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The Perception of Declarative and Interrogative Sentences of Chinese Children with Autism Spectrum Disorder

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Abstract

This paper analyzes perceptual disparities between children with autism spectrum disorders (ASD) and their typically developing (TD) peers with respect to Chinese interrogative and declarative sentences. By synthesizing a continuum from interrogative to declarative sentences and conducting an identification experiment, this research systematically analyzes these differences. The experimental results reveal relatively significant differences in performance between both groups. These findings indicate that when teaching children with ASD to answer questions, educators need to employ more emphatic prosody in their questioning to achieve the intended interrogative effect.

Index Terms: Autism Spectrum Disorder, Declaration, Interrogation, Intonational Perception

1. Introduction

Individuals who lack social interaction and interpersonal communication skills, and exhibit rigidity and repetitiveness in behavior and interests (Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition, DSM-5), are defined as individuals with Autism Spectrum Disorder (ASD). Research has shown that a considerable number of children with ASD have difficulties in understanding and raising questions (Stone et al., 1997; Koegel et al., 2014; Verschuur et al., 2017; Popovic et al., 2020), especially general yes-no questions that heavily rely on intonation patterns (Paul et al., 2005). Question-and-answer training is also an important component of language rehabilitation for children with ASD. Based on the experience of language rehabilitation educators, a significant number of children are unable to engage in this type of training because they cannot identify questions.

The recognition of yes-no questions relies on the perception and processing of rhythmic information in speech. Clarifying the differences in the perceptual and processing abilities of rhythmic information between children with ASD and will enhance our understanding of this issue and facilitate language training for this type of sentence structure. Most studies on the prosody of autism have focused on tone and its categorical perception (Lindner et al., 2006; Huang et al., 2021). Thus, research on rhythmic perception, especially regarding perception of question sentences, is currently scarce.

Therefore, this study aims at exploring the perceptual patterns and categorization of these sentence types among children with ASD and their typically developing counterparts. With this aim, we conducted identification experiments utilizing synthesized continuum that manipulate acoustic parameters, including fundamental frequency, duration, and intensity, from declarative to interrogative sentences. The results of this research may contribute to enrich our understanding of language cognition in children with ASD and provide critical insights for enhancing the understanding and treatment of language impairments.

2. Experiment

2.1. Stimuli

The materials designed for this experiment consist of general interrogative sentences that do not contain question words. The rhythmic features of the statement and question sentences within the same set are identical. To avoid the influence of the final tone on perception, the last word of each sentence incorporates all four tones of Mandarin Chinese. The speaker is a female student majoring in broadcasting and hosting at Peking University, aged 32. She is highly proficient in Mandarin Chinese and displays precise control over pronunciation and intonation. The recording equipment utilized includes a Lenovo ThinkPad computer, a RODE NT-USB condenser microphone, and Adobe Audition recording software. The sampling frequency is set at 44100Hz, with a quantization of 16 bits. The recordings were made in a quiet indoor space. The experimental materials are as follows:

这是老师?这是老师。Is this the teacher？This is the teacher.
这是铅笔?这是铅笔。Is this the pencil？This is the pencil.
这是橡皮?这是橡皮。Is this the eraser？This is the eraser.
这是学校?这是学校。Is this the school？This is the school.

Acoustic analysis reveals that the average pitch of interrogative sentences is consistently higher than that of declarative sentences, irrespective of the final tone. In declarative sentences, with the exception of the high rising tone, the terminal tones predominantly display a descending contour. Furthermore, declarative sentences tend to be more concise than their interrogative counterparts, and this conciseness extends to the duration of the final word, which is notably shorter in declarative sentences than in interrogatives. Apart from instances where the final word carries a high-level tone, interrogative sentences typically allocate a larger proportion of their duration to the final word compared to corresponding declarative sentences.

