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Effects of Irrelevant Object Structure on Early Attention Deployment

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Abstract

Event-related potential (ERP) studies have suggested that Gestalt principles or grouping factors in a visual scene modulate attention deployment in early visual processing. The present study examined the effects of an extrinsic grouping factor, region commonality, on early ERP spatial attention. Effects of sex were also explored, since the processing of task-irrelvant objects may differ between the sexes. Twenty-four participants were required to discriminate one side of rapidly-presented bilateral letters, and attention effects were indexed by hemispheric lateralization accroding to attended visual fields. In results, an early P1 attention effect (70-110 ms) increased when the letters were surrounded by an object, compared to the control stimulus without a complete object, and this result was more prominent in women than in men. The present study demonstrates that visual object and sex differences play a novel role at very early cortical stages of processing in attention deployment to a task-irrelevant visual structure.

Keywords

Spatial Attention, Perceptual Organization, Event-related Potential, Gender Effect

1. Introduction

Due to the enormous amount of information present in the environment, our visual system cannot fully process all sensory inputs at one time. For relevant behaviors, however, goal-directed top-down attention and stimulus-driven bottom-up mechanisms can bias the competition among multiple stimuli for cortical representation (Desimone & Duncan, 1995). One of these bottom-up mechanisms is perceptual organization with Gestalt principles, such as common fate, similarity, and shape goodness, which groups fragmentary inputs into coherent and meaningful objects and provides units of attention. The present study focused on spatial attention that depends on perceptual organization and addresses whether there may be individual differences in such basic cognitive function.

Previous behavioral studies have accumulated evidence that spatial attention deployment depends on object structures in the visual scene, irrelevant to the task at hand. For example, it has been shown that spatial attention is obligatorily guided to cover the whole region of an "object", or products of visual grouping with color and shape similarity, closure, or connectedness (e.g., Egly et al., 1994; Hein et al., 2017; Marino & Scholl, 2005; for reviews, Chen, 2012; Scholl, 2001). Such a finding has mainly been revealed by effects of task-irrelevant object structures or grouping factors on behavioral performances in spatial-cueing paradigms. However, attention involves multiple stages of cortical processing that involves processing before behavioural outputs (Hillyard et al., 1998; Luck & Hillyard, 2000). Event-related potentials (ERPs) with fine temporal resolution may provide more detailed information on the stages of processing of object-based attention.

In our previous ERP studies, grouping factors between bilateral stimuli were manipulated in a sustained spatial attention task. The amplitude of posterior P1 (at around 100 ms after stimulus onset) was enlarged at contralateral versus ipsilateral electrode sites with respect to the attended visual fields, consistent with the original finding using this task, suggesting a

gain control mechanism of feedforward sensory processing (Heinze et al., 1990, 1994; Luck et al., 1990). Importantly, subsequent N1 lateralized attention effects (about 150-200 ms) were decreased or became positive in polarity when bilateral stimuli were grouped with connectedness, amodal completion, and feature similarity (Kasai, 2010; Kasai et al., 2011; Kasai & Takeya, 2012; Takeya & Kasai, 2014). This suggests that visual grouping guides spatial attention to cover the whole object region and object-based attention involves a cortical mechanism that is partly shared with spatial attention (He et al., 2004; Martínez et al., 2006, 2007a, b). However, in similar experiments that included the manipulation of stimuli, open line drawings lacked the N1 object-based attention effect (Kasai et al., 2015), and shape similarity or symmetry increased P1 attention effect (Takeya & Kasai, 2014). The latter finding leads a question whether visual grouping with particular grouping factors causes earlier cortical representations of perceptual objects or figures that facilitate spatial selection. Thus, the roles of different grouping factors in early spatial selective attention remain open.

To investigate the commonality and distinctiveness across grouping factors in spatial attentional guidance, the present study focused on a familiar extrinsic grouping factor, region commonality (Palmer, 2003). As shown in Figure 1a, bilateral letters were surrounded by a closed line drawing, which should form an object that grouped the letters. A closed shape with convex curves involves high objecthood or figural enhancement (Wagemans et al., 2012). In contrast, the control stimulus did not have any complete objects. The task was to discriminate letters at the to-be-attended side of the visual field, so that the surrounding shapes were completely task-irrelevant. Such stimulus manipulation enables us to examine the effects of the existence of an object/shape on the spatial deployment of attention, in addition to the effect of grouping. The existence of an object itself can be hypothesized to modulate earlier ERP attention effects rather than N1 associated with perceptual grouping.

More specifically, if the existence of object or figure can facilitate earlier spatial selection processes, P1 attention effect should increase when the letters were presented with the common-region stimulus compared to the control stimulus.

As a secondary purpose, the present study explored sex differences in the above experiment. Previous studies have suggested that there are individual differences in the processing of task-irrelevant objects. Females, compared to males, may prioritize the processing of object shapes (Kimchi et al., 2009; McGivern et al., 2012) or allocate more attention to irrelevant visual objects than males, consistent with an evolutional account of hunter/gatherer strategies (Stoet, 2010, 2017). Such an individual difference may hamper to identify object-based attention that exists if data are averaged for both sexes. Thus, the present study included gender as an independent factor in analyses, although the number of participants was relatively small compared to those in general studies of sex differences. However, this exploration may potentially reveal the cortical stages of processing where spatial attention deployment to task-irrelevant object structures differs between the sexes. If the sex difference in implicit object processing manifests at early visual cortical processing, females may show greater object-based P1 or N1 attention effects than males.

