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Auditory interference control in children with learning disability: An exploratory study

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ABSTRACT

Objectives: The current study aimed to compare the auditory interference control of participants with Learning Disability (LD) to a control group on two versions of an auditory Stroop task.
Methods: A group of eight children with LD (clinical group) and another group of eight typically developing children (control group) served as participants. All the participants were involved in a semantic and a gender identification-based auditory Stroop task. Each participant was presented with eight different words (10 times) that were pre-recorded by a male and a female speaker. The semantic task required the participants to ignore the speaker's gender and attend to the meaning of the word, and vice-versa for the gender identification task. The participants' performance accuracy and reaction time (RT) was measured on both the tasks.
Results: Control group participants significantly outperformed the clinical group participants on both the tasks with regard to performance accuracy as well as RT.
Conclusion: The results suggest that children with LD have problems in suppressing irrelevant auditory stimuli and focusing on the relevant auditory stimuli. This can be attributed to the auditory processing problems in these children.

1. Introduction

In our everyday environment, we are exposed to multiple sources of information that compete for our attention. In most instances the human brain suppresses the irrelevant stimuli and processes the relevant stimuli. An example to illustrate this phenomenon is Stroop effect, in which an individual is able to attend to a certain dimension of a stimulus, while ignoring the other dimension. The delay in reaction time (RT) in attending to the target stimulus in the presence of a conflicting stimulus is termed as Stroop effect [1]. The Stroop effect has been extensively applied to investigate cognitive abilities over the past 70 years [2–5].

In case of visual Stroop effect, naming the color of a word takes longer time and is more prone to errors when the name of the color (e.g., blue, green, or red) is printed in a color not denoted by the name (incongruent) (e.g., the word "red" printed in blue ink instead of red ink), than when the color of the ink matches the name of the color (congruent). Congruency refers to the compatibility of a verbal label to the relevant physical attribute of the stimuli. Incongruency refers to the incompatibility that exists between the verbal label and relevant physical attribute of the stimulus [1].

Over the past few years, there have been numerous variations of the classic visual Stroop task. One such variation is the auditory Stroop task [6,7]. Auditory Stroop effect reveals an individual's ability to control the interfering auditory stimuli, and selectively attend to the relevant auditory stimuli. Past studies have either used linguistic stimuli or non-linguistic stimuli to elicit auditory Stroop effect to investigate interference control in healthy individuals [8–10]. For example, Henkin et al. measured auditory Stroop effect in 16 individuals using a word meaning task and a gender identification task [8]. To elicit the auditory Stroop effect, the participants were required to identify the meaning of the presented words while ignoring the gender of the speaker's voice, and vice-versa. The results indicated that incongruent condition elicited a significant auditory Stroop effect characterized by prolonged RT, and reduced performance accuracy. There have also been attempts to investigate the auditory Stroop effect across age [11–13], and gender [7,14–16].

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Interference control using auditory Stroop tasks has not been investigated in clinical population to the extent it has been investigated in healthy individuals [15,17]. A handful of studies have investigated interference control using auditory Stroop tasks in individuals with hearing impairment (HI) [18], learning disability (LD) [19], and attention deficit hyperactivity disorder (ADHD) [20,21].

Jerger et al. subjected 20 children with HI and 60 normal hearing children to an auditory Stroop task, which required them to selectively attend to the voice-gender of speech targets while ignoring the sematic content [18]. The results revealed that children with HI showed minimal Stroop interference in comparison to the normal hearing children. Van Mourik et al. compared the interference control of children with ADHD to a control group on visual and auditory Stroop tasks [21]. It was found that children with ADHD demonstrated similar performance as the control group with regard to interference control. Kumar et al. compared selective attention in typically developing children to children with LD using an auditory Stroop task [19]. The researchers employed a word meaning/laterality auditory Stroop task, where the words "left" and "right" were randomly presented to one of the ears of the participants. The participants were required to depress the "L" button on the keyboard if the word was heard in the left ear, and similarly depress the "R" button if the word was heard in the right ear. Children with LD exhibited poorer selective attention (interference control) manifested by increased RT and reduced performance accuracy for the auditory Stroop task.