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Next, we utilized eight recorded sentences from the speaker as source material and manipulated the fundamental frequency and duration of the original sentences to synthesize experimental stimuli. Since this study does not specifically analyze which parameter contributes the most to perception, we changed all parameters simultaneously to ensure that the synthesized stimuli are as natural as possible for auditory discrimination. Taking the example of "Is this the teacher? This is the teacher.", we first split the two sentences into eight individual words. Using Praat software, we extracted fundamental frequency and duration data for each word with equal intervals. Then, using the interrogative sentence "Is this the teacher?" as the source material and the first stimulus sample within the group, we gradually modified the F0 and duration in seven steps uniformly. This resulted in the synthesis of seven stimulus samples, creating a continuum from "Is this the teacher?" to "This is the teacher." In the continuum, the duration and F0 information of the first stimulus are identical to the original sample "Is this the teacher?", while the duration and F0 information of the last stimulus are identical to the target sample "This is the teacher." Figure 1 shows the spectrogram and fundamental frequency curve for the continuum from "Is this the teacher?" to "This is the teacher."

Different sources can potentially influence the perceptual results of participants. Therefore, we subsequently used the declarative sentence "This is the teacher." as source material and followed the same method of gradually modifying the fundamental frequency and duration. This resulted in a set of seven stimulus samples from "This is the teacher." to "Is this the teacher?" as a continuum. In the end, we obtained eight continua, each with seven samples, for a total of 56 stimuli.

2.2. Subjects

This study conducted a comparative experiment between children with autism (ASD) and typically developing children (TD). Considering the special characteristics of children with ASD, with the informed consent of their guardians, the experiment was conducted with the assistance of the Beijing Xing Hope Autism Rehabilitation Center. The control group children were randomly sampled from public kindergartens in Beijing. The experimental group children were preliminarily screened based on the milestone assessment results of the Verbal Behavior Milestones Assessment and Placement Program (VB-MAPP), which is a Skinner-based language behavior analysis program (Sundberg, 2014). It provides assessment procedures for children with ASD as well as other children with speech and language delays and can be used to quantitatively measure children's language, social, and other skills. The control group and the experimental group were matched in terms of age and gender. Participants who were unable to cooperate or understand the purpose of the experiment were excluded. A total of 20 valid participants were obtained: 10 children with ASD (M = 5.72, SD = 0.88) and 10 typically developing children (TD) (M = 5.15, SD = 0.82). Due to the higher prevalence of males than females among individuals with ASD in natural settings (Maenner et al., 2021; Ratto et al., 2018), both the experimental and control groups consisted of 6 boys and 4 girls each. The VB-MAPP scores for children with ASD were provided by the Beijing Xing Hope Autism Rehabilitation Center (M = 129.45, SD = 24.78)

2.3. Procedure

We employed an identification task in the classic paradigm of speech perception research. All stimuli were played by computer. The experiment and data collection were conducted using the psychology experiment design software E-PRIME. The experiment involved a random presentation of 8 stimulus groups, with each group containing 7 stimuli randomly appearing twice. Each stimulus was played consecutively twice, resulting in a total of 112 ($8 \times 7 \times 2 = 112$) responses required from each participant. While the sound was playing, two options, "Question" (Q) and "Statement" (S) appeared on the screen. After the playback, participants had to make a judgment and select whether the sentence they heard was a question or not from the two options. The experiment for children with ASD was assisted by teachers familiar with them. Before the formal experiment, participants had the opportunity to engage in practice sessions to become familiar with the experimental procedure. During the experiment, participants were allowed to pause and take breaks as needed.