2. Methods

2.1 Participants

Twelve males (aged 18-24 years, M = 21.2) and 12 females (19-30 years, M=22.5), who were all undergraduate and graduate students at Hokkaido University, participated in the study. All had normal or corrected-to-normal vision and were right-handed. The study was approved by the local ethics committee and written informed consent was obtained from each participant after the nature of the study had been fully explained.

2.2 Stimuli and Procedure

Stimuli were black drawings against a gray background (Figure 1a), displayed on a Hitachi CRT monitor, controlled by PsyScope on a personal computer (Macintosh G3) with a PsyScope button box (Cohen, MacWhinney, Flatt, & Provost, 1993). The viewing distance was 70 cm, and a central fixation cross that extended across a visual angle of 0.4°×0.4° was presented throughout the experiment. Stimuli consisted of two different letters selected from among M, N, and W (Gothic font), which were surrounded by a large oval (common-region stimulus) or a control stimulus (uncommon-region stimulus), drawn by lines of 0.1°. The oval extended 9.8° (width)×2.1° (height), displayed 0.5° above the center (to the bottom edge). The control stimulus was formed by cutting the oval at the center and reversing the left and right sides such that its overall physical strength was equal to the common region stimulus. The letters extended 0.5°×0.5°, and were displayed horizontally 3.7° to the left and right (to the inner edge of the letters).

---------- Figure 1 about here ----------

The letter M was the target, and N and W were standards. Stimuli consisted of either two standard stimuli (75 % of the trials) or one standard and one target (25 % of trials) in the separate hemi-fields. The combinations of the left and right letters were randomly varied across trials. As shown in Figure 2b, the bilateral stimuli were presented for 100 ms, and the inter-stimulus interval (ISI, offset to onset) was randomly varied between 300 and 650 ms (8 steps, rectangular distribution). While the ERPs in response to successive stimuli overlapped, due to the short ISI, this overlap was consistent across conditions because of the random order of stimulus presentation.

The participant was seated in a reclining chair in a sound- and electric-shielded room and instructed to attend to either the left or right hemi-field during the blocks and to press a button with the right thumb in response to the current target (i.e., M) presented in the attended field as accurately and quickly as possible. It was emphasized that they had to

maintain fixation and to try not to move their eyes during the block. The whole experiment consisted of attend-left and attend-right conditions, each of which consisted of 12 blocks (100 trials for each). The attend-left and attend-right blocks were alternated, and the initial visual field to be attended was counterbalanced across the participants. The experiment started with 1-3 practice blocks for each attention condition to stabilize task performance and eye movement, which were monitored online with electrooculograms (EOGs).

2.3 Recordings and Analyses

The electroencephalogram (EEG) was recorded using an electrocap (Neuroscan) with 25 Ag-AgCl electrodes (Fp1, Fp2, F7, F3, Fz, F4, F8, T3, C3, Cz, C4, T4, T5, P3, Pz, P4, T6, O1, Oz, O2, PO7, PO3, POz, PO4, and PO8 according to the International 10-20 System), which were referenced to the nose. Blinks and horizontal eye movements were monitored with electrodes at the outer canthi of the eyes (horizontal EOG) and Fp2 and below the right eye (vertical EOG). The impedance of the electrodes was kept below 10 kOhm. EEGs were filtered with a bandpass of 0.1-30 Hz and sampled at 200 Hz.

Behavioral performance was measured, including the percentage of correct target detections (hits) and response times (RTs) for hits. Responses were scored as correct if they occurred within 200-1000 ms after a target was presented in the attended location. Responses to other stimuli were classified as false alarms (FAs).

ERPs were averaged separately for each region, attention condition, and stimulus type. Averaging epochs were 1000 ms, starting 200 ms before the onset of the stimulus and ending 800 ms post-stimulus, while correcting for differences in the 200-ms pre-stimulus baseline. Automatic artifact rejection was applied to eliminate epochs contaminated above 75 μV, and epochs with incorrect responses were also excluded. The overall average number of remaining trials following artifact rejection was 82.3 % and there were no large differences across conditions.

3. Results

3.1 Behavioral Data

Figure 2 shows the behavioral results. Hits and RTs were subjected to mixed-design three-way analysis of variance (ANOVA): attended visual field (left, right) and commonality (common, uncommon) as within-subject factors, and gender (male, female) as between-subject factor. The same factors were combined with type (standard, unattended target) as a within-subject factor for FAs.

Figure 2a shows hit rates, which were above 0.8 on average and had no significant effects (*ps*>0.16). Figure 2b shows RTs for hits, which had a main effect of commonality [$F(1, 22)=6.6$, $p=0.018$, $\eta p^2=0.23$] and an interaction of commonality and attended visual field [$F(1, 22)=5.4$, $p=0.030$, $\eta p^2=0.20$]. Post-hoc tests revealed that RTs were faster in the uncommon versus common conditions when attending to left [$F(1, 22)=14.0$, $p=0.001$, $\eta p^2=0.39$], but the difference was absent when attending to right ($p=0.76$).

Figure 2c shows mean FA rates, which were below 0.05 and had significant main effects of type, attended visual field, and commonality [$F(1, 22)=9.9$, $p=0.005$, $\eta p^2=0.\ 31$; $F(1, 22)=7.3$, $p=0.013$, $\eta p^2=0.25$; $F(1, 22)=10.4$, $p=0.004$, $\eta p^2=0.32$]. These effects indicate that FAs were greater for unattended targets than for the standards, for the attend-right than attend-left conditions, and in the common than uncommon conditions. However, the interaction of attended visual field and commonality [$F(1, 22)=12.9$, $p=0.002$, $\eta p^2=0.37$] reflects that FAs were greater in the common condition when attending to right [$F(1, 22)=20.9$, $p<0.001$, $\eta p^2=0.49$].

