

The Relationship between Speech Recognition Ability and Short-term Memory in Children with Down Syndrome

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Abstract: In order to compare the difference in speech recognition ability and short-term memory between children with Down syndrome (DS) and normal children (TD), and to explore the relationship between DS children's speech recognition ability and short-term memory, this study tested two groups of children with Chinese minimal phoneme pairs. Results: (1) The speech recognition ability of DS children was significantly lower than that of TD children in the control group; The short-term verbal memory of DS children is significantly lower than that of TD children in the control group. (2) The difference between DS children's speech recognition ability and speech short-term memory performance of four stimuli is significantly lower than the difference between speech short-term memory performance of four stimuli and six stimuli; There was no significant difference between the speech recognition ability of TD children and the speech short-term memory scores of four stimuli and between the speech short-term memory scores of four stimuli and six stimuli. Conclusion: DS children have defects in speech recognition and short-term memory. DS children's speech recognition ability is not the main reason for their poor short-term memory.

Keywords: Down's syndrome; speech recognition; speech short-term memory

1. Asking Questions

Verbal short-term memory (verbal short-term memory) is a memory of human processing and coding of speech-based stimuli. The main features of short-term memory are short-term retention and limited capacity [1]. The traditional method of measuring short-term memory is the memory breadth test, which is a process in which subjects are presented with a series of stimuli and the subjects are allowed to reproduce the stimuli in the order in which they were presented. Miller (1956) showed that people's short-term memory breadth is 7 ± 2 chunks (Chunk) regardless of ethnic and cultural background [2].

Downsyndrome (DS) is the most common type of chromosomal disease that causes mental retardation [3]. Speech short-term memory disorder is widespread in the DS population and is one of its most prominent features [4]. The memory breadth test showed that the short-term memory of most DS individuals was 2 to 5 chunks [5]. Compared with children with normal language ability [6], non-verbalmentalage [7] and mental age (8), the short-term memory of DS children is poor; Age-matched Williamsyndrome children [9] and non-verbal age-matched specific language disorder (Specific language impairment) children [10], DS children's short-term memory is poor; and visual-space Short-term memory (visuo-spatial short-term memory) is also worse than DS children's short-term memory [11-12]. In summary, short-term memory deficits in DS children are mainly directed at auditory and verbal stimuli. In order to better guide DS children's short-term memory intervention, in addition to understanding its characteristics, it should also explore its influencing factors.

The academic circles explored the influence of hearing [13], verbal production ability [14] and lexical effect [15] on DS children's short-term memory. The results show that these factors are not the cause of short-term memory differences in children's speech. Thorn et al. [16] believe that verbal short-term memory is related to the input and decoding ability of speech information, especially the individual's speech recognition ability will affect its short-term memory. Speech recognition (phonemic discriminating), also known as speech recognition, refers to the ability to grasp various character

istics of sound and distinguish different sounds based on the determination of the presence or absence of sound [17]. Keller et al. [18] studied the speech recognition ability of DS children by using phonemic contrast in English system. The results show that DS children's speech recognition ability is abnormal. Speech short-term memory is based on speech coding ability [19]. If an individual cannot correctly recognize the information contained in the speech, errors may occur during storage and retrieval. Brock et al. [20] studied the relationship between speech recognition ability of DS children and verbal short-term memory by regression analysis. The results showed that DS children's speech recognition ability and their short-term memory ability were reflected by regression analysis. The relevance is low. Purser et al. [21] compared the differences between DS children and TD children in speech recognition tasks and short-term memory tasks, indicating that the difference between verbal short-term memory abilities of the two groups of children is greater than that of speech recognition, and that DS children's speech recognition is not the main reason for the short-term memory of speech. At present, there is no research on the use of phoneme pairs in China to explore the characteristics of children's speech recognition and short-term memory characteristics and relationships. Moreover, China's language system is dominated by Mandarin Chinese, and Mandarin Chinese is a typical tone language. Therefore, this study will use the phoneme pairs in the Chinese system as the research material to explore the relationship between DS children's speech recognition and verbal short-term memory, DS children's speech recognition and verbal short-term memory, aiming to enrich DS children's short speech. The theoretical basis of the factors affecting memory.

