Electrophysiological correlates of local–global visual processing in college students with schizotypal traits: An event-related potential study

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We examined local–global visual processing in college students with schizotypal traits using event-related potentials (ERPs). Local–global processing was assessed using a divided-attention task, in which large numbers (global level) composed of small numbers (local level) were presented. The control group had faster response time (RT) and more accurate responses to global-level than to local-level stimuli, whereas RT and accuracy did not differ between levels in the schizotypal-trait group. N150 amplitudes for local stimuli were larger than those for global stimuli in the schizotypal-trait group, whereas N150 amplitudes did not differ between levels in the control group. P300 amplitudes for local stimuli were larger relative to global stimuli in the control group, whereas P300 amplitudes did not differ between levels in the schizotypal-trait group. These results indicate that the global precedence effect was reduced in the schizotypal-trait group, possibly because of local-biased visual processing or difficulty in global processing.

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1. Introduction

Visual processing abnormalities are associated with impairments in cognitive function including memory and attention (Brenner, Lysaker, Wilt, & O'Donnell, 2002; Haenschel et al., 2007; Lee & Cheung, 2005), increases in psychotic symptoms (Silverstein, Kovacs, Corry, & Valone, 2000; Uhlhaas, Phillips, Mitchell, & Silverstein, 2006), illness severity or chronicity (Silverstein et al., 2006), and impaired social functioning (Butler et al., 2005; Kim, Doop, Blake, & Park, 2005) in patient with schizophrenia. Moreover, visual processing abnormalities are thought to be a biological marker of schizophrenia, because they are present in patients with schizotypal personality disorder (Granholm, Cadenhead, Shafer, & Filoteo, 2002; Kent, Weinstein, Passrelli, Chen, & Siever, 2011), in nonclinical individuals with schizotypal traits (Goodarzi, Wykes, & Hemsley, 2000; Koychev, El-Deredy, Haenschel, & Daekein, 2010; Tsakanikos & Reed, 2003), and in healthy first-degree biological relatives of patients with schizophrenia (Green, Nuechterlein, & Breitmeyer, 1997; Ross, Hommer, Randant, Roath, & Freedman, 1996).

Several studies have shown a deficit in global visual processing or a bias toward local visual processing in patients with schizophrenia; that is, patients tend to over-focus on local or irrelevant details at the expense of global or relevant information (Butler et al., 2005; Coleman et al., 2009; Landgraf et al., 2011; Poirel et al., 2010). Navon (1977) developed a local–global paradigm, in which hierarchically organized stimuli, such as large letters or numbers (global level) composed of small letters or numbers (local level), are presented, and participants are required to respond to either the global- or local-level stimuli. Based on the results of studies using this paradigm, Navon (1977) proposed the global precedence effect, which is characterized by a global advantage effect (perception of the global level occurs prior to perception of the local level, as indicated by faster and more accurate responses to global-level than to local-level stimuli) and a global interference effect (a conflicting global-level stimulus interferes with processing the local-level stimulus, but not vice versa). Most studies of local–global processing have observed the global precedence effect in healthy individuals (Navon & Norman, 1983; Peressotti, Rumita, Nicoletti, & Job, 1991; Poirel, Pineau, & Mellet, 2008; Roux & Ceccaldi, 2001; Shedden & Reid, 2001).

Patients with schizophrenia have deficits in global-level processing of visual information and have a tendency for local-biased visual processing (Ferman, Primeau, Delis, & Jampala, 1999; Johnson, Lowery, Kohler, & Turetsky, 2005; Poirel et al., 2010;
Local–global visual processing can be assessed by directed-attention or divided-attention tasks, which produce different performance patterns in patients with schizophrenia. The directed-attention task consists of global and local conditions. For the global condition, participants are required to detect a target stimulus that occurs at the global level, whereas for the local condition, participants are required to respond to a target stimulus that occurs at the local level. Congruent (same features at both global and local levels) and incongruent (different features at global and local levels) stimuli are presented in the directed-attention task. However, in the divided-attention task, participants are required to detect a target stimulus whether it is presented at the global or local level, and only incongruent stimuli are presented. Previous studies have shown that performance on the divided-attention, but not on the directed-attention, task is impaired in patients with schizophrenia compared with control subjects because it requires greater cognitive effort, such as attentional shift, than the directed-attention task (Belgrove, Vance, & Bradshaw, 2003; Coleman et al., 2009).