There were no statistically significant effects involving gender among the all behavioral indices (*ps*>0.08).

---------- Figure 2 about here ----------

3.2 Electrophysiological Data

In Figure 3a, the grand-averaged ERPs in response to standards at occipital-temporal sites (PO7, PO8) involved typical P1, N1, and P2 components of visual-evoked responses, with peaks at around 120, 170, and 240 ms, respectively. To clarify lateralized spatial attention effects, subtraction ERPs at electrode sites ipsilateral versus contralateral to the task-relevant visual field are demonstrated for each stimulus condition, collapsing the attended sides and sexes (Figure 3b). Most clear attention effects were observed at these electrode sites, consistent with our previous studies (e.g., Kasai, 2010; Kasai et al., 2011). However, the P1 attention effects appeared to differ by stimulus. In visual inspection, the attention effect for the common-region stimulus initiated at around 70 ms post-stimulus and continued to have positive amplitudes with a peak at around 110 ms, while that for the control stimulus firstly dropped and then became positive after around 110 ms. To evaluate the attention effect for each stimulus with minimal overlap, two latency windows were set for calculating mean amplitudes: 70-110 ms and 130-160 ms, labeled as early P1 and late P1, respectively. Subsequent time window of 160-205 ms was determined based on previous studies of N1 attention effect.

These measurements were subjected to mixed-design four-way ANOVA: the attended visual field (left, right), commonality (common, uncommon), and laterality of the electrode sites relative to the attended visual field (ipsilateral, contralateral) were within-subject factors, and gender (female, male) was between-subject factor. Table 1 summarizes the statistical results of omnibus ANOVAs for mean amplitudes in the corresponding time windows.

---------- Figure 3 about here ----------

---------- Table 1 about here ----------

3.2.1 Early P1 attention effect

In Figure 3b, the earliest ERP attention effects occurred at the latency range of the initial rise of P1 (70-110 ms), which were observed to be more positive for the common condition but negative for the uncommon condition. The different attention effects across the stimuli were indicated by the significant interaction of laterality and commonality [$F(1, 22)= 16.9$, $p<0.001$, $\eta p^2=0.43$]. However, such a pattern of results was more prominent for females than for males, as can be seen in Figure 4a. Consistently, there was a three-way interaction of laterality, commonality, and gender [$F(1, 22)= 5.9$, $p=0.024$, $\eta p^2=0.21$]. The post-hoc tests showed that the laterality by commonality interaction was significant in females [$F(1, 11)= 12.8$, $p=0.004$, $\eta p^2=0.54$], but only marginal in males [$F(1, 11)= 4.1$, $p=0.066$, $\eta p^2=0.27$]. Further post-hoc tests in females showed a significant laterality effect in the common condition and a marginal laterality effect in the uncommon condition [$F(1, 11)= 6.5$, $p=0.027$, $\eta p^2=0.37$; $F(1, 11)= 4.8$, $p=0.051$, $\eta p^2=0.30$]. These early P1 attention effects in females were observed at occipito-temporal electrodes as shown by topographical maps in Figure 4b. The mean amplitude data are summarized in Figure 4c.

The early P1 attention effect for uncommon stimulus appeared to have opposite polarity (Figure 3b, Figures 4), which was more obvious in the condition when attending to right rather than left visual fields (Figure 5a), which was reflected by the interaction of attended visual field and laterality [$F(1, 22)= 8.6$, $p=0.008$, $\eta p^2=0.28$]. This indicates that the right electrodes showed more positive potentials than the left electrodes when attending to left, while the right electrodes also showed more positive potentials than the left electrodes when attending to right. This was reflected in enlarged amplitudes at the right hemisphere in this P1 latency range (Figure 5b).

---------- Figures 4 and 5 about here ----------

3.2.2 Later P1 and N1 attention effects

In Figures 3a and 3b, the later P1 amplitudes (130-160 ms) were more positive at contralateral compared to ipsilateral sites, as reflected by the main effect of laterality [F(1, 22)= 5.6, p=0.038, ηp^2=0.46]. However, the attention effect over occipito-temporal sites was greater for the uncommon stimulus for females (Figures 4a, 4b, and 4c), as indicated by a three-way interaction of laterality, commonality, and gender [F(1, 22)= 5.7, p=0.026, ηp^2=0.20]. Post-hoc tests showed a significant laterality by commonality interaction in females [F(1, 11)= 5.6, p=0.038, ηp^2=0.18], but not in males (p=0.24). Further post-hoc tests in females showed that laterality was significant in the uncommon condition [F(1, 11)= 10.0, p=0.009, ηp^2=0.48], but only marginal for the common condition (p=0.051).

The amplitudes of N1 latency range (165-200 ms) were more positive at contralateral rather than ipsilateral sites (Figures 3a and 3b), as reflected by the main effect of laterality [F(1, 22)= 21.8, p<0.001, ηp^2=0.50]. This effect was more positive for the common compared to uncommon stimuli (Figure 3b), as indicated by the laterality by commonality interaction [F(1, 22)= 4.7, p=0.041, ηp^2=0.21]. Post-hoc tests showed significant laterality effects in both the common and uncommon conditions [F(1, 22)= 26.5, p<0.001, ηp^2=0.54; F(1, 22)= 11.7, p=0.002, ηp^2=0.34]. There were no effects involving gender in the N1 time range (ps>0.11).