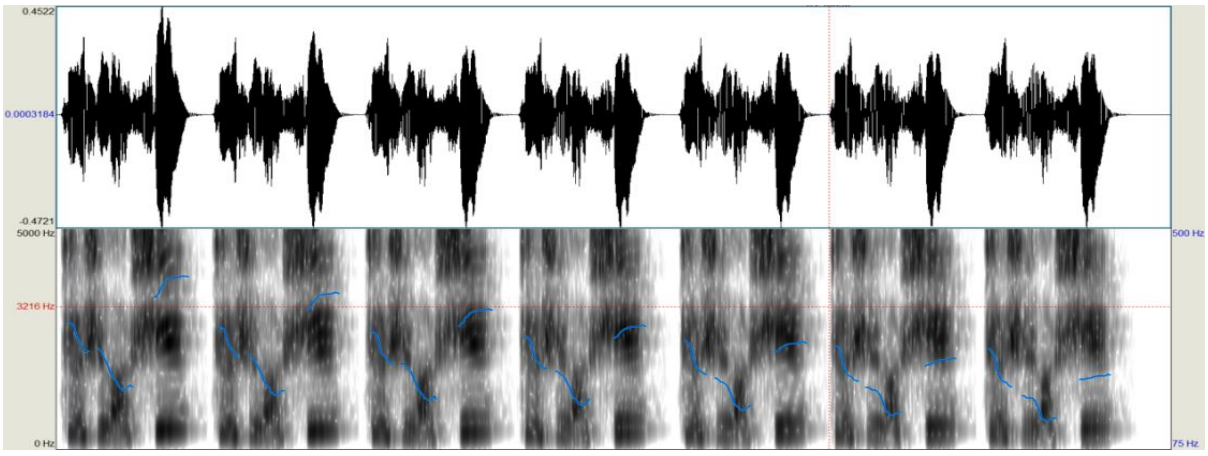

Figure 1: Spectrogram and F0 curve for the continuum from "Is this the teacher?" to "This is the tea

2.4. Data Analysis

The identification score was defined as the percentage of responses with which participants identified that stimulus as being either "Question" or "Statement". Then the boundary position and boundary sharpness were measured by applying logistic regression analysis described by Xu et al. (2006). If the identification rate does not reach 75%, it is considered that the recognition curve is not steep enough, and the participant cannot produce an effective recognition boundary. The steeper the recognition curve, the narrower the boundary width and the higher the degree of categorization. We conducted our data analysis using R, a software environment for statistical computing and graphics.

3. Results and Discussion

During the experiment, children with ASD faced significant difficulties in perceiving the continua synthesized from four interrogative sentences. They were unable to understand and distinguish each stimulus correctly, and therefore, they were unable to complete the four experimental sets. On the other hand, TD children were able to differentiate these four continua synthesized from interrogative sentences and produced a relatively steeper recognition boundary, as shown in Figure 2. In other words, children with ASD were unable to understand and distinguish the continua from "interrogative sentence" to "declarative sentence".

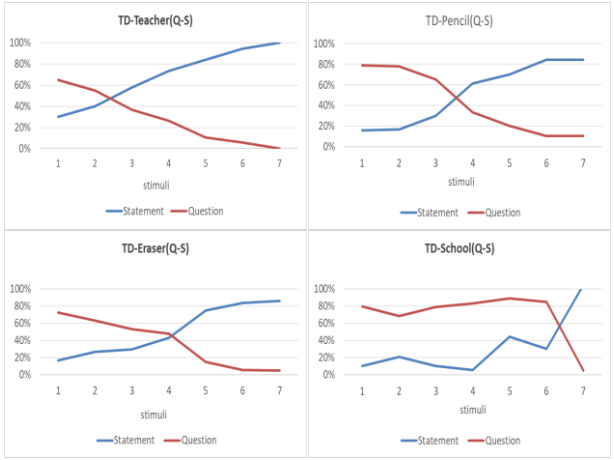

Figure 2: Results of the continua from "interrogative sentences" to "declarative sentences" by TD children

Figure 3 shows the perception results of the continua from "declarative sentence" to "interrogative sentence "synthesized from the declarative sentences. The left side represents the perception results of TD children, while the right side represents the perception results of children with ASD. Observations and data analysis reveal that the recognition boundaries of TD children for the four continua are as follows: 5.81, 5.61, 4.51, and 5.40. The boundary widths are 4.25, 4.44, 3.26, and 4.12, respectively. The recognition rates for identifying the first stimulus of each continuum as a "declarative sentence" are generally above 90%, and the recognition rates for identifying the last stimulus of each continuum as an "interrogative sentence" are also above 75%.

