Part II

Symposium 1—Time in Perception and the Brain

An Introduction to Symposium 1: Time in Perception and the Brain

Symposium Organizer: Makoto Ichikawa

Time is one of fundamental subjects in psychophysics, because the mental time is not the same as the physical time and neural time, and because it is related to anomalous behaviors of the human perception and action and thus helps us to understand the basis for both perception and action. Various approaches are possible to the researches on time in perception. Among them we will concentrate on psychophysical approaches and brain imaging approaches, where the former places emphasis on experimental observation whereas the latter places emphasis on neural basis of the time perception. In this symposium, we invite three researchers from psychophysical research field and one researcher from the brain imaging research field. Makoto Ichikawa will talk how cognitive and emotional factors affect the perception of duration, as well as the temporal precision in visual perception. Vincent Laflamme will show how the perception of the duration of emotional stimulus is affected by sex differences, social context, and attention. Masahiko Terao will show how the visual system integrates retinal inputs over space and time in peripheral vision for perception and saccadic eye movement. Masamichi Hayashi will show how the population coding are involved in the basis of encoding time intervals across parietal and medial premotor cortices by the use of functional fMRI.

DOES THE MISSED FRAME IN VIEWING RSVP DISPLAY AFFECT THE PERCEIVED DURATION?

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Abstract

It has been known that the perceived duration reduces with the decrease of perceived events during the period. We examined whether failure to detect targets in RSVP (Rapid Serial Visual Presentation) display, which indicates the reduction of perceived frames, causes the reduction of perceived duration by the use of attentional blink paradigm. In each trial, two series of RSVP display were presented; in the first display, two, one, or no numerals were presented as targets within a series of alphabets while, in the second display, only alphabets were presented. We found that failure in target detection caused no reduction in perceived duration. However, the perceived duration for the two-targets-condition with no detection failure was shorter than those for the no-target-condition. These results suggest that the perceived duration in viewing RSVP display reduces not with the decrease of perceived event, but with the increase of cognitive load in target detection.

Perceived duration for a given period decreased with the decrease of perceived event frequency during the period (e.g., Brown, 1995; Fraisse, 1963; Poynter, 1989). In viewing RSVP (Rapid Serial Visual Presentation) display, which includes two targets, observers often fail to detect the second target if the lag between the first and second targets was less than 500 ms. This failure in detecting the second target is known as Attentional Blink (AB). If observers fail to detect either of the targets in viewing RSVP display, they would perceive fewer frames for the RSVP display. In such a case, do they perceive the duration as shorter than the duration of the display for which they detect the targets?

Herbst et al. (2012) reported that the number of subjectively perceived target stimuli determines subjective duration in viewing RSVP display. In this previous study, target was always the same character (X) in RSVP display, which presented only alphabetic characters. In their experiment, the cognitive load could be lite because the target was fixed. In the present study, we examined how failure in target detection task for RSVP display with more cognitive load affects the perceived duration for the display by the use of different alphabetic characters as targets in a series of numerals. In order to vary cognitive load in target detection task, we prepared the No-target condition, in which RSVP display include no target for the detection task, as well as the One-target condition and Two-targets condition, in which RSVP display included one or two targets, respectively.

Experiment

In each trial, two series of RSVP display were presented one after another. Eight participants conducted target detection task for the first RSVP display, and then they conducted relative length judgment task between the first and second RSVP displays.