Although the present study focused on lateralized attention effects, rather than stimulus-evoked responses, several effects of stimulus itself were observed. The ERPs in the late P1 and N1 latency ranges showed more negative amplitudes for the uncommon-region compared to the common-region stimuli (Figure 5b), as reflected by main effects of commonality [F(1, 22)= 8.2, p=0.009, ηp^2=0.27; F(1, 22)= 35.4, p<0.001, ηp^2=0.62]. The negative enhancement for the uncommon stimulus in the later P1 and N1 latency ranges was greater when attending to right compared to left visual fields, as indicated by the attended

visual field by commonality interaction [$F(1, 22)= 4.9$, $p=0.037$, $\eta p^2=0.18$; $F(1, 22)= 5.9$, $p=0.024$, $\eta p^2=0.21$].

4. Discussion

The present study examined the effects of the existence of contextual surrounding objects on early spatial attentional selection, with consideration for sex differences in the processing of task-irrelevant objects, by indexing posterior ERPs lateralized to attended visual fields.

4.1 Decreased attention effects by perceptual organization

Previous studies showed that the N1 spatial attention effect decreased, or even became positive in polarity, when bilateral stimuli were grouped, which indicates that attention was guided to the side opposite the to-be-attended side by perceptual grouping (Kasai, 2010; Kasai et al., 2011, 2012). In the present results, overall attention effects in the N1 latency range (165-200 ms) were positive, likely because the bilateral letters were similar in shape (M, N) and the contextual stimuli had symmetric structures, so that bilateral regions of space may have been strongly grouped. However, the effect was more positive for the common-region stimulus. These results suggest that region commonality defined by a simple line drawing is equivalent to other grouping factors that additively operate on early spatial attention guidance (Takeya & Kasai, 2014).

Behavioral performance also indicated the presence of object-based attention guidance. RTs to discriminate letters in the common-region condition were increased compared to those in the uncommon-region condition, which suggests decreased processing resources at a task-relevant location within an object according to attention-spreading (e.g., Baylis & Driver, 1992; Richard et al., 2008). The increased FAs in the common-region compared to uncommon-region conditions may support the notion that figural regions were activated and salient. However, there was visual field asymmetry: the increased RTs for the

common-region stimulus occurred only when attending to left, while the increased FAs for this stimulus occurred only when attending to right. These results may be accounted for by the left hemifield advantage or right-hemisphere superiority in visuospatial attention processing, which has widely been recognized (e.g., Bartolomeo & Seidel Malkinson, 2019; Jewell & MacCourt, 2000). However, the visual field assymetry in the present behavioral results and the greater early P1 in amplitude at the right hemisphere were not found for geometric shapes (e.g., Kasai, 2010; Kasai et al., 2011, 2012). Since right-lateralized P1 was previously found for rapid serial presentation of bilateral letters (Asanowicz et al., 2017), such asymmetry in early visual processing may be associated with the task to discriminate letters or small details in rapid stimulus presentation.

4.2 Increased attention effects by perceptual organization

The most prominent result in the present study was that lateralized attention effects in the P1 latency ranges were modulated by contextual stimulus that was simultaneously presented with task-relevant stimuli (letters). The modulation differed in the early and later latency ranges by stimulus, which may be in line with the notion that lateralized attention effect of P1 reflects sequential attention-related enhancement of early visual cortical areas, rather than simple amplification of evoked response (Woldroff et al., 2002). The early P1 spatial attention effect (70-110 ms) was greater for the common-region stimulus than for the uncommon-region stimulus. Although it overlapped the rightward enlargement of the initual rise of P1, the attention effect indicates that attention was deployed to to-be-attended locations of the surrouding object at early stages of visual processing. On the other hand, the uncommon-region stimulus that had no complete objects caused a later P1 attention effect (130-160 ms). These results suggest that objects provide the medium of spatial attention selection at early cortical stages of processing. The early object-based facilitation of spatial

attention may not be limited to region commonality, since a similar effect was found when separate bilateral stimuli had the same shape and size (Takeya & Kasai, 2014).

Such early modulation of spatial attention by grouping factors may not be surprising because neurons in early cortical areas like V2 represent figures or border-ownerships that interact with attention at around 50 ms after stimulus onset in the monkey (Qiu et al., 2007; von der Heydt, 2015). While previous studies showed that objects or figures in visual scene can capture attention (Kimchi et al., 2007; Marini & Marzi, 2016; Senkowski et al., 2005), the present study suggests that contextual objects play a new role in selecting part of an object location at a very early stage of visual processing. However, it is noteworthy that the early object-based P1 spatial attention effects were statistically significant only for female participants, but not for male participants.

4.3 Sex difference in very early object-based attention

To my best of knowledge, the finding is the first demonstration of a sex difference in electrophysiological correlates of object-based attention guidance. However, why did such early object-based effects lack for males? This may be associated with the fact that the early attention effect can be decreased when the task is not perceptually demanding (Luck & Hillyard, 2000). Actually, the current task to discriminate the letter M from N and W appears to be easier than the use of compound letter-like stimuli in the original studies of the P1 lateralized attention effect (Heinze et al., 1990, 1994; Luck et al., 1990). Given this notion, the present task may have been less demanding for males than for females, and previous studies have indicated that females are weaker in perceptual discrimination in some feature dimensions of both visual and auditory modalities than males (e.g., Shaqiri et al., 2018; Zündorf et al., 2011). However, behavioral performance did not differ across the sexes in the present study, while this may be due to relatively small number of participants. Thus, future

research is required to include more participants for clarifying the relationships between behavioral performance and electrophysiological indices of object-based attention.

