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Short Communication

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Abb e a :
ANOVA, repeated measures analyses of variance
EEG, electroencephalogram
ERP, event-related potential
ISI, interstimulus intervals
LVF, left visual field
RVF, right visual field
SF, spatial frequency

ABSTRACT

Event-related potentials (ERPs) were recorded to investigate the neural mechanisms of attention to the same or different levels of two compound letters presented concurrently in the left and right visual fields, respectively. Relative to the condition when attention was allocated to the global level of one compound stimulus and the local level of another one (across-level attention), attention to the same level of the two compound stimuli (within-level attention) increased an early positivity between 100 and 140 ms (P1) over the occipito-parietal cortex. A long-latency positivity between 320 and 560 ms (P3) over the central–parietal area was also increased in the within-level relative to across-level attention conditions. The ERP results suggest that, relative to across-level attention, within-level attention to multiple compound stimuli facilitates both early sensory-perceptual processing and late process of stimulus evaluation and identification in hierarchical analysis.

Hierarchical stimuli in our visual environment consist of global structures made up of local parts. Visual attention can be focused on a specific (global or local) level of a compound stimulus or divided among more than two levels of a compound stimulus. Event-related brain potential (ERP) studies have shown that, relative to attention to the global level of Navon-type compound stimuli (Navon, 1977) as those in Fig. 1, attention to the local level increases the amplitude of an occipital positive activity between 80 and 120 ms (P1) after sensory stimulation (Han et al., 1997). Local attention relative to focused global attention also elicits an enhanced long-latency negative wave (N2) but decreases the P3 amplitudes (Han et al., 1997). Neuroil0T2between the global an

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stimulus in the same block of trials (Fink et al., 1996; Han et al., 2000), suggesting that similar neural mechanisms are involved in differentiating global/local processing of compound stimuli when attention is focused on one level or divided between two levels of a compound stimulus.

Most previous studies have manipulated attention to the global or local level of a single compound stimulus (Fink et al., 1996; Han et al., 1997; Heinze and Münte, 1993; Proverbio et al., 1998). However, since the perceptual system is often confronted simultaneously with multiple compound stimuli, it is important to examine how the neural system deals with the processing of these. Existing research using multiple compound stimuli has usually asked subjects to attend to one compound stimulus while ignoring the other: but it has been shown that while subjects can ignore the local properties, they cannot ignore the global properties of the unattended compound stimulus (

were larger in the within-level than across-level attention conditions ($F(1,13) = 5.1$, $P < 0.04$). There was a similar pattern of attentional modulation of the N1 component, but the effect did not reach significance ($F < 1$). The ANOVAs with four levels of attention showed a reliable effect of Level of Attention between 240 and 300 ms at electrodes over the occipito-parietal electrodes ($F(3,39) = 7.15$, $P < 0.001$) due to the fact that the N2 amplitudes were largest when subjects attended to the local level of the left compound stimulus but the global level of the right compound stimulus and the N2 amplitudes were smallest when subjects attended to the global level of both compound stimuli. The mean P3 amplitudes at 320–480 ms were also larger in the within-level than across-level attention condition ($F(1,13) = 15.88$, $P < 0.001$). In particular, there was no evident P3 in the condition when subjects attended to the global level of the left compound stimulus and the local level of the right compound stimulus.

The behavioral data from the current experiment showed that the identification of global letters of both compound stimuli presented concurrently was faster and more accurate than the identification of local letters of the compound stimuli, replicating a global precedence effect when a single compound stimulus was of task relevance (Han et al., 1999; Navon, 1977). Moreover, we found that subjects responded faster and more accurately in the within-level than across-level attention conditions, suggesting that the visual system finds it easier to attend to the same level of multiple compound stimuli than to divide attention among different levels of multiple compound stimuli. It is noticeable that response accuracy was about 50% in the across-level attention condition. This does not necessarily mean that subjects were guessing in these conditions (i.e., that subjects did not pay attention to the left local and right global targets or the reverse as required by the instruction). A pure "guessing" condition would result in both low response accuracy and the same ERPs in the local–global and global–local attention conditions. However, the differences in ERPs between these conditions (i.e., both the N2 and P3 components) indicate that subjects were able to differentiate the two conditions.

One possible explanation for the better behavioral performance in within-level compared with across-level attention conditions is based on the hypothesis that global and local

response accuracy found in the within-level compared with across-level attention conditions.

