Effects of Kanizsa object context on flanker interference: Behavioral and electrophysiological evidence

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Abstract

The Eriksen flanker task is often used to test the effectiveness of spatial attention. Objects are capable of influencing perceptual organization and spatial attention. We used Kanizsa objects (illusory rectangles created by pacmen inducers) to create different surrounding contexts onto which we presented the letter arrays. Our aim was to provoke increased flanker interference effects when target and flankers are presented in the same object context, and to decrease effects when the target was in an isolated object context. In addition to performance data, we used event-related potentials (ERPs) as an index of both how the objects were processed and how the letter arrays were processed. Object context did not influence the flanker interference effect, but presentation of the letter array evoked larger N1 components when the target letter was presented in an isolated object context than when letter arrays were presented onto other objects. This suggests that the object context altered perceptual organization without altering the flanker interference effect.

4.1 Introduction

Visual selective attention enables a person to filter out irrelevant visual information and focus on relevant information. However, selective attention is not perfect. A well known paradigm in clinical settings as well as in experimental psychology to study the limitations of normal and disturbed attention is the Eriksen task (Eriksen and Eriksen, 1974; Eriksen and Yeh, 1985; Eriksen & St James, 1986; Eriksen and Hoffman, 1972). Eriksen and coworkers showed that when subjects had to respond to a letter on a fixed location, accuracy and speed of responses were highly dependent on whether or not surrounding letters (so-called flankers) were congruent with the response associated with the target letter. Competition of the flanking letters on identification of the target letter occurred when they were located closer than 1° to the target letter. To investigate the locus of such flanker-target interactions, Eriksen and Eriksen (1974) assigned two types of letters to each of the two hands as an appropriate response (for instance, an ‘H’ and ‘K’ to the left and ‘C’ and ‘S’ to the right hand). Responses to letter arrays in which the flankers and the target indicated different response hands were slower than to letter arrays in which flankers and target indicated the same response hand. Critically, when flankers were non-identical, but indicating the same response hand as the target (i.e. a ‘K’ target flanked by ‘H’s) subjects’ response speed was hardly distinguishable from RTs on targets flanked by identical letters. This suggests that the locus of flankers-target interference is in response selection, rather than in perceptual identification. Miller (1991) pursued elimination of the flanker effect by task manipulations which supposedly altered the early selection of the target letter and found in 10 Experiments that ‘early selection rarely, if
ever, completely excludes unattended stimuli from semantic analysis’ (Miller, 1991, p273). The locus of interference in the Eriksen paradigm is still a subject of debate (Magen & Cohen, 2002), but the consensus nowadays seems to be that interference reflects both a perceptual and a response conflict.

The use of event-related potentials (ERPs) has been especially informative regarding the functional locus of interference in the Eriksen paradigm. Incompatible arrays are usually associated with longer P300 latencies than compatible arrays (Coles, Gratton, Bashore, Eriksen, & Donchin, 1985), indicating a perceptual conflict. In Coles et al’s study, the compatibility effect on P300 latency was about half that on reaction time (RT). The additional effect on RT could be attributed to response conflict. Incompatible flankers led to an early activation of the incorrect response, reflected in the ‘lateralized readiness potential’ or LRP, which is derived from the EEG and indexes the preferential preparation for moving one hand or the other (Coles, 1989; Smid & Mulder, 1995). Activation of the incorrect response appears to ‘compete’ with activation of the correct response and, therefore, to delay the selection and execution of the correct response (Coles et al., 1985; Coles, Smid, Scheffers, & Otten, 1995). Thus, the use of ERPs has also pointed to a contribution of both response and perceptual competition.

On the basis of his experiments Eriksen proposed the ‘zoomlens’ model of visual attention (Eriksen and Yeh, 1985; Eriksen and St James, 1986), according to which spatial attention can be dynamically allocated along a continuum from tightly focused to widely distributed. The resolution of the attentional beam is inversely related to its width. Thus, with difficult discriminations, a concentrated beam of attention with high resolving power would be necessary for successful processing of the stimulus array. On the other hand, relatively easy discriminations could be made with attention distributed more broadly across the visual field.