Although it is beyond the scope of this study, previous studies of sex differences have shown abundant evidences suggesting that males are superior than females in spatial cognitive ability, mainly measured by mental rotation tasks (for a recent review, Levine et al., 2016; but see Hyde, 2016). On the other hand, recent studies have shown differences in more fundamental functions across the sexes: females, compared to males, prioritize the processing of object versus space (McGivern et al., 2012, 2019) or task-irrelevant objects (Kimchi et al., 2009; Stoet, 2017), and local versus global levels of hierarchical stimuli (e.g., Roalf et al., 2006; Scheuringer & Pletzer, 2016). The former behavioral findings may be consistent with the present pattern of P1 results that suggests preference of object shape processing in females compared to males. A novel point of the present finding is that it demonstrates that such a difference in the processing of task-irrelevant object shapes across the sexes can occur at early cortical stages of visual processing. The latter, sex difference in local/global processing, could be attributed to hemispheric spatialization (Roalf et al., 2006), while the present results did not reveal sex differences in hemifields/hemispheres asymmetry. Generally speaking, to execute higher-level cognitive tasks should require multiple more basic metal operations, so that to reveal sex differences in early stages of processing is potentially significant for improving the understanding of cognitive sex differences (Shaqiri et al., 2018).

There are several limitations in this study. First, it is not clear whether the result was due to region commonality or a convex shape in part of the stimuli. This notion can be tested in future studies by manipulating closure with parentheses. It is also unknown whether the result was specific to Japanese participants, since the processing of irrelevant or contextual stimuli may differ according to cultures (e.g., Nisbett & Miyamoto, 2005). Furthermore,

biological factors (i.e., cycle and sex hormones) fluctuate attention and neuronal binding (Hausmann, 2005; Pletzer & Harris, 2018), and we should explore the effects of these factors on the early effect of object-based attention guidance in future studies.

5. Conclusion

The visual scene involves many perceptual organization factors and the effects of these factors or their interactions on spatial attention are largely unrevealed. The present study casts light on a novel role of the existence of objects, defined by region commonality, in spatial attentional guidance at very early stages of visual processing, while clear effects were observed only for female participants.

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Table 1 The result of omnibus ANOVAs

	70-110 ms		130-160 ms		160-205 ms	
	F	*p*	*F*	*p*	*F*	*p*
Attended VF (VF)						
Laterality (L)			19.0	<.001	21.8	< .001
Commonality (C)			8.2	.009	35.4	< .001
Gender (G)						
VF × L	8.6	.008				
VF × C			4.9	.037	5.9	.024
L × C	16.9	<.001			4.7	.041
L × G						
L × C × G	5.9	.024	5.7	.026		
VF × L × C × G						

Note: All significant *F* and *p* values for omnibus ANOVAs are shown. Laterality refers to the difference between ERPs at sites contralateral and ipsilateral to the attended visual field.