Psychophysiological and neuroimaging studies have identified neuroanatomical substrates underlying the global visual processing deficit observed in patients with schizophrenia (Butler et al., 2001, 2005; Inami & Kirino, 2004; Martinez et al., 2008, 2012). For example, using steady-state visual evoked potentials (ssVEP), Butler et al. (2001, 2005) found selective deficits in the magnocellular pathway, which is involved in processing gestalt or global features, in patients with schizophrenia. Compared with control subjects, the signal-to-noise ratio was reduced in patients in response to stimuli with low luminance contrast and low spatial frequency (LSF) but not in response to stimuli with high luminance contrast and high spatial frequency (HSF). Calderone, Martinez, et al. (2013) also observed that patients with schizophrenia showed selective deficit under LSF ssVEP condition, and reduced occipital activation volume for LSF, but not HSF condition. Martinez et al. (2008) observed reduced activation in the magnocellular visual pathway, including the striate and extrastriate visual areas, while processing stimuli with LSF in patients with schizophrenia compared with controls. In addition, Inami and Kirino (2004) found that local-level stimuli elicited greater activity in the left precentral and global-level stimuli elicited less activity in the right middle/inferior occipital gyrus in patients compared with control subjects. Recently, Calderone, Hoptman, et al. (2013) investigated the cortical activations during an object recognition task, where objects containing either LSF or HSF were presented. Control subjects showed increased activation for LSF over HSF information in precuneus, superior temporal, and medial/dorsolateral prefrontal areas, whereas schizophrenia patients showed increased activation for HSF over LSF information in these areas. The authors suggested that these results demonstrate impaired processing of LSF information or a preference for local over global visual processing in patients with schizophrenia.

Event-related potentials (ERPs) arise from neural populations involved in information processing and, thus, may provide valuable information on the stages underlying local–global processing (Osman et al., 1992). Previous investigations of ERPs revealed that different neurophysiological mechanisms are involved in processing local and global aspects of stimuli (Beaucousin et al., 2011; Proverbio et al., 1998). For example, Johannes et al. (1996) reported that the posterior negative component occurring between 250 and 500 ms post-stimulus differed between local and global stimuli, and Proverbio et al. (1998) observed that N180 and P300 amplitudes were larger when attention was focused on global-level rather than local-level stimuli. Furthermore, Han et al. (2001) found that posterior P1 and N2 amplitudes were enhanced under the local stimuli relative to the global stimuli, and Jiang and Han (2005) reported that P1 amplitudes were larger under the local than the global condition; however, P2 amplitudes were larger under the global condition.

Few studies have used ERPs to investigate local–global processing in patients with schizophrenia. Johnson et al. (2005) found no differences in RT and accuracy between patients and healthy control subjects in response to local-level stimuli; however, responses to global stimuli were significantly slower and less accurate in the schizophrenia group. The N150 ERP amplitude, which was correlated with the speed of the response to global stimuli, was significantly reduced in the patients. Furthermore, the control group, but not patients, showed enhanced P300 amplitudes under the local relative to the global condition. The authors concluded that their findings supported a deficit in global visual processing in patients with schizophrenia.

Given that schizophrenia is highly heterogeneous and that several factors including antipsychotic drugs and length of illness or hospitalization can affect performance, investigating endophenotypes associated with schizotypal personality disorder (SPD) and non-clinical schizotypal traits have been viewed as a promising approach to understand schizophrenia (Siever & Davis, 2004). Indeed, SPD and schizophrenia share common genetic (Lin et al., 2005), neuroimaging (Dickey et al., 2002; Moorhead et al., 2009), and neuropsychological (Noguchi et al., 2008) abnormalities. Furthermore, visual processing abnormalities in figure/ground discrimination (Tsakanikos & Reed, 2003) and global–local processing (Goodarzi et al., 2000) have been detected in non-clinical individuals with schizotypal traits.

We used ERPs to investigate local–global processing in non-clinical college students with psychometrically defined schizotypal traits. The present study investigated whether individuals with schizotypal traits showed local-biased visual processing or deficits in processing of global-level stimuli as well as whether ERPs reflected these deficits. Based on previous findings in patients with schizophrenia, we hypothesized that behavioral and electrophysiological measures would reveal impaired processing of global information or a bias toward processing local information in individuals with schizotypal traits. To our knowledge, ours is the first reported study to use ERPs to investigate local–global processing in non-clinical individuals with schizotypal traits.

