

Fundamental research on the verbal transformation effect in Japanese

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ABSTRACT

The verbal transformation effect is a phenomenon that occurs when a person hears a repeated single word without pause and illusory changes in the physically unchanging word are induced. There are few studies of the verbal transformation effect in Japanese. Therefore, in this study, we examine whether the verbal transformation effect occurs with respect to changes in the inter stimulus interval (ISI) in Japanese. The studied ISIs were 0 sec, 0.02 sec, 0.05 sec, 0.1 sec, and 0.15 sec. The subjects were 16 native Japanese university students. The stimuli consisted of a word with three syllables. We found that the perceptual transition time changed with changes in the ISI. “The number of perceived stimuli” until the perceptual transition occurred was 24.7 for an ISI of 0 sec but 57.4 for an ISI of 0.15 sec. ANOVA showed a significant effect for “the number of perceived stimuli” ($F(4,73) = 2.585$ ($p = 0.0439$)). Moreover, a *post hoc* test revealed that “the number of perceived stimuli” for an ISI of 0.15 s was significantly larger than that for an ISI of 0 sec ($p = 0.0051$). The mechanisms for the verbal transformation effect are discussed.

Keywords: ISI, Satiation, Delay

1. INTRODUCTION

Listening to repetitions of a single word without a pause induces illusory changes in the physically unchanging word. For example, “tress” may be transformed into a variety of verbal forms, such as “dress,” “stress,” “drest,” or even “Esther” (1, 2). This phenomenon is known as the verbal transformation effect (VTE) (1). Warren has examined the influence of F0, loudness, and noise on the VTE in English (1).

In Japanese, Kondo and Kashino (3) and Kashino and Kondo (4) have studied VTE in terms of brain science. Using fMRI, they found that the left inferior frontal cortex, the anterior cingulate cortex, and the left prefrontal cortex are activated during this perceptual transition. Few studies to date, however, have examined the VTE in terms of behavioral science in Japanese. This is a preliminary study to analyze the mechanisms of VTE in terms of behavioral science.

The perception of speech is satiated due to repeated activation (2). We examined whether perceptual transitions occur with and without pauses. In addition, because the state of satiation changes due to the inclusion of pauses, we also measured how long it takes for perceptual transitions to occur.

2. METHODS

2.1 Stimuli and subjects

The stimulus was /banana/ uttered by a male native Japanese speaker. /banana/ is an actual Japanese word for which VTE has been found to occur (3) (Figure 1).

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The subjects were 16 native Japanese university students aged 21–23 (4 males and 12 females). The subjects were instructed to listen to the stimulus sequences and then click a button on a computer display when they perceived a change in the sound.

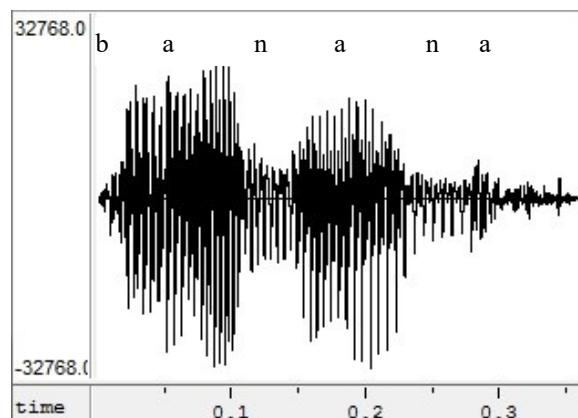


Figure 1 – Wave form of /banana/

2.2 Procedure

The subjects heard five sequences through their headphones. To avoid influences due to the presentation order (ISIs of 0 sec, 0.02 sec, 0.05 sec, 0.1 sec, and 0.15 sec), the subjects were divided into two groups. Each group consisted of eight subjects.

- The ascending order (ASC) group heard the stimulus sequences in the following order: /banana/ with a 0-sec ISI, /banana/ with a 0.02-sec ISI, /banana/ with a 0.05-sec ISI, /banana/ with a 0.1-sec ISI, and /banana/ with a 0.15-sec ISI.
- The descending order (DSC) group heard the stimulus sequences in the following order: /banana/ with a 0.15-sec ISI, /banana/ with a 0.1-sec ISI, /banana/ with a 0.05-sec ISI, /banana/ with a 0.02-sec ISI, and /banana/ with a 0-sec ISI.

The start time of the sequences (t_0) and the click time (t_c) were recorded on a computer, and the perceptual transition time (PTT) was calculated by subtracting t_0 from t_c . Then, the number of perceived stimuli prior to the occurrence of a perceptual transition was calculated via the following formula:

the number of perceived stimuli = $\text{PTT} / (\text{stimulus length} + \text{ISI})$, where the stimulus length was 0.365 sec.

The values of “the number of perceived stimuli” obtained from the individual subjects were averaged for each ISI. After the perception tests were completed, we asked each subject what they perceived the sound to be.

3. RESULTS

In the case of the DSC group, a perceptual transition did not occur for one subject for ISIs of 0.1 sec and 0.15 sec. Figure 2 shows the results for the ASC group, and Figure 3 shows those for the DSC group. In the case of the 0-sec ISI, “the number of perceived stimuli” for the ASC group was 31.0 and that for the DSC group was 18.5. In the case of the 0.15-sec ISI, “the number of perceived stimuli” for the ASC group was 55.3 and that for the DSC group was 59.7. Namely, in the cases of 0-sec and 0.15-sec ISI, “the number of perceived stimuli” in the ASC group did not differ from that in the DSC

group. An ANOVA with two factors, Order and ISI, was performed. The ANOVA showed a significant main effect for the ISIs ($F(4,68) = 2.802$ ($p = 0.0324$)) but not for the Orders ($F(1,68) = 2.025$ ($p = 0.1593$)) and for the interaction ($F(4,68) = 2.0166$ ($p = 0.1020$)). The Order was not significant; therefore, the data from the ASC and DSC groups were pooled (Figure 4). In these pooled data, an ANOVA showed significant difference for the ISI ($F(4,73) = 2.585$ ($p = 0.0439$)). The *post hoc* test showed a significant difference between the 0-sec ISI and the 0.15-sec ISI ($p = 0.0051$).