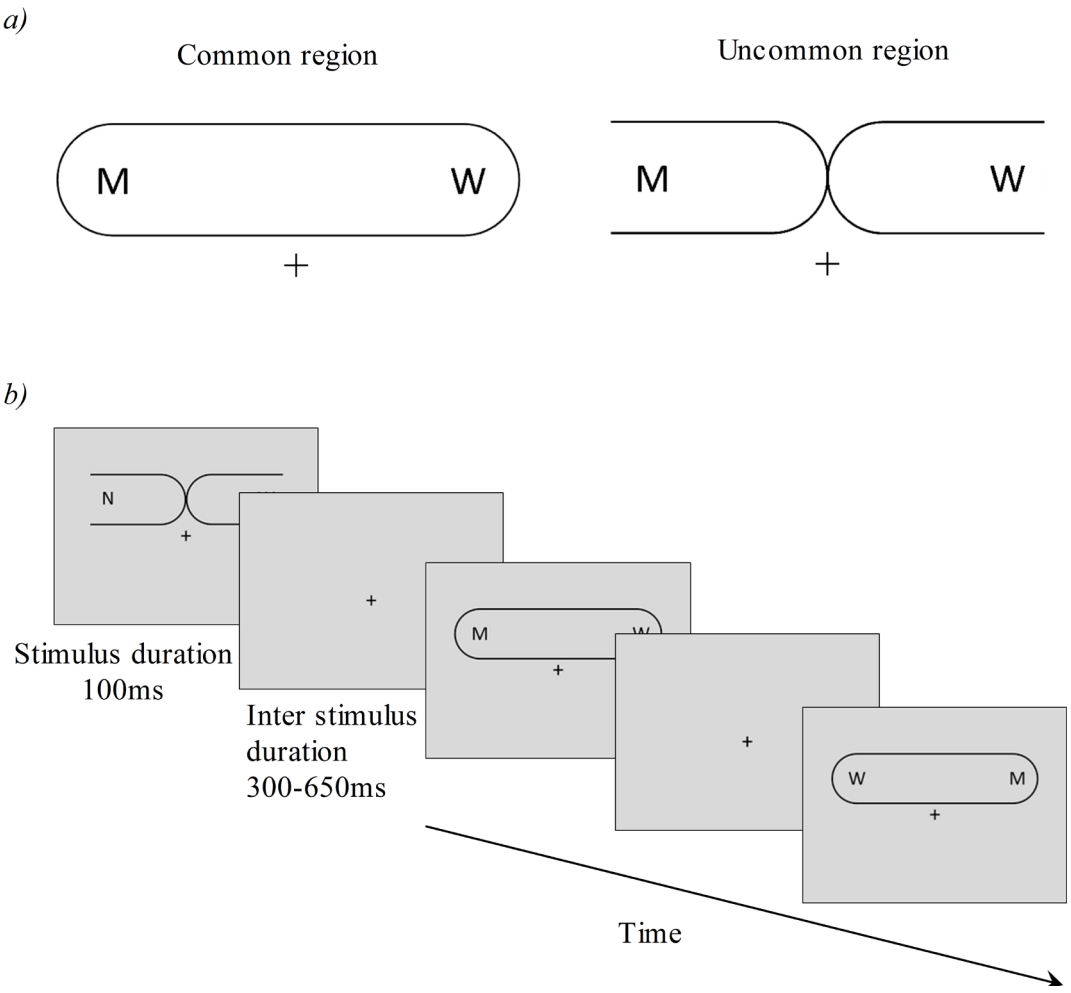

Figure 1 a) Stimulus conditions in the present study. b) Schematic illustration of stimulus sequence. The task was to pay sustained attention to one hemifield and to press the bottom when the target (letter M) was presented at the attended visual field.

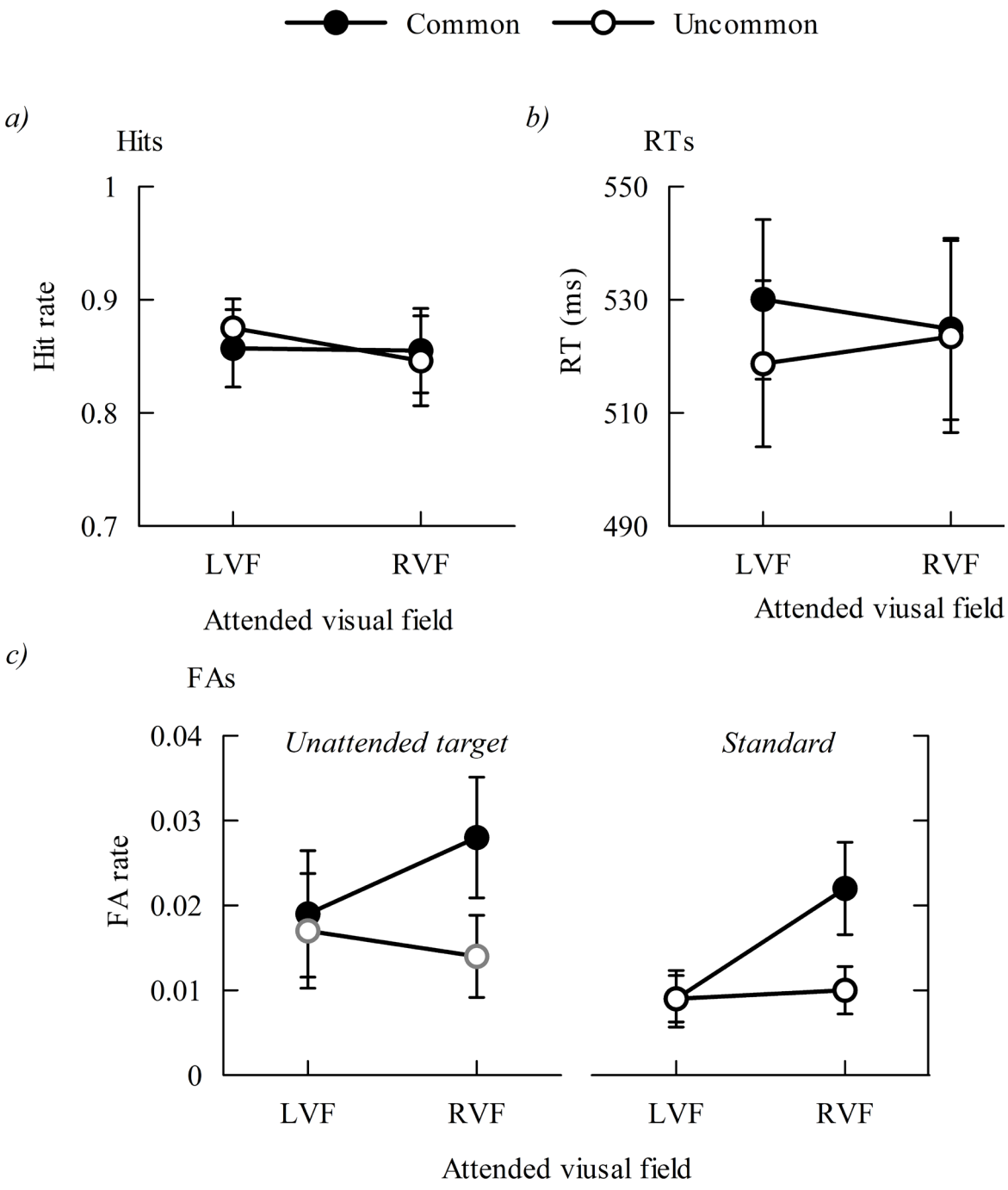

Figure 2 Behavioral performances, collapsing the sexes. a) Hit rates. b) Reaction times for hits. c) False alarm rates for unattended targets and standards. LFV and RVF indicate left and right visual fields, respectively. Error bars indicate S.E.