2. Method

2.1. Participants

We recruited 38 female college students from a pool of 564 students based on the Korean version of the Schizotypal Personality Questionnaire (SPQ; Moon et al., 1997; Raine, 1991) scores. The SPQ is a 74-item self-administered questionnaire with a “yes/no” response format. All “yes” responses receive a score of one, and higher scores indicate more schizotypal features. Students scoring in the top 5% of the SPQ were included in the schizotypal-trait group (n = 19), and the control group (n = 19) comprised students with average scores (±1 standard deviation [SD]) on this instrument. The Structured Clinical Interview for DSM IV, non-patient version (First et al., 1996) was administered to ensure that participants did not have a history of psychiatric, medical, or neurological disorders or drug/alcohol abuse. The Korean version of the Wechsler Adult Intelligence Scale (K-Wechsler; Yum et al., 1992) was administered to determine the IQ. All participants were right-handed, and none was taking medication at the time of testing. The participants were paid...
for their participation, and they provided written informed consent after receiving a complete description of the study. The study was approved by the Sungshin Women’s University Institutional Bioethics Review Board.

2.2. Local–global paradigm

We used a divided-attention task to assess local–global processing. The stimuli consisted of larger numbers “1,” “2,” and “3” (global level) that were composed of small numbers “1,” “2,” and “3” (local level). The target number “1” was presented at the global or local level but never at both levels simultaneously, and the participants were required to press open the button for the number “1” and to press the other button for the numbers “2” and “3.” The buttons assigned for these two responses were counterbalanced across participants. Four target stimuli (large “1” composed of small “2s,” large “1” composed of small “3s,” large “2” composed of small “1s,” and large “3” composed of small “1s”) and two non-target stimuli (large “2” composed of small “3s,” and large “3” composed of small “2s”; Fig. 1) were used. We randomly presented 240 target stimuli (60 for each target stimulus) and 240 non-target stimuli (120 for each non-target stimulus) divided into two blocks.

All stimuli were presented in white on a black background. The vertical and horizontal visual angles for the large numbers were 5.43° and 2.85°, respectively, and the vertical and horizontal visual angles for the small numbers were .57° and .26°, respectively. The stimuli were presented in the center of a computer monitor for 300 ms at an inter-stimulus interval of 1700–2200 ms. A cross (+) was presented for 500 ms prior to the presentation of each stimulus as a fixation point. Prior to the experimental session, participants performed a block of 20 practice trials to ensure that the instructions were understood. E-Prime version 1.2 (Psychology Software Tools, Inc., Pittsburgh, PA, USA) was used to present the stimuli.

2.3. Electrophysiological recording procedure

Electroencephalographic (EEG) activity was recorded using a 64-channel HydroCel Geodesic Sensor Net connected to a 64-channel, high-input impedance amplifier (Net Amp 300; Electrical Geodesics, Eugene, OR, USA) in an electrophysically shielded and sound-proofed experimental room. Each electrode was referenced to Cz, and individual electrodes were adjusted until impedances were less than 50 kΩ (Tucker, 1993). Eye movements and blinks were monitored with electrodes placed near the outer canthus and beneath the left eye.

EEG activity was recorded continuously during the experiment using a 1–100 Hz analog bandpass and a sampling rate of 250 Hz. After data collection was completed, the EEG was segmented into an epoch that started 200 ms before the onset of stimulus, and lasted 800 ms after stimulus onset. Epochs contaminated by artifacts such as eye blinks and eye movements were rejected before averaging (the threshold for artifact rejection was ±peak-to-peak amplitude of 70 μV). Data were then averaged for each subject and each level (local and global). An average-reference transformation was used to minimize the effects of reference-site activity (Dien, 1998). ERPs were baseline-corrected with respect to the 200 ms pre-stimulus recording interval and were digitally low-pass filtered at 30 Hz. Only those EEGs associated with correct responses were subjected to statistical analysis.