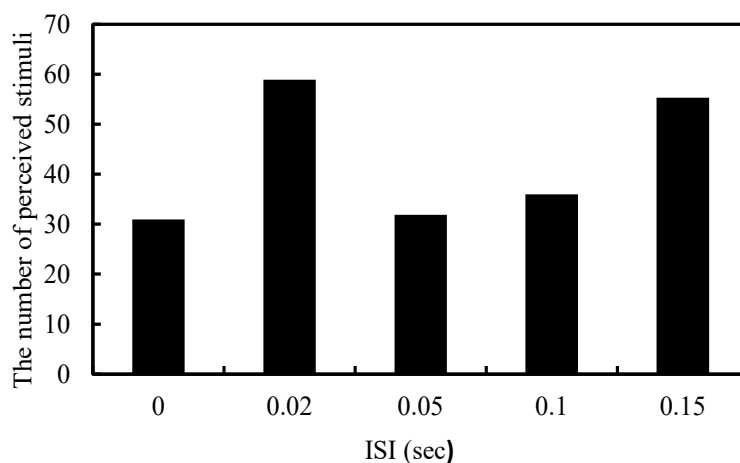


Figure 2 – The effect of ISI in the ascending order group

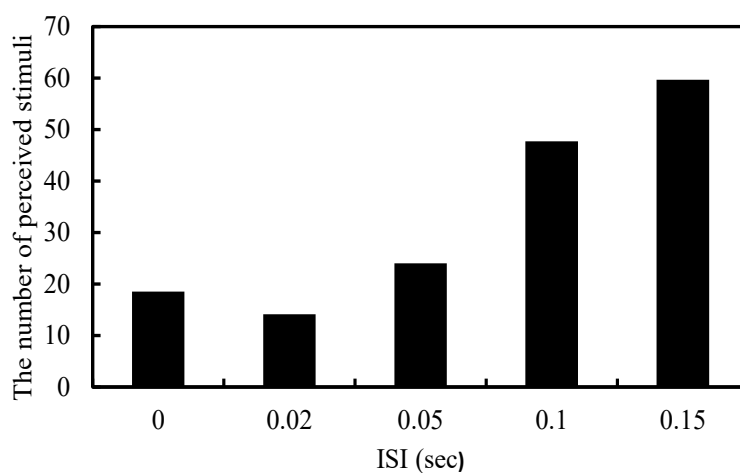


Figure 3 – The effect of ISI in the descending order group

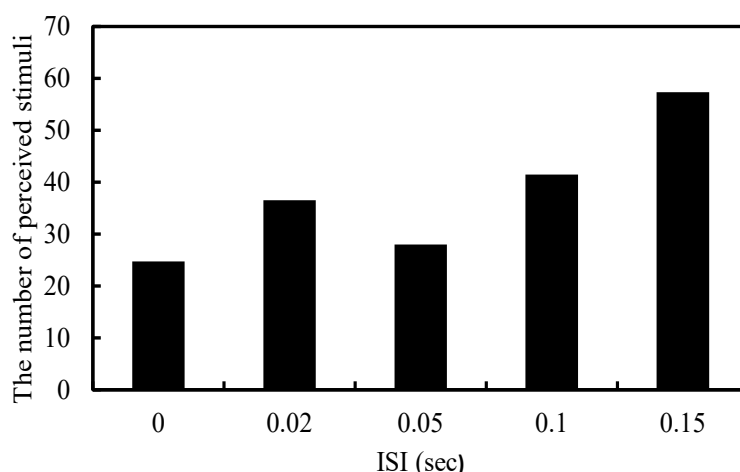


Figure 4 – The effect of ISI in the pooled data

4. DISCUSSION

A perceptual transition occurred when the ISI was 0.02–0.15 sec. As the ISI lengthened, there was an increase in “the number of perceived stimuli.” The stimulus length of /banana/ was 0.365 sec (Figure 1). When the ISI was 0 sec, subjects heard the stimulus approximately 24.7 times before a perceptual transition occurred; however, when the ISI was 0.15 sec, they heard it approximately 57.4 times before a perceptual transition occurred. Therefore, the subjects needed to hear more stimuli before the perceptual transition when the ISI was 0.15 sec than when it was 0 sec. One explanation for this phenomenon is satiation (2, 5, 3). Subjects satiate when they hear repeated stimuli, which triggers a criterion shift in the category boundary, which in turn leads to a perceptual transition. According to a study by Efron (6), the speech rate in everyday speech is ~12 phonemes/sec (the length of one CV syllable is approximately 0.16 sec). The length of one syllable in /banana/ in this study is 0.122 sec (0.365/3). Therefore, an ISI of 0.15 sec is nearly equal to the duration of one syllable. A pause equivalent to one syllable may delay or relax satiation.

5. CONCLUDING REMARKS

Even though the verbal transformation effect has generally been thought to occur only when there are no pauses between the repeated stimuli, we found in this study that it occurred in cases of inter stimulus intervals (ISI) of 0.02 sec, 0.05 sec, 0.1 sec, and 0.15 sec. When the ISI was 0 sec, 24.74 repetitions of /banana/ were perceived before a perceptual transition occurred. However, when the ISI was 0.15 sec, 57.4 repetitions of /banana/ were perceived before the transition occurred. Therefore, an increase in the ISI could result in reduced or relaxed satiation.

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