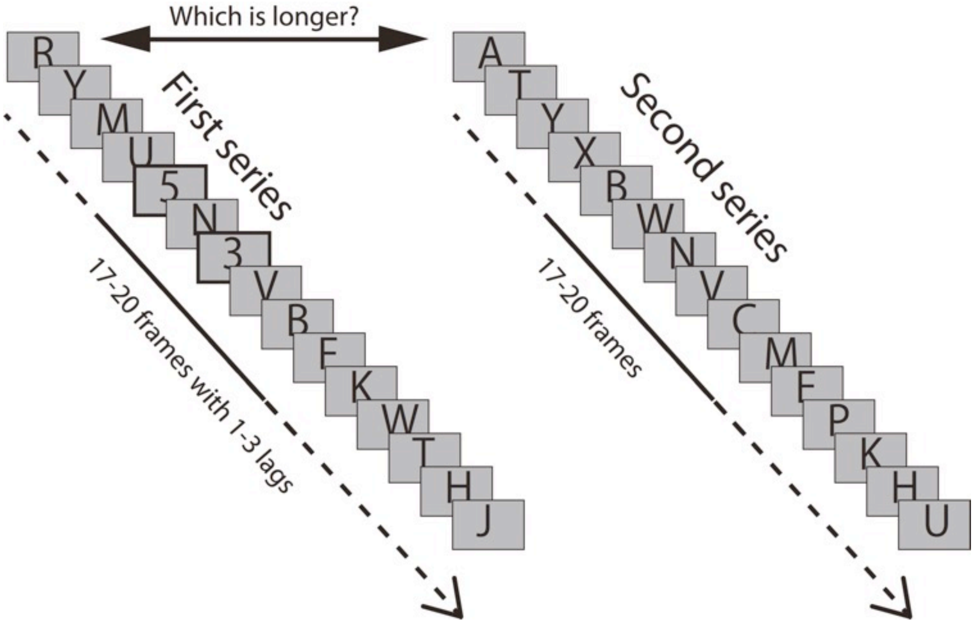

Fig. 1. Diagram of sequence in each trial of the Two targets condition.

Methods

Stimulus. In each trial, two RSVP series with black uppercase alphabets (1.47 × 1.47 deg, 0.03 cd/m^2) were presented on gray background (1.0 cd/m^2) (Fig. 1). That is, the first RSVP series might include black numerals (2, 3, 4, 6, 7, 8, or 9) as targets while the second series presented only alphabets. Each frame was presented for 70 ms with 23 ms of inter stimuli interval. The length of each RSVP series ranged from 17 to 20 frames. Viewing distance was 57 cm. In each trial, the frame difference between the first and second series was either of -1, 0 or +1 (-1 indicates that the first series was shorter than the second one by one frame).

In the Two-targets condition and One-target condition, at least 4 alphabets were presented before the first target. In the Two-targets condition, lag between the first target (T1) and second target (T2) was 1, 2, or 3 frames.

There were three conditions for the first RSVP series. a) Two-targets condition: two numerals were presented as targets within a series of uppercase alphabets [3 (frame difference) × 3 (lag) × 16 (repeat) = 144 trials]. b) One-target condition: one numeral was presented as a target within series of uppercase alphabets [3 (frame difference) × 16 (repeat) = 48 trials]. The serial position of numeral target corresponded to the T1 or T2 position in the Two-targets condition. c) No-target condition: only uppercase alphabets were presented [3 (frame difference) × 16 (repeat) = 48 trials]. Therefore, each observer had 240 trials.

Procedures. Each condition was presented in random order. In each trial, observers pressed the space key to start the first and second RSVP series. After the presentation of the second series, observers reported two target numerals by pressing number keys. They were allowed to press the "miss" key when they did not see target(s). Then, they reported which of the first and second series looked longer.