Although the perception experiment results of children with ASD for the continua "Teacher", "Eraser", and "School" show crossed curves, we can see that each identification curve is relatively flat. For the continuum “Teacher", except for stimulus #5 and #8, the identification rates for other stimuli did not reach 75%. For the continuum “School", the identification rate for each stimulus did not reach 75%, and for the continuum "Pencil", the perception results could not produce clear recognition boundaries, resulting in confusion.

However, it is worth noting that due to the different tones at the end of the sentence, both groups of participants showed better perception results for the continuum "Eraser" with a high rising tone at the end. The identification rates for identifying the first stimulus of this continuum as a "declarative sentence" and identifying the last stimulus of each continuum as an "interrogative sentence" are both close to 100%. Children with ASD also achieved a recognition rate of 100% for identifying the last stimulus of this continuum as an "interrogative sentence". In summary, for the continua from "declarative sentence" to "interrogative sentence", although children with ASD can produce identification boundaries, there are significant differences compared to the control group. Often, stimuli with a more emphatic pitch at the beginning and end of the continuum can elicit better response and recognition.

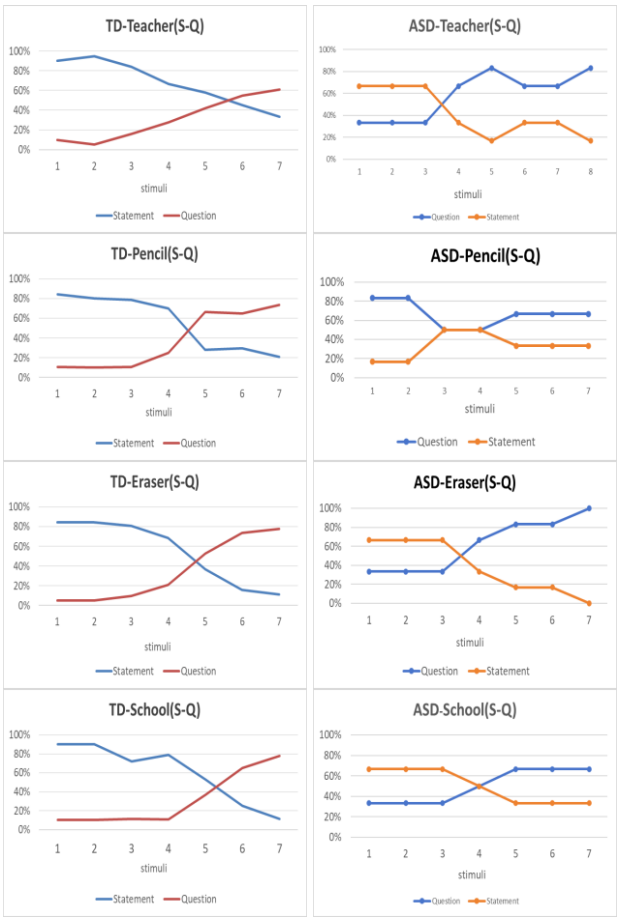

Figure 3: Results of the continua from "declarative sentences" to "interrogative sentences"

4. Conclusions

This study investigates the perceptual patterns and distinctions between declarative and interrogative sentences

among TD children and children with ASD, utilizing sample synthesis and perceptual experiments. The results of the experiments indicate that TD children can distinguish the categories of "interrogative" and "declarative" sentences well, whether it is a continuum from "declarative" to "interrogative" synthesized based on declarative sentences or a continuum from "interrogative" to "declarative" synthesized based on interrogative sentences. Children with ASD, on the other hand, cannot differentiate the categories of "interrogative" and "declarative" sentences in the continuum synthesized based on interrogative sentences. Although they can produce identification boundaries in the continuum synthesized based on declarative sentences, there are significant differences in comparison to TD children. Often, they require stimuli with more emphatic pitch at the beginning and end of the continuum for better response and recognition. This result suggests that when teaching children with ASD to answer questions, the educator's questions need to be more emphatic in terms of rhythm to achieve the desired questioning effect. However, due to limitations in stimulus design and the number of participants in this study, further exploration is needed for more in-depth results in the future.

5. Acknowledgements

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