2. Research Methods

2.1 Subject

The participants were randomly selected. 23 DS children from Shanghai special education schools, 13 males and 10 females; average age 13.23 ± 1.98 years old, maximum age 16.17 years old, minimum age 9.83 years; mild mental retardation 4 Name, 19 moderate mental retardation. DS children do not have hearing impairment: According to the definition of hearing impairment by WHO (World Health Organization), the average hearing threshold of the pure ear of the hearing-impaired person is less than 25dBHL, and the pure-tone audiometry is performed by the Arrow portable audiometer. The pure tone threshold of the participant is 20.83 ± 3.12 dBHL. The language ability of DS children was measured using the Peabody Picture Vocabulary Test-Revised (PPVT-R) [22]. The average PPVT-R was 60.69 ± 17.22 . According to the results of DS children's PPVT-R, 23 preschool children were selected in two kindergartens in Shanghai, including 12 males and 11 females; the average age was 4.46 ± 0.6 years old, the maximum age was 5.5 years old, and the minimum was The age is 3.67 years old; the average original PPVT-R of TD children is 63.26 ± 20.16 . There was no significant difference in the original PPVT-R score between DS children and TD children by independent sample t test ($t(44) = -0.464, p > 0.05$). All subjects were in good spirit and health during the test.

2.2 Experimental Materials

2.2.1 Experimental Materials for Speech Recognition Ability

Brock [23] examined the speech recognition ability of DS children by judging the similarities and differences between the two words. Purser [24] examined the speech recognition ability of DS children by letting the subjects directly identify the target words from the familiar two pictures. Since the second method is susceptible to the cognitive ability of the subjects, this study used the first method to examine the speech recognition ability of DS children.

Both of the above studies follow the principle of "there is only one phoneme difference" to select the research materials. According to this principle, combined with the Chinese phonetic structure and the minimum phoneme contrast*, the materials of this study are formed. The speech recognition capability test material contains a total of 32 pairs of minimum phonemes, 16 pairs of consonant minimum phonemes, and 16 pairs of vowels. All phoneme pairs are derived from the "Evaluation of Children's Phonetic Contrast Speech Recognition Ability" [25] tool compiled by Teacher Liu Qiaoyun.

Audio materials were recorded by a woman with standard Mandarin in a quiet laboratory through a microphone and computer. Each stimulus is recorded as a separate stereo waveform file, File Sampling Frequency 44100Hz and Bit Depth 16bit. All the stimuli were standardized by the sound editing software AdobeAudition, and the sound intensity of the output was measured with a sound level meter to ensure that the sound output intensity was 70dB SPL; the sound length was uniformly standardized to 500ms.

2. 2 Experimental Materials for Speech Short-term Memory

This study explores the short-term memory of speech by asking subjects to judge the similarities and differences between two groups of materials of the same length composed of phoneme pairs. Bird and et al.[26] Research shows that DS and Children's Short Term Memory of Speech is 2 to 5 Chunks. When the subjects judge the difference between the two groups of stimuli of one stimulus in each group, only need DS to memorize two words, this amount is within ds and children's memory capacity, this test method is more to examine the speech recognition ability of the subjects. Therefore, in this study, the speech short-term memory test starts with four stimuli in total, in which subjects are asked to memorize two stimuli in each group. When the subjects judged the stimulation stimuli of each group of four stimuli at the same time, it is necessary to maintain eight stimuli at the same time, which exceeds the average memory capacity of the DS children and is prone to floor effects. Therefore, the experimental materials in this study were divided into two levels of four stimuli (two stimuli per group) and six stimuli (three stimuli per group).

The four stimuli contain 32 trials. The two groups of the 16 trials were identical (eg, ba2, yi3, and ba2, yi3); the two groups of the 16 trials were different, and the first of the 4 trials was the final. Different (eg, ba2, yi3 and bi2, yi3), the second stimuli of the 4 trials have different vowels (eg, ba2, yi3 and ba2, yu3), the first vowel of the 4 trials Different (eg, mao1, zhu1 and bao1, zhu1), the second stimuli of the 4 trials are different (eg, mao1, zhu1 and mao1, shu1).

