalization to other individuals about planning. Based on Vygotskian theory, Noguchi and Matsuno [15] conducted the ToH test under the "duo condition" in children with IDD. In the duo condition, a child was not allowed to touch the child's ToH apparatus, but was allowed to dictate verbally to the experimenter information about the procedure to complete the ToH test. Results indicated that task modifications of this type improve the ToH test performance in children with IDD. One possible explanation for this improvement was that verbalization to other individuals introduces overt speech like interpersonal dialog, which is a precursor of intrapersonal dialog or inner speech related to cognitive control in children with IDD. Although the above finding of Noguchi and Matsuno [15] is extremely interesting for elucidating cognitive control in children with developmental disabilities such as ASD and IDD, no further research has been conducted using this method. As described above, if the role of language or inner speech on cognitive control in children with ASD is not homogeneous, then it is expected that the effect of verbalization to other individuals on the cognitive planning is again not homogeneous. In addition, what participant attributes are related to such individual differences? This study analyzed three fundamental attributes of ASD such as participants' chronological ages, intelligence quotients, and severity of social impairment. A study of such issues might well provide further understanding and new insights into cognitive control impairments in children with ASD.

Methods

Participants

The study participants were 21 children with ASD (19 male, 2 female), free from sensory, motor, and severe intellectual impairments. Their chronological ages (CAs) were 7–15 years (mean (M) = 11.0, standard deviation (SD) = 1.9). We measured the participants' intelligence quotients (IQs) using the Wechsler intelligence scale. Their full IQs were 78–137 (mean = 98.7, SD = 15.8). To confirm the accuracy of ASD diagnoses, the Japanese version of the Social Responsiveness Scale (SRS) [16], the internationally accepted parent report measure of a child's social impairments in an ordinary social setting, was conducted with each participant's mother. The SRS, a 65-item questionnaire, was rated on a four-point scale. The norm attached to the test manual was used when raw scores were converted to a total *T*-score (mean = 50, SD = 10). Higher scores indicate greater severity of social impairment. We classified each participant's level of social impairment based on SRS scores according to the SRS manual. They ranged from the 'severe range (n = 9),' to the 'mild to moderate range (n = 10).' Children in the 'severe range' and 'mild to moderate range' met the DSM criteria for PDD.

Materials

Tower of Hanoi (ToH) test

Two sets of a wooden apparatus for the typical ToH test were used. The apparatus consisted of a board with three 0.7-cm diameter upright rods set 4.5 cm apart and discs measuring 2 cm, 2.5 cm, 2.7 cm, and 3 cm diameter. Participants were instructed to move discs across three rods from a start state to a goal state in the fewest number of moves,