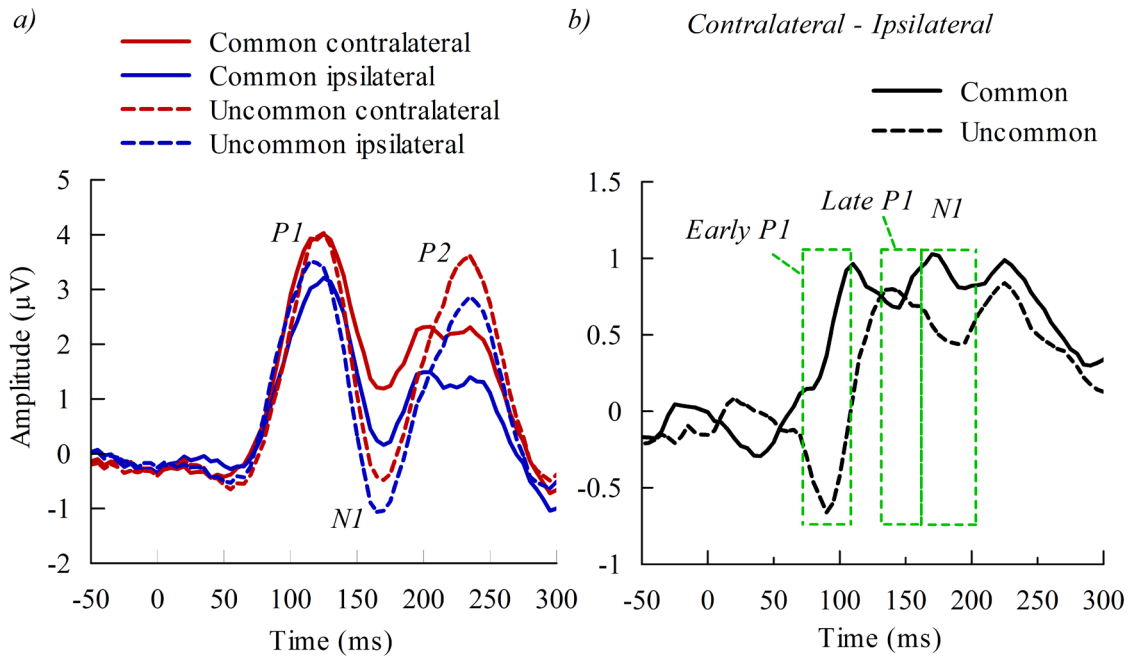

Figure 3 a) Grand-average ERPs at electrode sites contralateral and ipsilateral to attended sides (PO7/PO8), collapsing the sexes and attended visual fields. b) Subtraction ERPs between the contralateral and ipsilateral sites. Time windows for analyses are indicated by green segments.

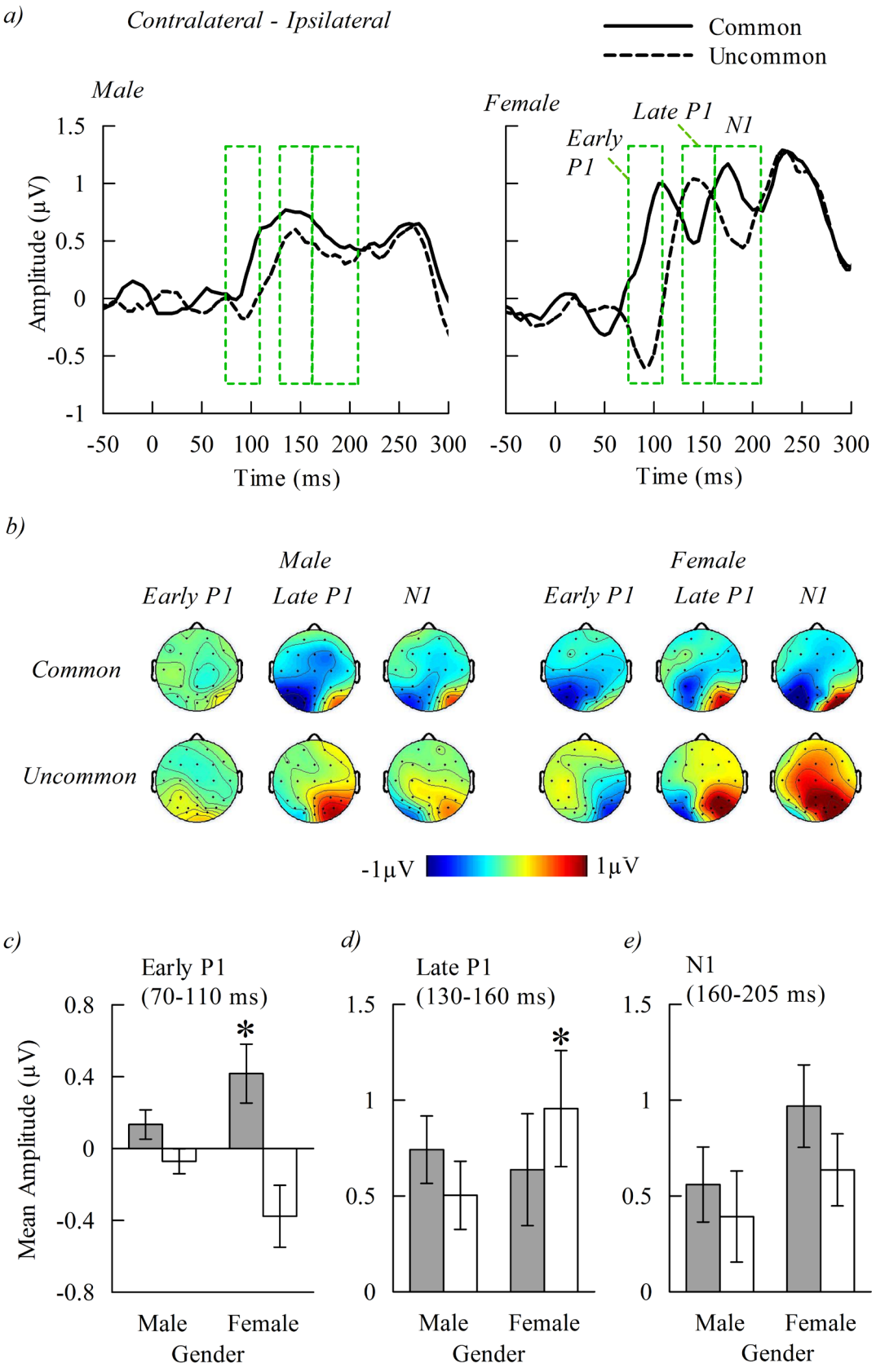
a)
Contralateral - Ipsilateral
Common
Uncommon
Male
Female
Early P1
Late P1
N1
Amplitude (μV)
Time (ms)
b)
Male
Female
Early P1
Late P1
N1
Common
Uncommon
-1μV
1μV
c)
Early P1
(70-110 ms)
d)
Late P1
(130-160 ms)
e)
N1
(160-205 ms)
Mean Amplitude (μV)
Male
Female
Gender