The six stimuli included 48 trials. The two groups of the 24 trials were identical (eg, ba2, yi3, xia1 and ba2, yi3, xia1); the two groups of the 24 trials were different, with the first of the 4 trials The vowels of the stimuli are different (eg, ba2, yi3, xia1 and bi2, yi3, xia1), and the second stimuli of the 4 trials have different vowels (eg, ba2, yi3, xia1 and ba2, yu3, xia1), The third stimuli of the four trials have different vowels (eg, ba2, yi3, xia1, and ba2, yi3, xing1), and the first one of the four trials has different initials (eg, mao1, zhu1, chou4) And bao1, zhu1, chou4), the second stimuli of the 4 trials are different (eg, mao1, zhu1, chou4, and mao1, chu1, chou4), and the third stimuli of the 4 trials are different. (eg, mao1, zhu1, chou4, and mao1, zhu1, rou4).

2. 3 Experimental Tool

One 14-inch Thinkpad notebook computer, one AWA6291 sound level meter, one GSI Arrow portable audiometer, one pair of air-conducting TDH50 earphones, several recording papers and several reinforcements.

2. 4 Experimental Process

The test was conducted in a quiet classroom with background noise lower than 45dB(A), Two trained graduate students took the lead test.

2. 4. 1 Speech Recognition Ability Experiment

The testee sits in front of the computer, and the eyes are flush with the screen, and the distance is about 70cm. A trained master tried Eprime 1.0 to present the test material and asked the subjects to determine if the two stimuli were consistent. Before the formal test, the main test informs the test instructions by means of screen presentation and verbal expression, and enters the formal test after the subject understands the test requirements. In the official test, the gaze point "+" is first displayed in the center of the screen, and automatically transferred to the stimulation interface after 800ms. In the stimulus interface, pictures of pandas and brown bears appear in the left and right positions of the computer, first playing a stimulus (for 500ms) by the panda, and playing another stimulus by the brown bear after 1s (for 500ms). The two pictures have been presented since they appear, until the end of the trial. The subjects were then asked to

determine if the two stimuli were the same.

The main test controls the computer button according to the feedback of the subject, and the program automatically enters the next test according to the computer button. The tests were conducted in individual tests and the test time per test was approximately 10 minutes.

2. 4. 2 Speech Short-term Memory Experiment

The testee sits in front of the computer, and the eyes are flush with the screen, and the distance is about 70cm. A trained master tried Eprime 1.0 to present the test material and asked the subjects to judge whether the sounds represented by the two animals were the same. Before the formal test, the main test informs the test guide by means of screen presentation and verbal expression, and enters the formal test after the subject understands the test requirements. During the official test, the gaze point “+” is first displayed in the center of the screen, and automatically transferred to the stimulation interface after 800ms. In the stimulus interface, the pictures of the panda and the brown bear appear in the left and right positions of the computer, and the first group played by the panda is composed of two stimuli or three stimuli (each stimuli last for 500ms, with an interval of 500ms). The words are displayed, and then the words to be recognized by the brown bear are displayed in the same number as the displayed words. The display words and the recognition words are separated by 1 s, and the two pictures are presented since the appearance of the words until the end of the test. The subjects were then asked to judge the similarities and differences between the two groups of sounds. The main test controls the computer button according to the feedback of the subject, and the program automatically enters the next test according to the computer button. The order of the questions is random. Measurements were performed in individual tests with a test time of approximately 20 minutes per test.

2. 5 Experimental Design and Data Processing

Speech short-term memory research uses a 2×3 two-factor mixed experiment design. The first independent variable is a child type, which is designed for the test room and divided into two levels: experimental group (DS children) and control group (TD children). The two independent variables are the length of the stimulus, designed for the subject, divided into two levels of stimulation (speech recognition), four stimuli (speech short-term memory) and six stimuli (speech short-term memory); the dependent variable is The processing ability of the participants to different lengths of speech stimulation was examined with the correct rate.

The difference between the two groups of subjects with different task scores was designed by a 2×2 two-factor mixed experiment. The first independent variable was a child type, which was designed for the test room. It was divided into experimental group (DS children) and control group (TD children). Two levels; the second independent variable is the difference type, designed for the subject, divided into the difference between the speech recognition task and the four stimulating speech short-term memory task scores and the four stimulating speech short-term memory The difference between the score and the six stimulating verbal short-term memory scores; the dependent variable is the difference between the correct scores of the subjects in different tasks.