Attention to the local level of LVF stimuli and to the global level of RVF stimuli induced an enhanced N2 component over both the central and posterior areas compared with other attention conditions. This is interesting because, under this condition, the local and global properties are initially projected to the right and left hemispheres, respectively. The right and left hemispheres have been shown to be efficient in processing global and local information, respectively (Fink et al., 1996; Han et al., 2002; Ivry and Robertson, 1999; Martinez et al., 1997). If the N2 wave reflects processing related to stimulus categorization and identification (Mulder, 1986; Ritter et al., 1983), the enlarged N2 observed in the condition of attention to the local level of LVF stimuli and to the global level of RVF stimuli suggests that, relative to other attention conditions, increased neural activities were induced when the right hemisphere was initially involved in local processing while the left hemisphere was initially involved in global processing. Given that the left and right hemispheres dominate local and global processing, respectively (Ivry and Robertson, 1999), the N2 results imply that global/local processing requires more neural resources in the inefficient hemisphere. The attentional modulation of the N2 was also indicated by finding the smallest N2 amplitudes in the condition of attention to the global level of both compound stimuli. It appears that within-level attention to the global aspects requires least neural resources at this stage of processing.

While previous studies using presentation of multiple compound stimuli have examined attention to one of the compound stimuli or to one (global or local) level of the compound stimuli, the present study investigated across-level attention to multiple compound stimuli. Our behavioral and ERP data demonstrate that across-level attention to multiple compound stimuli is more difficult than within-level attention. In addition, the ERP results provide electrophysiological data for understanding the neural mechanisms behind the advantage of the within-level attention, involving a mechanism of amplitude modulation of an early ERP wave at 100–140 ms and a long-latency ERP component at 320 to 480 ms. Mechanisms of both early sensory-perceptual processing and late processes of stimulus evaluation are involved in the facilitation of behavior responses in the within-level relative to the across-level attention condition.

Fourteen undergraduate and graduate students (8 men, 6 women, aged between 18 and 26 years) participated in this study as paid volunteers. All participants were right-handed, had normal or corrected-to-normal vision, and gave informed consent.

The stimuli were global letters (“S” and “H”) made up of local letters (“S” and “H”) in a 7 × 7 matrix, as shown in Fig. 1. The global and local letters in one compound stimulus were always different, i.e., the stimuli always contained one S and one H on the global or local level. At a viewing distance of 120 cm, global letters were 2.1° wide and 3.0° high and local letters were 0.22° wide and 0.35° high. The compound letters were dark against a grey (116 cd/m

Reaction times (RTs) and response accuracies were subjected to repeated measures analyses of variance (ANOVAs) with Level of Attention (global–global, local–local, global–local, and local–global) and Response Type (Yes vs. No response) as independent variables. The ERP components were subjected to ANOVAs with factors being Level of Attention and Hemisphere (electrodes over the left or right hemisphere). There were four levels of attention (global–global, local–local, global–local, and local–global) or two levels of attention (within-level attention vs. across-level attention) in the ANOVAs of ERP data.

Ack ledg e

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REFERENCES

Evans, M.A., Shedden, J.M., Hevenor, S.J., Hahn, M.C., 2000. The effect of variability of unattended information on global and local processing: evidence for lateralization at early stages of processing. NeuroPsychologia 38, 225–239.

Fink, G.R., Halligan, P.W., Marshall, J.C., Frith, C.D., Frackowiak, R.S.J., Dolan, R.J., 1996. Where in the brain does visual attention select the forest and the trees? Nature 382, 626–628.

Han, S., Fan, S., Chen, L., Zhuo, Y., 1997. On the different processing of wholes and parts: a psychophysiological study. J. Cogn. Neurosci. 9, 686–697.

Han, S., Humphreys, G.W., Chen, L., 1999. Parallel and competitive processes in hierarchical analysis: perceptual grouping and encoding of closure. J. Exp. Psychol. Hum. Percept. Perform. 25, 1411–1432.

Han, S., He, X., Woods, D.L., 2000. Hierarchical processing and level-repetition effect as indexed by early brain potentials. Psychophysiology 37, 817–830.

Han, S., Weaver, J., Murray, S., Yund, E.W., Woods, D.L., 2002. Hemispheric asymmetry in global/local processing: effects of stimulus position and spatial frequency. NeuroImage 17, 1290–1299.