Figure 4 a) Subtraction ERPs for sites ipsilateral and contralateral to the attended side (PO7/ PO8) shown separately for males and females, collapsing attended visual fields. b) Equipotential maps for mean amplitude for attention effects (left-attend minus right-attend conditions). c, d, e) Mean amplitudes of attention effects (ERPs contralateral minus ipsilateral to attended sides of visual fields) for males and females in early P1, late P1, and N1 latency ranges. Error bars indicate S.E.

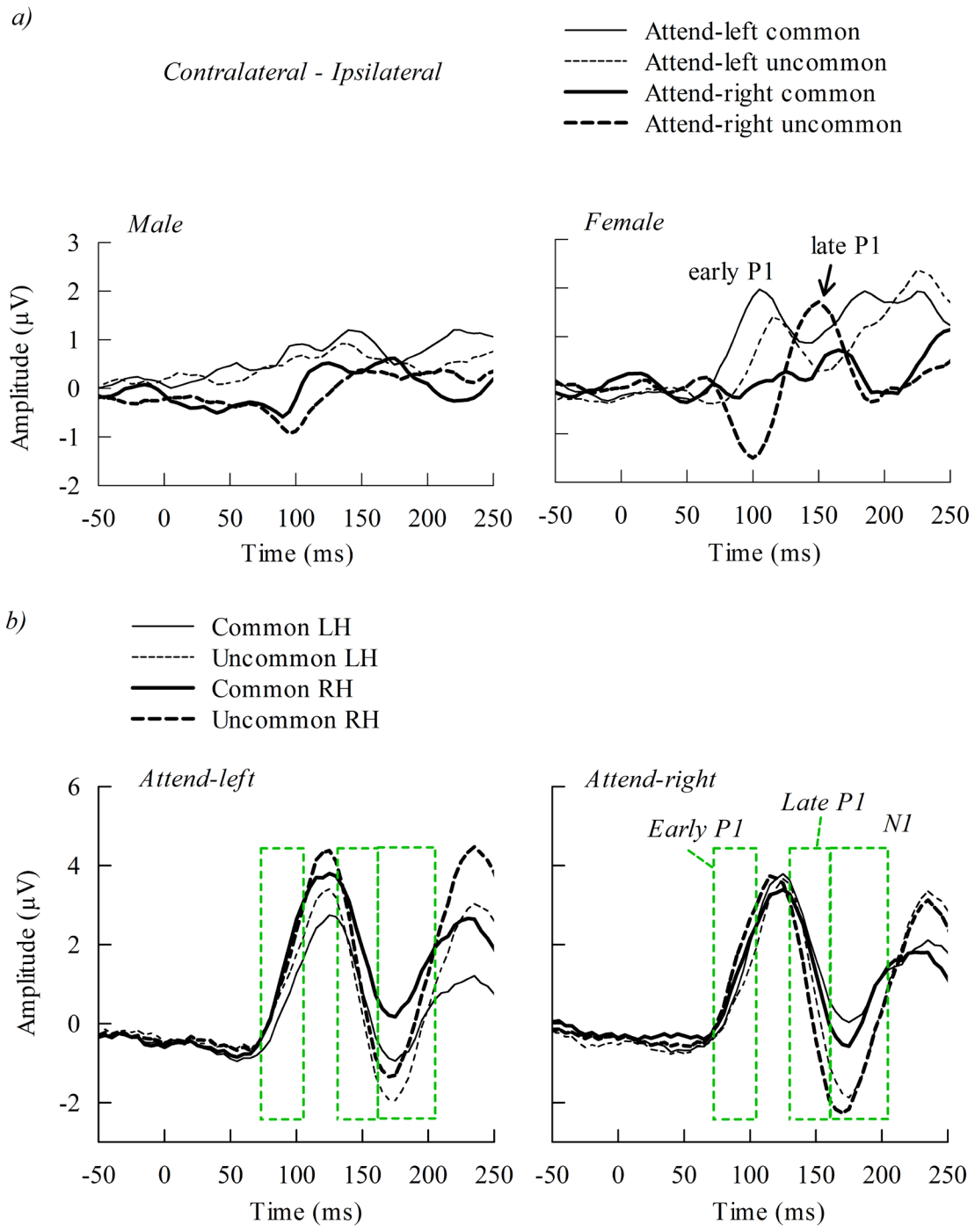

Figure 5 a) Subtraction ERPs across ipsilateral and contralateral sites (PO7/PO8) shown separately for the attended visual fields and hemispheres in each gender. b) ERPs in attend-left and attend-right conditions. LH and RH indicate the left and right hemispheres (i.e., PO7, PO8), respectively.