BRIEF REPORT

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Abstract

Rhythm perception can be distorted following prolonged exposure to an isochronous rhythm. It has been suggested that this might arise from the neural adaptation of temporal interval selective neurons. However, the rhythm in our daily life is not always isochronous, and the mechanism that rules the anisochronous rhythm is unclear. Here, we used a sensory adaptation paradigm to investigate whether rhythm perception can be affected by adaptation to the anisochronous rhythm. In Experiments 1 and 2, the direction of tempo change (accelerating vs. decelerating) judgment task and the rhythmic isochronism (isochronous vs. anisochronous) judgment task were used to evaluate participants' perception of rhythms, respectively. We found that after adaptation to a decelerating rhythm, participants tended to perceive the subsequent isochronous rhythm as accelerating. In Experiment 3, visual test rhythms followed the auditory adapting rhythm. In this situation, we did not find any adaptation effects on subsequent rhythm perception. Our results suggest that adaptation to the decelerating rhythm can induce a modality-specific rhythm aftereffect, which is consistent with the temporal order contingent duration aftereffect. It implies a unified timing mechanism for duration and rhythm perception.

Ke d Temporal perception · Anisochronous rhythm · Adaptation · Rhythm aftereffect

Introduction

A fundamental function of the brain is to realize temporal properties of events in our daily life. To ensure our survival, it is necessary for the brain to be sensitive to a variety of temporal properties, such as the duration and rhythm information. Compared with the perception of the single duration, the rhythm perception refers to the perception of complex temporal information, requiring the processing of structured information over time. The rhythm perception is essential for various kinds of human activity, such as the perception of speech and music and the execution of skilled movements (Flaugnacco et al., 2014; Kraus & Chandrasekaran, 2010; Thaut, McIntosh, McIntosh, & Hoemberg, 2001). Gaining knowledge about how the brain processes the rhythm information will be of interest to the fields of language and music perception, action control, etc.

et al., 2015; Motala et al., 2018). These studies suggest that clearly accelerating (first/second interval: 710/310 ms) or decelerating (first/second interval: 310/710 ms) adapting rhythm was repeated 80 times with an inter-rhythm interval (IRI) of 1,500–2,000 ms (Fig. 1B). Thus, the mean adapting frequency was about 1.08 Hz. In each top-up/test trial, one of seven test rhythms (first/second interval: 420/600, 450/570, 480/540, 510/510, 540/480, 570/450, and 600/420 ms) was presented randomly following a top-up adaptation period, where four top-up rhythms that were the same as the adapting rhythms in the initial adaptation phase were presented. After the test rhythm disappeared, participants were asked to indicate whether the test rhythm was accelerating or decelerating by pressing one of two labeled keys on a QWERTY keyboard (the "F" and "J" keys were used). The response mapping was counterbalanced across participants. During the entire block, participants were asked to stare at the fixation on the screen. The color of the fixation was always blue except during the IRI between the last top-up rhythm and the test rhythm. The color pattern was blue (500–750 ms) – red (500 ms) – blue (500–750 ms) during this period. This was to remind participants that the response period would begin shortly. There were two adaptation conditions: "adapt to accelerating rhythm" (AA) and "adapt to decelerating rhythm" (AD). Thus, for each adaptation condition, participants completed two blocks of 35 test trials with five trials for each of the test rhythms. Both the order of trials in each block and the order of blocks were selected randomly. After each block, participants took a break of at least 3 min to wash out any potential carry-over effect between blocks. Moreover, a baseline (BA) performance was collected before the adaptation blocks. That is, participants completed a pretest block of 70 trials, which were similar to these in the adaptation blocks except that there was no adaptation phase and no top-up adaptation period. The total experiment lasted approximately 80 min.

Mea e e

In Experiment 1, for each participant, the proportion of "accelerating" responses to the test rhythms for each condition was plotted as a function of the difference between first and second intervals (FSD: 0, ± 60, ± 120, ± 180) and fitted with a logistic function (Fig. 2A): $y = \frac{1}{1+e^{-\frac{(x-x0)}{b}}}$, where $x0$ is the FSD corresponding to the point of subjective isochronism (PSI; 50% response level on the psychometric function) and b provides an estimate of the rhythm discrimination threshold (DT; approximately half the offset between the 27% and 73% response levels). The PSI refers to the relative point in the FSD where participants were equally likely to classify the test rhythm as "accelerating" or "decelerating." The DT was taken as a measure of participants' sensitivity at judging the direction of tempo change. The PSI and DT values were obtained for all observers in all of the conditions, and were analyzed

0.881; 95% CI [-90.55, −26.83], p = 0.021) conditions. However, there was no significant difference on the PSIs between AA and BA conditions (p = 1.000, Cohen's d = 0.091; 95% CI [-24.42, 31.92], p = 0.755). Moreover, the repeated-measures ANOVA on the DT showed that the main effect of adaptation was not significant ($F(2, 26)$ = 1.835, p = 0.180, η_p^2 = 0.124), which sunst-408(A99987792((p62T877l.262T87tici-275-19(5,TD.0127Tc[(How407.799pan-346

Results and discussion

As in Experiment 1, a repeated-measures ANOVA was performed on the PSI (Figs. 3B and S2B). The main effect of adaptation was significant ($F(2, 30) = 8.063$, $p = 0.002$, $\eta_p^2 = 0.350$). Specifically, the PSI in the AD condition was significantly larger than the PSIs in AA ($p = 0.031$, Cohen's $d = 0.732$; 95% CI [7.27, 35.14], $p = 0.018$) and BA ($p = 0.004$, Cohen's $d = 0.980$; 95% CI [12.66, 34.57], $p = 0.003$) conditions. However, there was no significant difference on the PSIs between the AA and BA conditions ($p = 1.000$, Cohen's $d = 0.074$; 95% CI [-9.78, 12.99], $p = 0.771$). We also found that the main effect of adaptation on the DT was significant ($F(2, 30) = 8.356$, $p = 0.001$, $\eta_p^2 = 0.358$). That is, the DT in the AA condition was significantly larger than that in the BA condition ($p = 0.004$, Cohen's $d = 0.985$; 95% CI [10.27, 31.67], $p = 0.002$). However, there were no significant differences on the DTs between the AA and AD conditions ($p = 0.130$, Cohen's $d = 0.552$; 95% CI [1.55, 20.63], $p = 0.059$), and between the AD and BA conditions ($p = 0.195$, Cohen's $d = 0.498$; 95% CI [0.36, 23.37], $p = 0.100$). These results provide further evidence of the aftereffect resulting from adaptation to the decelerating rhythm, suggesting it emerges on a rhythms were present on the CRT monitor (85-Hz refresh rate, 1,600 × 1,200 pixels) with a gray background.

Mea e e

As in Experiment 1, for each participant, the proportion of "accelerating" responses to the test rhythms for each condition was plotted as a function of the FSD (0, ± 80, ± 160, ± 240) and fitted with the logistic function (Fig. 4A). The data from two participants in Experiment 3 were excluded from further analyses due to their improper performance according to the fitting coefficient ($R^2 < 0.6$). The PSI and DT values were calculated for the remaining 14 participants for each condition.

Res lts and disc ssion

The results of the repeated-measures ANOVA showed that there were no significant main effects of adaptation on the PSI ($F(2, 26) = 0.304$, anddec

Levitan, C. A., Ban, Y. H., Stiles, N. R., & Shimojo, S. (2015). Rate