RHYTHMIC GROUPING AND TEMPORAL GAP DISCRIMINATION

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1. INTRODUCTION

The temporal sensitivity for discriminating a gap marked by two tones is affected by the structure of markers. The sensitivity is impaired when the markers are lengthened (Rammsayer & Leutner, 1996), and the sensitivity is improved when the markers are repeated (Schulze, 1989). The purpose of the present experiment was to examine how temporal sensitivity, expressed with the probability of responding correctly, would be changed by repeating a short and a long marker alternately (Figure 1A).

It is known that successive tones are segmented to construct rhythm in perception, and the temporal sensitivity for repeated gaps is changed depending on what rhythmic grouping takes place (Trainor & Adams, 2000). To examine whether similar effects would be caused for the present discrimination tasks, an additional phase was conducted for measuring what rhythmic grouping would be caused for the repetition of a short and a long marker.

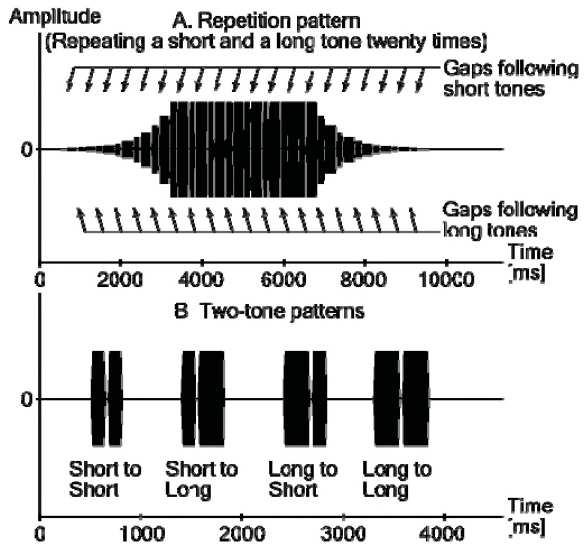

Figure 1. Stimulus patterns

2. METHOD

2.1. Participants

Sixteen Laval University students and employees volunteered to participate. They were all native French speakers between 19 and 30 years-old, and reported they had normal hearing. They received $50 CAN for their participation.

2.2. Apparatus and stimuli

Digital signals of stimuli were sampled at 44100 Hz and quantized to 16 bits. The stimuli were delivered from headphones (Sennheiser HD 477) connected to a computer (IBM Netvista). Each stimulus pattern was made of a 150-ms tone called the *short* tone (S) and/or a 262.5-ms tone called the *long* tone (L). Each tone was square-like wave generated by mixing the fundamental and the first three odd sinusoidal components. The amplitude of each tone rose and decayed during 20 ms at the beginning and the end with raised-cosine ramps. The markers were presented at a level that was 30 dB higher than the threshold level measured before each session.

2.3. Grouping measurement

Due to the lack of space, the details of this measurement are omitted here. The purpose of this measurement was to estimate the participants' preferred rhythmic grouping for the repetition patterns (Figure 1A). The results indicate that the current French-speaking participants were likely to perceive the repetition patterns as successive chunks consisting of a short and a long marker in this order, not as chunks consisting of a long and a short marker.

2.4. Discrimination measurement

This measurement was conducted after the grouping measurement, and estimated participants' gap discrimination level for the repetition patterns (R) and for the two-tone patterns. It was divided into two phases carried out in counterbalanced order.

The repetition-pattern phase consisted of two sub-phases for two types of tasks, which were carried out in counterbalanced order. In the gap-following-short-tone task (RS), two repetition patterns were presented successively in each trial, and the second pattern was compared with the first pattern in terms of the gap duration following the short tones. In the gap-following-long-tone task (RL), the second pattern was compared with the first pattern in terms of the gap duration following the long tones.

There were 11 gap-duration pairs to be compared for each task. In the gap-following-short-tone task, the gaps following the short tones in the first pattern were varied from 10 to 30 ms and those in the second pattern were varied from 30 to 10 ms both in steps of 2 ms. The gaps following the long tones were fixed at 20 ms. In the gap-following-long-tone task, the gaps following the long tones in the first pattern were varied from 10 to 30 ms and those in the second pattern were varied from 30 to 10 ms both in steps of 2 ms. The gaps following the short tones were fixed at 20 ms.