2.4. Statistical analysis

ERP amplitude can be measured by the maximum (peak), mean or area amplitude in the defined time window (Luck, 2005), and we employed the peak amplitude measure, since ERP components, P100, N150, and P300, were observed on the grand average and individual ERP waveforms. The P100 was defined as the most positive peak observed 80–130 ms after stimulus onset, and N150 was the most negative peak observed 150–220 ms post-stimulus. The amplitudes and latencies of P100 and N150 were analyzed separately using a mixed-design repeated-measures analysis of variance (ANOVA) with level (local and global) and channel (Oz, O1, O2, Pz, P3, P4) as within-subject factors and group (schizotypal-trait and control) as the between-subjects factor. P300 was defined as the most positive peak observed 300–500 ms after stimulus onset, and the amplitude and latency of P300 were analyzed separately using mixed-design repeated-measures ANOVAs with level (local and global) and channel (FCz, FC3, FC4, Cz, C3, C4, Pz, P3, P4) as within-subject factors and group (schizotypal-trait and control) as the between-subjects factor. Greenhouse–Geisser corrections for sphericity violations were used when appropriate, and corrected p values are reported. Variables showing significant main effects were further analyzed by post hoc comparisons using a one-way ANOVA.

RT and accuracy were subjected to a mixed-design repeated-measures ANOVA with level as the within-subject factor and group as the between-subjects factor. The demographic characteristics of the schizotypal-trait and control groups were compared using independent sample t-tests. Only correct responses were included in the statistical analysis.

3. Results

3.1. Demographic characteristics

The demographic characteristics of the schizotypal-trait and control groups are shown in Table 1. No between-group differences were found for age ($t(36)=1.36$, ns), length of education ($t(36)=1.51$, ns), and IQ ($t(36)=1.04$, ns). However, the SPQ scores of the schizotypal-trait group were significantly higher than those of the control group ($t(36)=−20.92$, $p<.001$).

3.2. Behavioral results for the local–global task

The statistical analysis of RT on the local–global task revealed a main effect of level ($F(1,36)=16.43$, $p<.001$) and a group × level interaction ($F(1,36)=5.56$, $p<.05$). RT was faster for the global-level than the local-level stimuli across groups. RT was significantly faster under the global-level compared with the local-level

| Table 1 | Demographic information of control and schizotypal traits. |
|---------|-------------------------------------------------------------|
|          | Control group $(n=19)$ | Schizotypal trait group $(n=19)$ | $t$  |
| Age (year) | Mean (SD) | Mean (SD) |  |
| 21.37 (2.71) | 20.37 (1.71) | 1.36 |
| Education (year) | 14.74 (1.41) | 14.11 (1.15) | 1.51 |
| IQ | 111.89 (7.05) | 109.63 (6.34) | 1.04 |
| SPQ | 16.36 (3.15) | 40.63 (3.40) | −20.92 $^*$ |

SD, standard deviation; SPQ, Schizotypal Personality Questionnaire. $^*$ $p<.001.$
condition in the control group ($F(1,18) = 21.17, p < .05$); however, RT was not significantly different between the local-level and global-level conditions in the schizotypal-trait group ($F(1,18) = 1.40, ns$).

The analysis of accuracy revealed a main effect of level ($F(1,36) = 10.40, p < .01$) and a group x level interaction ($F(1,36) = 8.02, p < .05$). Accuracy was lower under the local-level than under the global-level condition across groups. Responses were significantly more accurate when the stimuli were presented at the global level than at the local level in the control group ($F(1,18) = 10.95, p < .05$), whereas accuracy did not differ significantly between local-level and global-level stimuli in the schizotypal-trait group ($F(1,18) = 2.4, ns$). Table 2 shows the mean RTs and accuracy in response to local- and global-levels stimuli.

### 3.3. ERP results

The grand average ERP waveforms and the topographical distributions of the ERP components elicited by local- and global-level stimuli at Fz, Cz, Pz, and Oz in the schizotypal-trait and control groups are shown in Figs. 2 and 3, respectively.

#### 3.3.1. P100 amplitude and latency

The statistical analysis of P100 amplitude revealed main effects of level ($F(1,36) = 8.60, p < .01$) and channel ($F(5,180) = 15.19, p < .001$). The schizotypal-trait and control groups did not differ with regard to P100 amplitude ($F(1,36) = 1.31, ns$). The P100 amplitude in response to local-level stimuli was larger than that to global-level stimuli, and the largest P100 amplitude was observed at O2 and the smallest at P3 across groups. Furthermore, we found an interaction between level and channel ($F(5,180) = 2.99, p < .05$). The P100 amplitude elicited by local-level stimuli was larger than that for global-level stimuli at O1; however, the P100 amplitude was not significantly different between levels at the other channels. In terms of P100 latency, only a main effect of channel was observed ($F(5,180) = 6.86, p < .001$), with the longest latency at P4 and shortest at Oz across groups. Mean P100 amplitudes and latencies according to level and group are shown in Table 3.