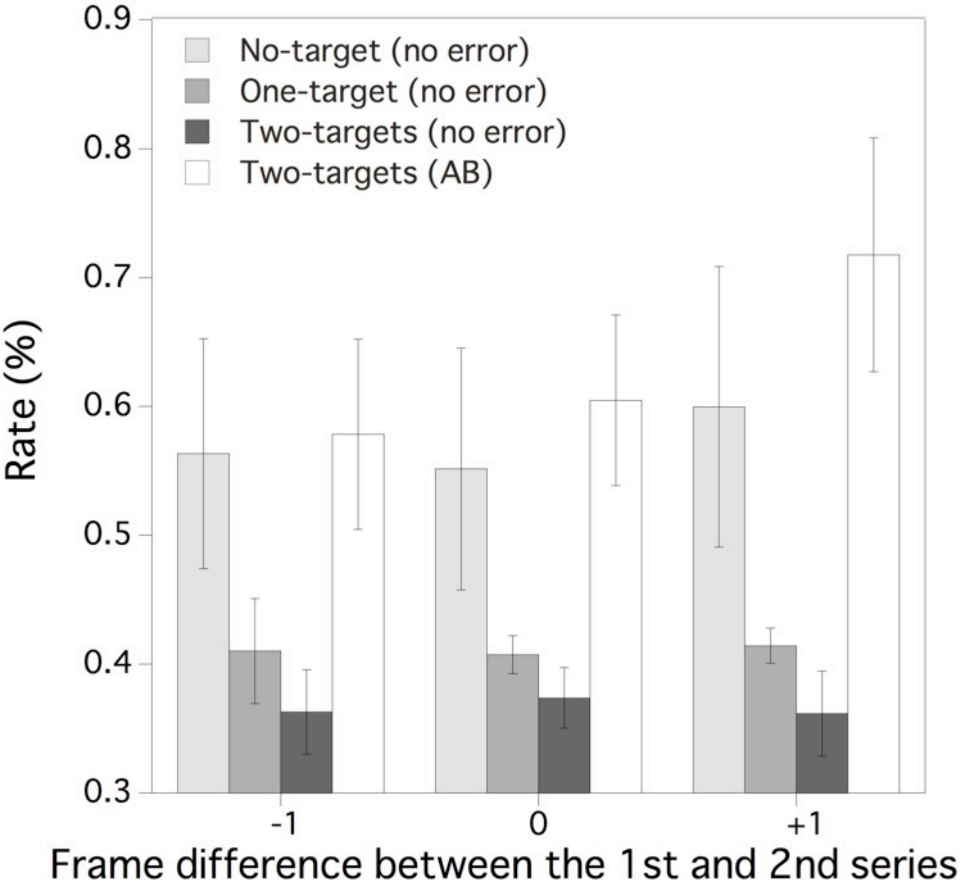

Fig. 2. Rate of duration judgment. Each bar shows the frequency rate of the trials in which the first series was perceived as longer than the second series. Error bars show SEM.

Results and Discussion

For the Two-target condition and One-target condition, if observers reported wrong numerals as target, and if they missed the target, we counted their report as error. Also, if observers reported any numerals as target for the No-target condition, we counted their report as error. Error rates in the One-target and No-target conditions were respectively 9.1% and 5.2% while it was 39.1% for the Two-target condition. For the Two-target condition, frequency of the attentional blink was 24.5%. Frequency of T1 detection error was 0.7%.

We calculated the rate of the trials in which observers reported the first series as longer one for the error trials and no error trials in each condition. By the use of these rates, we conducted a two-way repeated measures analysis of variance (ANOVA) with the frame difference between the series (-1, 0, and +1) and trials (no error trials for the No-target, One-target, and Two-targets conditions, and trials with the attentional blink for the Two-target condition) as factors (Data of one observer who obtained no attentional blink in one of the frame difference condition was eliminated from this analysis). Fig. 2 shows the averages from seven observers, which were used in the ANOVA. Main effect of the trial factor was significant $[F(3, 18) = 6.679, p = 0.0032]$ while the main effect of the frame difference $[F(2, 12) = 1.934, p = 0.1871]$ and interaction of the two factors

$[F(6, 36) = 1.524, p = 0.1984]$ were insignificant. Ryan's post hoc test for the main effect of trials found that the rates for the trials with the attention blink and no error trials in the No-target condition were significantly higher than the rates for the other two cases.

Note that the rate in which the first series was reported as longer one varies among the Two-targets, One-target and No-target conditions even if observers were successful in target detection task. That is, even if observers had no error in target detection, the first series, which may include targets, looked longer than the second series in the No-target condition while it looked shorter than the second series in the Two-target and One-target conditions. These results indicate that the successful target detection has effect to shorten the subjective duration in viewing RSVP display.

If observers failed T2 detection in the Two-target conditions (if the attentional blink occurred), they tended to perceive the first series as longer one. This result suggests that the shortening effect on subjective duration, which observed with successful target detection, would be canceled by attentional blink.

The rates in which the first series was reported as longer one was 61.0% if attentional blink was observed for the Two-targets condition. The rates were respectively 25.0% and 52.0% for T1 detection failure in the Two-targets condition and for target detection failure in the One-target condition. These results suggest that the failure in T2 detection (attentional blink) has unique effect on the subjective duration in observing RSVP display.

We found no effect of the real frame difference between two RSVP series on the relative length judgment. In addition, no result shows that successful target detection causes the elongation of perceived duration in viewing RSVP display, compared to failure of target detection. Rather, failure in T2 detection in the Two-targets condition caused the elongation of the subjective duration. These results were very different from those in Herbst et al. (2012). The difference between two studies would be caused by difference in cognitive load required in target detection. The present results suggest that effects of heavy cognitive load in target detection task upon the subjective duration in viewing RSVP display would be stronger than the effects of objective, or subjective number of stimulus.