The findings of the above studies suggest that children with LD exhibit deficits in auditory interference control by taking longer time to respond to incongruent stimuli compared to children with ADHD and HI. This finding in children with LD is not surprising as children with LD are known to present with auditory processing difficulties [22]. Investigating auditory interference control in children with LD could reveal how these children perceive spoken language in real world environment. This information in turn could have implications for designing effective intervention strategies. To our knowledge, as there has been limited research to measure auditory interference control in children with LD using a Stroop task, it is important to examine the reliability of the findings in a similar cohort of individuals with LD. This was the first aspect that was examined in this study.

Findings from previous studies suggest that the amount of interference levels differ among the auditory Stroop tasks based on the type of incongruent stimuli presented [15,23]. In the study by Kumar et al. participants were required to just focus on laterality, and ignore the semantic content of the words [19]. If the participants in the study were instructed to focus on the semantic content of the presented words, rather than laterality, it is likely that the results of the Stroop task would have been different. Hence, it is necessary to examine the auditory interference control in individuals with LD as a function of auditory Stroop task. This was the second aspect examined in the current study.

Taking the above two aspects into consideration, the objectives of the current study were to measure RT and performance accuracy in participants with LD and a control group on two different versions of an auditory Stroop task (gender identification task and semantic task). The current study attempted to answer the following research questions:

(1) Is there a difference between participants with LD and control group participants in performance accuracy on semantic and gender identification-based auditory Stroop tasks?
(2) Is there a difference between participants with LD and control group participants in RT on semantic and gender identification-based auditory Stroop tasks?
(3) Is there an influence of the nature of the auditory Stroop task on the performance accuracy and RT among both the groups of participants?

2. Methods

2.1. Participants

2.1.1. Clinical group

The clinical group comprised eight participants (5 males & 3 females) in the age range of 12–15 years (M = 13.3, SD = 1.13), who were recruited based on a non-probability convenience sampling from a school that provided inclusive education. The clinical group participants were diagnosed to have LD since one year at the time of recruitment by the school clinical psychologist. The clinical group participants were raised in a middle socio-economic status. In the context of the current study, the term "learning disability" referred to a heterogeneous group of disorders characterized by difficulty in acquisition and use of listening, speaking, reading, writing, reasoning, or mathematical abilities due to central nervous dysfunction, and without other co-morbid conditions [24]. As LD is a heterogeneous group of disorders, the specific type of learning disability for each participant was determined based on the performance on:

(1) a psycho-educational assessment battery. This included administration of National Institute of Mental and Neurosciences (NIMHANS) Index for Specific Learning Disability (NIS), Malin's Intelligence Scale for Indian Children (MISIC), and Binet-Kamat Test of Intelligence (BKT), and
(2) a comprehensive contextual assessment.

Detailed interviews were also conducted with participants as well as with their parents to gather additional information.

The assessment protocol was based on the practice guidelines for diagnosis of learning disability proposed by the Indian Association of Clinical Psychologists [25]. As all the participants were enrolled in a school where the medium of instruction was English, the assessment was carried out in English. The assessment was conducted by a clinical psychologist and a learning disability co-ordinator at the school where participants were recruited. The details of the assessment protocol are described below.

2.1.1.1. Psycho-educational battery.

- NIS: This is a standardized assessment tool developed by Kapur et al. [26]. It includes an attention test (number cancellation task), language test (for assessing reading, writing, spelling and comprehension), arithmetic test (that assesses addition, subtraction, multiplication, division and fractions), visuomotor integration test, and an auditory memory test. If there was a two-year discrepancy between the participant's potential and his/her performance in any one or more of the four areas (i.e. (e.g., reading, writing, language, mathematics), that earned him/her a diagnosis of SLD as per ICD-10.
- MISIC: This assessment tool is an Indian version of Wechsler Intelligence Scale for Children developed by Malin [27]. It is designed to assess aspects such as comprehension, arithmetic abilities, vocabulary, digit span, picture completion, picture arrangement, block design, assembly, and coding. Norms are provided for children aged 5–15 years. MISIC is a very popular tool that has been widely used in India to assess intelligence.
- BKT: This is an Indian adaptation of the Stanford–Binet test of intelligence [28]. It includes both verbal as well as performance tests, and can be used for individuals aged 3–22 years.