In the two-tone-pattern phase, two two-tone patterns were presented successively, and the second pattern was compared with the first pattern in terms of the gap duration between two tones. This phase consisted of four sub-phases for four arrangements of a short and a long marker: SS, SL, LS, and LL. These sub-phases were carried out in counterbalanced order. There were 11 gap-duration pairs to be compared; the gap in the first pattern was varied from 10 to 30 ms and the gap in the second pattern was varied from 30 to 10 ms both in steps of 2 ms.

Both in the repetition-pattern phase and in the two-tone-pattern phase, a silent interval of 2500, 2750, or 3000 ms was inserted between the first pattern and the second pattern. The participants judged whether the gap in the second pattern was "shorter" or "longer" than the gap in the first pattern. The participants could answer that the second gap was "equal" to the first gap, and they could also answer that they perceived the two gaps as different but were "unsure" whether the second gap was shorter or longer. The participants were instructed not to use the last two alternatives except when definitely necessary.

The participants went thorough ten blocks in each sub-phase for the repetition and the two-tone patterns. Each block consisted of 11 trials for 11 duration pairs, which were arranged in random order. Two warming-up trials were carried out, and, for these trials, the stimulus pairs that were to be presented at the last two trials of the block were presented.

3. RESULTS and DISCUSSION

The gap discrimination level for each pattern was determined by two types of probability to respond correctly: one type called *correct-shorter* is the probability that the participant selected "shorter" when the second gap was physically shorter than the first gap, and the other type called *correct-longer* is the probability that the participant selected "longer" when the second gap was physically longer. Conditions where the two gaps were physically equal were omitted from these probabilities, and thus, each probability was based on 50 responses (5 steps × 10 responses) for each condition and for each participant. The average probabilities of correct responses are shown in Figure 2. A repeated-measure analysis of variance (ANOVA) according to a 2 probability-type × 6 pattern design adjusted with the arcsine square root transformation and the Greenhouse-Geisser criterion showed that the pattern effect was significant, $F(5, 75) = 10.417$, $p < .001$, $\eta_p^2 = .410$, the probability-type effect was significant, $F(1, 15) = 15.417$, $p = .001$, $\eta_p^2 = .507$, and the interaction was significant, $F(5, 75) = 3.674$, $p = .020$, $\eta_p^2 = .197$.

It turned out that the gap discrimination level was changed systematically according to the arrangements of a short and a long marker. In the two-tone patterns, the correct-probability decreased when the markers were lengthened. This decrease was larger when the preceding marker was lengthened than when the following marker was lengthened. Lengthening both markers, however, didn't cause larger decrease than lengthening only the preceding marker. The correct-probability was increased by repeating a short and a long marker, but the discrimination for the gaps following short tones and for the gaps following long tones caused almost the same correct-probability. Finally, analyses with Pearson's correlation coefficient revealed that the gap discrimination results didn't depend on the participants' preferred rhythmic grouping.

It should be noted that, whereas lengthening the preceding marker decreased the correct-probability more largely than lengthening the following marker in the two-tone patterns, the discrimination for the gaps following short tones and for the gaps following long tones caused almost the same correct-probability in the repetition patterns. If a *linear* improvement of the temporal sensitivity had been caused by repeating the gaps, the discrimination performance should have been better for the gaps following short tones than for the gaps following long tones. This indicates that discriminating repeated gaps is based on a different mechanism from discriminating single gaps.

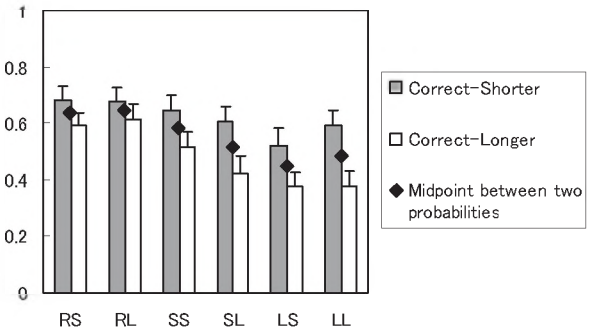

Figure 2. Correct-probability: RS represents the repetition pattern where the gaps following short tones were discriminated. RL represents the repetition pattern where the gaps following long tones were discriminated.

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