Acknowledgements

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THE EFFECT OF NUMERICAL MAGNITUDES ON THE PERCEIVED DURATION OF MULTI-DIGIT OR SINGLE-DIGIT INTERVALS

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There is a wealth of evidence supporting the notion that temporal perception is affected by numerical magnitudes. Relatively little is known about this relation in the context of the timing of empty intervals. This is what we sought to address. Participants were asked to compare the duration of two temporal intervals presented successively and marked by a single digit (filled intervals) or two digits (empty intervals), namely 0, 4 or 8. For one of the experimental groups, the first interval was always marked by the digit 0 and for the second by the digit 4 and the third, by the digit 8. Results show a significant interaction effect on perceived time between the nature of the intervals to-be-timed (filled or empty) and numerical values, but no significant effect involving the group factor (See Fig. 1). Empty and filled intervals seem affected differently by numerical magnitudes. We further argue for the special status of the digit "0" for the temporal-numerical association effect.

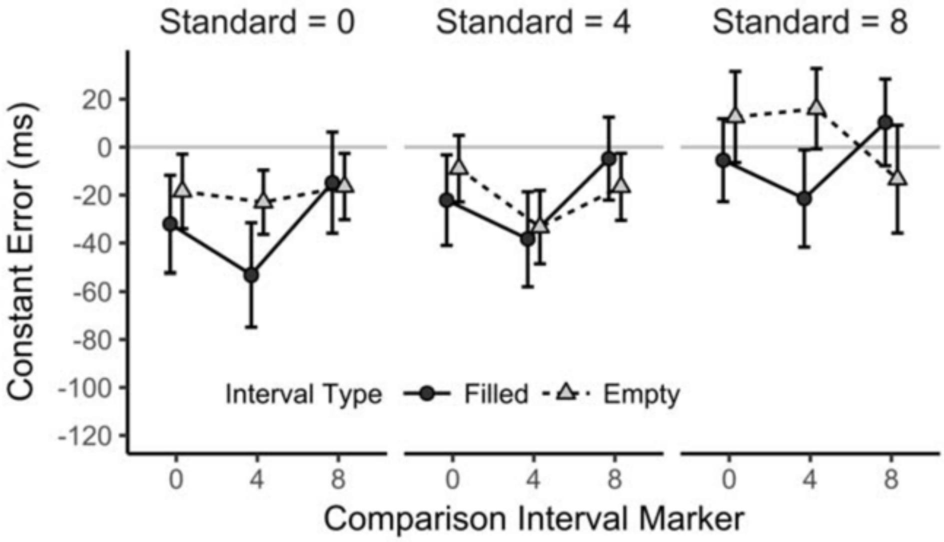

Fig. 1. Mean Constant Error as a function of the Comparison Interval Marker Numerical Value for each Interval Type condition (Filled vs Empty). The panels divide the results according to the different possible values for the marker of the standard interval. Error bars correspond to the standard error of the mean.

VISION AT THE PRESENT MOMENT: VISUAL FEATURE INTEGRATION OVER SPACE AND TIME IN PERIPHERAL VISION

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Psychophysical studies have shown that a retinal input presented later in time backwardly affects percept of another retinal input presented earlier in time. This suggests that visual perception at the present moment is a consequence of pooling visual inputs in the time lag between the timing of a retinal input and the corresponding visual perception. As retinal inputs is highly dynamic and noisy, this pooling of retinal inputs over time may contribute to stable perception. In this talk, I will first introduce a phenomenon in which the appearance of the visual features of an object assimilates to that of the surrounding objects presented later in time in peripheral vision, followed by showing that this backward spatial assimilation rapidly affects saccade control. Finally, I will discuss that this spatio-temporal pooling helps to regularize the appearance among cluttered objects and in turn might overcome the spatio-temporal limitation in peripheral vision.

TIME IN THE BRAIN: NEURONAL CODING OF DURATION

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Time is a fundamental dimension of our perception and action. The current understanding of the neural representations of time is, however, still limited. In this talk, I will show some neurophysiological evidence that duration information is represented by a population code, and this neural representation is associated with our experience of time. First, using neuroimaging techniques we show that repetition of an identical stimulus duration produces a reduction of the blood-oxygenation-level dependent signal in the right inferior parietal lobule (rIPL) (Hayashi et al., 2015). This suggests that the rIPL has a population of neurons tuned for specific durations. A follow-up study further supported this idea by showing that duration information is decodable from the rIPL activity patterns. Finally, we show that the rIPL activity reflects our experience of time rather than simply physical durations of stimuli. Together, our studies demonstrate that subjective experience of time is mediated by duration-tuned neural populations in the rIPL.

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