All data are collected by SPSS23. 0 Software for Data Processing and Analysis.

3. Research Results

3.1 DS Children’s Speech Recognition Ability and Speech Short-term Memory

Descriptive statistical results of speech recognition and speech short-term memory ability of two groups of children are shown in table 1.

Table 1 Descriptive statistical results of speech recognition and speech short-term memory ability of two groups of children (M ± SD)

	Speech Recognition Ability (two stimuli)	Speech Short-term Memory (four stimuli)	Speech Short-term Memory (six stimuli)
DS	90.22 ± 4.74	78.67 ± 6.44	61.3 ± 12.54
TD	94.43 ± 3.25	85.87 ± 5.72	78.04 ± 8.82

The 2×3 ANOVA of the short-term memory of the two groups was analyzed by the type of child and the length of the stimulus. The main effect of the child type was extremely significant ($F(1,44)=26.954, p<0.001, \eta^2=0.380$), DS children’s processing ability for different length stimulation (76.73 ± 6.72) is extremely significantly lower than TD children (82.27 ± 7.04); the main effect of material length is extremely significant ($F(2,88) = 202.658, p < 0.001, \eta^2 = 0.822$), children’s short-term memory ability (69.67 ± 13.66) for six stimuli was significantly lower than four stimuli (82.27 ± 7.04); short-term memory ability for four stimuli is significantly lower than speech recognition ability (92.32 ± 4.55); interaction between subject type and material length is extremely significant ($F(2,88)=16.840, p<0.001, \eta^2=0.277$), a simple effect test on the interaction, the results are shown in Figure 1.

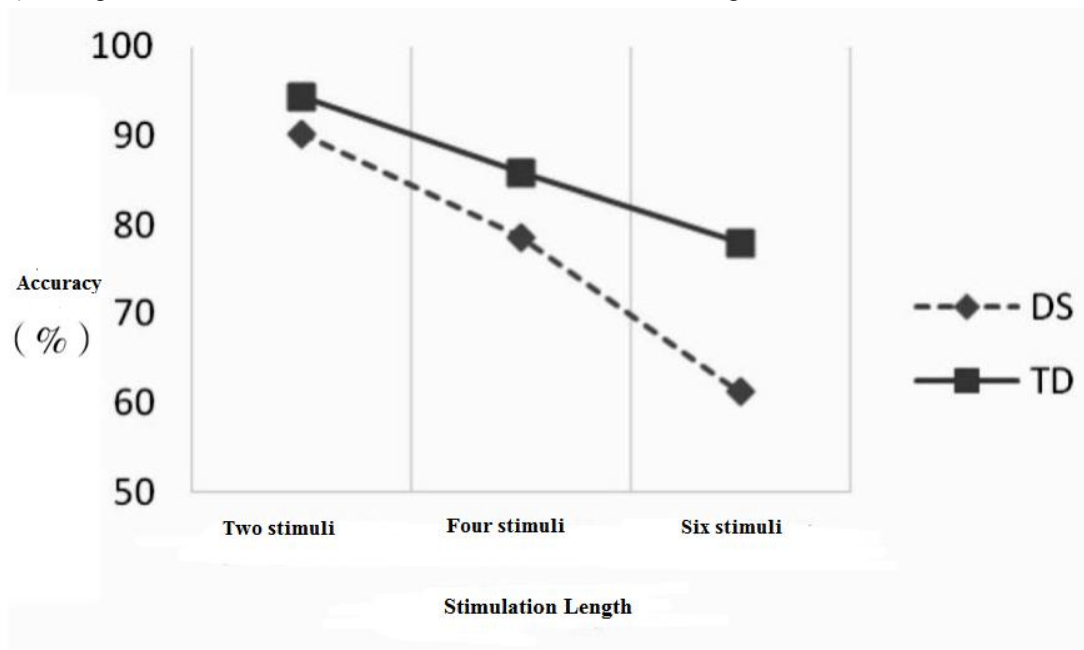


Figure 1 Interactive Effect of Child Types and Stimulation Length

It can be seen from Figure 1 that with the child type as the control variable, the speech recognition ability of DS children (90.22 ± 4.74) is extremely higher than ($p<0.001$). Four stimulating speech short-term memories (78.67 ± 6.44), four stimuli in speech short-term memory were significantly higher ($p < 0.001$) than six stimuli in speech short-term memory (61.3 ± 12.54). With the stimulation length as the control variable, DS children’s speech recognition ability was extremely significant ($p<0.01$) lower than TD children; DS children's four stimuli and six stimuli speech short-term memory scores were extremely significant ($p<0.001$) is lower than TD children.