#### 3.3.2. N150 amplitude and latency

We found a main effect of channel ($F(5,180) = 90.82, p < .001$), with the largest amplitude at O1 ($-10.17 \mu V$) and the smallest at Pz ($-2.81 \mu V$), and interaction effects for group x level

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**Table 2**

Mean response times and accuracy to global and local stimuli in control and schizotypal trait groups.

|                       | Control group (n = 19) | Schizotypal trait group (n = 19) |
|-----------------------|------------------------|---------------------------------|
|                       | Global                 | Local                           | Global               | Local               |
| Response time (ms)    | 368 (15.72)            | 391 (15.46)                     | 403 (15.72)          | 409 (15.46)         |
| Accuracy (%)          | 96.84 (.78)            | 92.79 (1.03)                    | 94.89 (.78)          | 94.63 (1.03)        |

SD in parenthesis

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**Fig. 2.** Grand averaged event-related potentials elicited at midline for local and global stimuli in control and schizotypal trait groups.
The amplitude 

Latency Pz

P3

P4

Oz

O1

O2

Latency Pz

P3

P4

Oz

O1

O2

The mean amplitudes (µV) and latencies (ms) of N150 in control and schizotypal trait groups.

SD in parenthesis.

Table 3

The mean amplitudes (µV) and latencies (ms) of P100 in control and schizotypal trait groups.

SD in parenthesis.

Table 4

The mean amplitudes (µV) and latencies (ms) of N150 in control and schizotypal trait groups.

SD in parenthesis.

The statistical analysis of P300 amplitude revealed main effects of level (F(1,36) = 25.39, p < .001) and channel (F(8,288) = 19.62, p < .001). Local-level stimuli elicited a larger P300 amplitude than did global-level stimuli across groups; the largest P300 amplitude was observed at Cz (8.16 µV) and the smallest at FC3 (4.46 µV). Furthermore, we found interaction effects for group × level.
Table 5
The mean amplitudes (µV) and latencies (ms) of P300 in control and schizotypal trait groups.

| Channel | Control group (n = 19) | Schizotypal trait group (n = 19) |
|---------|------------------------|----------------------------------|
|         | Global | Local | Global | Local |
| Amplitude |        |        |        |        |
| FCz     | 5.83 (1.82) | 7.33 (2.06) | 5.45 (4.02) | 6.10 (4.21) |
| FC3     | 3.87 (1.23) | 5.36 (1.12) | 3.85 (2.30) | 4.76 (2.34) |
| FC4     | 5.32 (1.85) | 6.34 (2.05) | 5.21 (2.91) | 5.42 (2.86) |
| Cz      | 7.40 (1.89) | 9.34 (2.19) | 7.79 (3.77) | 8.12 (3.99) |
| C3      | 3.95 (1.32) | 5.39 (1.40) | 4.43 (1.96) | 5.24 (1.98) |
| C4      | 4.66 (1.33) | 5.53 (1.41) | 4.56 (2.12) | 4.97 (2.75) |
| Pz      | 6.77 (2.76) | 6.96 (2.24) | 8.27 (4.32) | 8.22 (4.32) |
| P3      | 3.99 (2.15) | 4.63 (1.81) | 4.96 (2.41) | 5.58 (2.76) |
| P4      | 4.23 (1.61) | 4.16 (1.59) | 5.11 (2.26) | 4.91 (2.71) |
| Latency |        |        |        |        |
| FCz     | 425.79 (39.40) | 431.53 (39.06) | 432.21 (49.56) | 429.79 (44.24) |
| FC3     | 447.11 (42.39) | 449.95 (34.80) | 450.79 (46.57) | 451.11 (44.03) |
| FC4     | 430.42 (38.25) | 444.05 (32.47) | 432.21 (46.80) | 433.26 (39.87) |
| Cz      | 413.74 (44.17) | 431.26 (41.36) | 419.11 (46.18) | 413.58 (37.02) |
| C3      | 434.42 (38.64) | 458.42 (27.17) | 437.47 (44.64) | 437.00 (41.36) |
| C4      | 423.11 (36.60) | 439.00 (33.47) | 404.21 (39.17) | 417.89 (34.12) |
| Pz      | 374.05 (37.32) | 382.26 (34.42) | 363.37 (28.62) | 371.37 (34.35) |
| P3      | 381.42 (40.77) | 417.00 (33.75) | 386.16 (37.76) | 398.70 (32.67) |
| P4      | 364.79 (43.03) | 391.58 (44.31) | 364.47 (35.67) | 385.00 (34.48) |

SD in parenthesis.