3.2 DS The Relationship between Children’s Speech Recognition Ability and Speech Short-term Memory

If DS and childrens speech recognition ability are the main causes of poor speech short-term memory. Then with

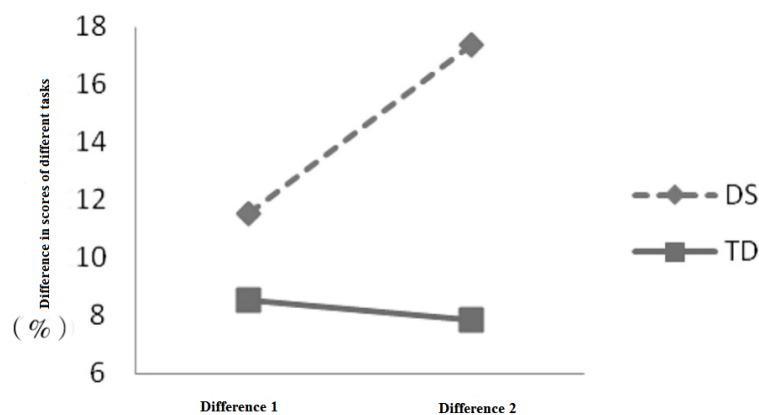
the increase of stimulus amount, DS and children's speech short-term memory performance should be consistent with TD and children's declining trend, that is, DS and children's speech recognition ability and speech short-term memory are equally weaker than TD and children. Therefore, this part uses the difference analysis method to compare the performance of the two groups of children in the three tasks of speech recognition (Two Stimuli), Four Stimulus Speech Short-term Memory and Six Stimulus Speech Short-term Memory. To explore whether the two groups of children's performance in the three tasks is consistent. Descriptive statistical results of the differences between DS children and TD children in speech recognition and four stimulus short-term memory, four stimulus and six stimulus short-term memory are shown in Table 2.

Table 2 Descriptive statistical results of achievement differences between two tasks of children in two groups (M ± SD)

	Difference between speech recognition and auditory short-term memory of four stimuli	Difference between four stimuli and six stimuli in auditory short-term memory
DS	11.55 ± 5.69	17.36 ± 8.71
TD	8.56 ± 4.64	7.83 ± 4.84

The difference between the two groups of subjects in different tasks was carried out by child type and difference type 2×2 ANOVA. The main effect of child type is extremely significant ($F(1, 44) = 18.270, p < 0.001, \eta^2 = 0.293$), the difference between different tasks of DS children (14.46 ± 7.85) is significantly higher than that of TD children (8.19 ± 4.7); the main effect of difference type is significant ($F(1, 44) = 5.453, p < 0.05, \eta^2 = 0.11$), the difference between children's speech recognition and short-term memory of four stimulating speech (10.05 ± 5.35) is significantly lower than four The difference between the stimulus and the short-term memory of the six stimulating speeches (12.6 ± 8.48); the interaction between the type of the subject and the difference type was extremely significant ($F(1,44)=9.057, p < 0.01, \eta^2 = 0.171$). A simple effect test was performed on the interaction, and the results are shown in Figure 2.

It can be seen from Figure 2 that under the condition of speech recognition and short-term memory difference of four stimulating speech, the difference between the two tasks of DS children (11.55 ± 5.69) and TD children (8.56 ± 4.64) There was no significant difference ($p > 0.05$); the difference between the two tasks of DS children (17.36 ± 8.71) was extremely significant under the condition of four stimuli and six stimuli short-term memory differences. ($p < 0.001$) was higher than TD children (7.83 ± 4.84). DS children's speech recognition and four stimulating speech short-term memory differences are extremely significant ($p < 0.001$) lower than four stimuli and six stimulating speech short-term memory differences; TD children's speech recognition and four stimulating speech There was no significant difference between the short-term memory difference and the four stimuli and the short-term memory difference of the six stimuli ($p > 0.05$).