The P300 amplitude in response to local-level stimuli was larger than that to the global-level stimuli in the control group (F(1,18) = 30.31, p < .05), whereas P300 amplitude did not differ between levels in the schizotypal-trait group (F(1,18) = 3.70, ns).

The local-level stimuli elicited a significantly larger P300 amplitude at FCz, FC3, FC4, Cz, C3, C4, and P3 than did the global stimuli; however, no significant differences between the two levels were observed at Pz and P4. The analysis of P300 latency revealed a main effect of level (F(1,36) = 7.59, p < .01). The P300 latency in response to the local-level stimuli was longer than that for the global level.

4. Discussion

We used ERPs to investigate whether the deficit in global visual processing or a bias toward local visual processing observed in patients with schizophrenia was present in non-clinical individuals with schizotypal traits. Behavioral and electrophysiological findings indicated that the global precedence effect is reduced in individuals with schizotypal traits relative to controls.

The schizotypal-trait and control groups performed differently on the behavioral components of the local–global task. The control group responded more quickly and accurately to the global-level than to the local-level stimuli, which is consistent with previous studies (Navon & Norman, 1983; Peressotti et al., 1991; Poirel et al., 2008; Roux & Ceccaldi, 2001; Shedden & Reid, 2001). The RT and accuracy of the schizotypal-trait group did not differ between the local- and global-level stimuli, indicating that the global advantage and interference effects are reduced in individuals with schizotypal traits. In other words, individuals with schizotypal traits have difficulty in processing global features or they are less distracted by incongruent global stimuli while processing local stimuli relative to controls.

Previous studies using the local–global paradigm in patients with schizophrenia found that patients' responses to global stimuli were significantly slower and less accurate than were those of controls (Johnson et al., 2005; Poirel et al., 2010) or RTs were significantly faster in response to local-level stimuli than was that of controls (Ferman et al., 1999). However, we found no between-group differences in RT or accuracy in response to global- or local-level stimuli. Different stimuli and participants employed in previous studies and in our study may contribute to the inconsistent behavioral results. Our study required participants to detect one target stimulus (“1”) and two non-target stimuli (“2” and “3”), whereas previous studies required to respond to two target stimuli (“1” and “2”) and two non-target stimuli (“3” and “4”) (such as that used by Bellgrove et al., 2003), or required a complicated response selection based on discrimination of multiple target stimuli (e.g., “H,” “S,” “E,” “A”) (such as that used by Goodarzi et al., 2000). In other words, the task used in our study may be easier for the participants to perform than those used in previous studies. Moreover, it has been suggested that visual abnormalities in patients with schizophrenia increase as symptoms and chronicity increase (Silverstein et al., 2006), which may explain why our non-clinical subjects showed no significant differences in RT and accuracy in the local–global task.

The P100 amplitude in response to the local stimulus was larger than that elicited by the global stimuli. This finding indicates that local and global stimuli are processed differently, even in the early stages of visual processing, because P100 is generated in the extrastriate cortex, which includes V3/V3a and the adjacent middle occipital gyrus (Di Russo et al., 2001; Vanni et al., 2004). The schizotypal-trait and control groups did not differ in terms of P100 amplitude and latency, which is consistent with previous studies in patients with schizophrenia (Johnson et al., 2005). P100 reflects the response to visual stimuli in the occipital region and has no clear connection to cognitive processing, as the P100 is observed in response to any visual stimuli (Bentin & Deouell, 2000; Campanella et al., 2000; Dhond et al., 2005). Thus, our results suggest that individuals with schizotypal traits maintain the capacity for primary visual processing.

The N150 amplitude did not differ between local and global stimuli in the control group; however, in the schizotypal-trait group, the N150 amplitude elicited by local stimuli was significantly larger than that elicited by global stimuli. The N150 is believed to reflect selective attention (Mangun & Hillyard, 1991) or visuospatial attention (Mangun & Hillyard, 1988). The enhanced N150 amplitude in response to local stimuli relative to global stimuli in the schizotypal-trait group indicates that these individuals pay more attention to local than to global features; that is, they have local-biased visual processing. In contrast to a previous study that found reduced N150 amplitudes in response to local and global stimuli in patients with schizophrenia relative to controls (Johnson et al., 2005), we detected no significant difference in
N150 amplitude between the schizotypal-trait and control groups. Structural and functional abnormalities in the extrastriate cortex and reductions in N150 amplitude have been reported to increase as the severity of the schizophrenic symptoms increases (van der Stelt et al., 2006). Thus, the inconsistency between our findings and those of previous studies may be attributable to differences in the patient populations studied.

Previous studies found that the right and left hemispheres were involved in the global and local aspects of stimuli, respectively (Robertson & Lamb, 1991), and that lateralization of local–global processing is observed in the early stages of visual processing (Evans et al., 2000). Our finding of enhanced P100 and N150 amplitudes in response to local stimuli relative to global stimuli at O1 across groups is consistent with previous investigations of the lateralization of local–global visual processing.

The P300 amplitude pattern differed between the schizotypal-trait and control groups. The P300 amplitude in response to local-level stimuli was larger than that to global-level stimuli in the control group, whereas no significant difference in P300 amplitude was detected in responses to the local and global stimuli in the schizotypal-trait group. These results are consistent with those of previous studies in patients with schizophrenia (Charbonnier et al., 1998; Johnson et al., 2005). For example, Johnson et al. (2005) found that the P300 amplitude elicited by local stimuli was larger than that elicited by global stimuli in controls; however, the authors found no significant difference in P300 amplitude between the local and global conditions in patients with schizophrenia. In the oddball paradigm, P300 is elicited in response to rare rather than frequently occurring stimuli; thus, P300 is believed to be an index of subjective expectancy or a predictor of unexpected or significant stimuli (Donchin, 1981; Donchin & Coles, 1988). Furthermore, P300 amplitude may reflect the intensity of the cognitive effort involved in information processing, such that P300 amplitude is proportional to the amount of attentional resources used in performing a given task (Kramer & Strayer, 1988; Polich, 1987).

Considering the functional significance of P300, it may be that the large P300 amplitude in response to local relative to global stimuli reflected the level of cognitive effort expended by the control subjects, who may be more inclined to attend to the global aspect of stimuli (Johnson et al., 2005). Our finding that local and global stimuli elicited similar P300 amplitudes in the schizotypal-trait group indicates that these individuals required less cognitive effort to process local-level stimuli than did controls, further supporting the argument for local-biased visual perception in the schizotypal-trait group.

Our study has several limitations that should be addressed in future studies. First, the generalizability of the study is limited due to the small sample of all female participants, particularly given that gender differences in local–global processing have been reported (Muller-Oehring et al., 2007; Roalf et al., 2006). Second, use of the same target stimulus, “I”, for all participants could limit the generalizability of the results, since “I” is more salient than “2” and “3”, which are perceptually similar. Therefore, future studies should counterbalance the target numbers across participants. Finally, findings of structural and functional abnormalities in the extrastriate cortex of patients with schizophrenia (Butler et al., 2005; Martinez et al., 2008) suggest that future studies should use structural–functional neuroimaging techniques as well as ERPs to further clarify the neurophysiological mechanisms underlying the impairment in local–global processing experienced by individuals with schizophrenia–spectrum disorders.

In summary, the schizotypal-trait and control groups showed different behavioral and electrophysiological response patterns in the local–global paradigm. The control group had faster and more accurate responses to the local-level than the local-level stimuli, whereas RTs and accuracy were not significantly different between levels in the schizotypal-trait group. N150 amplitudes elicited by local-level stimuli were larger than those elicited by global-level stimuli in the schizotypal-trait group; however, N150 amplitudes did not differ between levels in the control group. Finally, P300 amplitudes in response to local stimuli were larger relative to those for global stimuli in the control group, whereas P300 amplitudes did not differ between levels in the schizotypal-trait group. These results indicate that the global precedence effect is reduced in individuals with schizotypal traits, possibly reflecting local-biased visual processing or difficulty in processing the global aspects of information. Our results suggest that deficits in local–global visual processing could serve as a trait marker for schizophrenia–spectrum disorders including schizophrenia.

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