Note:“ Difference 1” Represents the Difference between Speech Recognition and Short-term Memory of Four Stimulated Speech; “Difference 2” Represents the Difference between Short-term Memory of Four Stimulated Speech.

Figure 2 Interactive Effect of Child Types and Difference Types

4. Discussion

4.1 DS Children’s Speech Recognition Ability and Speech Short-term Memory

The speech recognition ability test results show that the speech recognition ability of DS children is significantly lower than that of TD children with the same language ability. This shows that DS children have poor ability to process sound physical properties, master phoneme features and recognize similar phonemes. Predecessors are consistent [27]. Speech recognition is the primary stage of speech processing and the basis of speech-to-semantic transformation [28]. Therefore, in the educational rehabilitation of DS children, the ability of speech recognition should be strengthened, especially the intervention of the minimum phoneme contrast speech recognition ability.

The results of verbal short-term memory showed that DS children's short-term memory of four stimuli and six stimuli were significantly lower than TD children. The results are consistent with Purser et al. [29-30]. In this study, the minimum phoneme pairs in the Chinese system were used as materials to explore the short-term memory of children in DS, which indicated that DS children had poor short-term memory of auditory materials with higher phonetic similarity. Short-term speech plays an important role in the process of encoding, storing and extracting verbal information, and has an important influence on the acquisition of language ability [31]. DS children's short-term memory has high plasticity and the intervention effect remains good [32]. Therefore, in the educational rehabilitation process of DS children, the intervention of short-term memory of speech should be strengthened.

4.2 DS Relationship between Children’s Speech Recognition Ability and Speech Short-term Memory Ability

There is no significant difference between DS children and TD children in speech recognition and four stimulus speech short-term memory tasks, which shows that DS children and TD children keep the same downward trend as the number of stimuli increases when processing two stimuli and four stimuli. The difference between TD children’s speech recognition ability and the speech short-term memory performance of four stimuli and the difference between the speech short-term memory performance of four stimuli and six stimuli have no significant difference, which indicates that the tendency of TD children’s processing two stimuli, four stimuli and six stimuli to decline is relatively stable. The difference between DS children's speech recognition ability and the speech short-term memory performance of four stimuli is significantly lower than the difference between the speech short-term memory performance of four stimuli and six stimuli, which indicates that the speech short-term memory of DS children tends to decline rapidly when processing six stimuli. We speculate that this trend occurs because DS children reach the upper limit of short-term memory capacity earlier than TD children, which is a problem in DS children's short-term memory, and has nothing to do with DS children’s speech recognition ability. This is consistent with the results of Purser et al. [33]. Based on the strict control of the listening level of the subjects, this study explores DS children's short-term memory through non-verbal feedback. The results also indirectly indicate that listening and speech factors are not the main reasons for DS children’s short-term memory.

What causes DS children’s short-term memory to be poor? Bad-deley et al. use a working memory model to explain the processing of short-term memory. In this model, working memory consists of a speech loop, a visual space template, a scene buffer, and a central execution system. Among them, the voice loop is responsible for the storage and retelling of sound-based information, the storage refers to the storage of information in the form of voice coding, and the paraphrase refers to increasing the individual's retention of information within the voice loop by repeating; the central execution system is working. The core part of the memory model is mainly responsible for attention to resource coordination and strategy selection and planning [34]. DS children's short-term memory deficits may be related to some functional

abnormalities in the working memory model. First, there is an abnormality in the storage function of the DS children's voice loop [35], which affects the storage of voice information by DS children. Second, there is an abnormality in the central execution system of DS children [36-37]. Since the processing of voice information requires the participation of the central execution system [38], this can also lead to poor short-term memory. Third, Vi-cari et al. [39] suggested that the short-term memory of DS children's speech may be because the voice ring is faster for information storage than forgotten, but some studies have denied this view [40]. The relationship between short-term speech and speech loops and central execution systems can be further explored in subsequent studies.

5. Conclusion

In this study, the minimal phoneme pairs in Chinese system are used as research materials to compare the differences in speech recognition ability and short-term memory between DS children and TD children, and to discuss the relationship between DS children's speech recognition ability and short-term memory. Research shows that DS Children's speech recognition ability and short-term memory have defects; DS and Children's speech recognition ability is not the main cause of poor short-term memory of speech.

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