Space-based models of visual attention, such as the zoomlens model, can be contrasted with object-based models of visual attention, which stem from Gestalt theories (Wertheimer, 1923). These state that attention selects objects or groups of features on the basis of properties as proximity, colour, common fate, and closure. The influence of objects has been studied in a variety of settings, for instance in which features of one object interfere with features of another object. Duncan (1984) presented subjects with two superimposed objects and had them search for two features which were either on the same or on separate objects. When the target features belonged to separate objects, subjects identified the target features much slower than when they the same object. Importantly, the spatial distance between the two target features was constant, in either case. Furthermore, Vecera and Farah (1994) showed that when the objects are spatially separated, the results are the same as with superimposed objects. This indicates that selection is spatially invariant and that selection is biased towards selecting whole objects (see Kramer, Weber, and Watson, 1997, for another explanation, however).

Objects can also alter the spatial attentional distribution by acting as contextual landmarks. Egly, Driver, and Rafal (1994) presented subjects two parallel rectangles (vertically or horizontally) which enclosed all four potential target locations which were equidistant to each other. After 1 sec. they spatially cued one end of the two rectangles. Within half a second later a target stimulus was flashed to which the subject had to respond as quickly as possible, at either the same or another location as the preceding cue.
This target was most often presented on the same location as the cue (validly cued), but sometimes elsewhere. This could either be within the same rectangle as the cue or on the other one, which were, at equal distance of the originally cued location. Responses to validly cued targets were fastest. Responses to targets presented within the cued rectangle were faster than targets on uncued rectangles. This indicates that attention can be simultaneously based on space and objects and also that attention can be altered by figural context.

Object-based attention has also found to influence performance in the Eriksen task. An example is a study of Driver and Baylis (1989). In their experiment, they showed five letters of which some moved up or down. In one condition, the outer flanker positions were congruently moving with the target location whereas the inner flankers were stationary. Despite the closer spatial proximity of the inner flankers to the central target letter, they led to less interference with target processing than did the outer (more distant) flankers. Presumably common movement with the target overrules the effect of proximity. Some doubt has been cast upon this finding, however, as two studies failed to replicate this effect (Kramer, Tham, and Yeh, 1991; Berry and Klein, 1993) even when grouping of central and outermost letters by movement was aided by colouring the equimotional stimuli (Kramer and Jacobson, 1991). Other studies have found that colouring, however, has a modulating effect on the interference (Humphreys, 1981; Harms and Bundesen, 1983). Incompatible flankers had less impact when they had another colour than the target.

Kramar and Jacobson (1991) presented subjects with five vertical lines of which they had to report the texture of the central line. Nearby lines could have either the same or another (referring to another appropriate response) texture. In 3 experiments they showed that the interference effect was manipulable by grouping lines by colour (Exp 2) or by closure (Exp 3) alone, and in combination (Exp 1). Closure grouping was established by connecting the nearby flankers with the target in one condition (so that the target belonged to an object which also contained the nearby flankers), in which interference was higher than in a control in which no closure was used. In another condition, the inner flankers were connected to the outer flankers (and the target was solitary), and interference was reduced compared to control. Colour grouping was established the same way as closure, with similar results. Importantly, they also showed that the grouping effects on interference were strongly reduced when the distance between the stimuli was increased to more than 1°, but that the interference effect was still present. So, space and object based attention can be observed simultaneously.

Object based attention effects can also be observed in Kanizsa illusory objects. Mattingley et al. (1997) showed that an extinction patient (extinction patients tend to ignore stimuli in one hemifield (mostly the left) when they are stimulated simultaneously in the other hemifield) was able to orient to an otherwise ignored halffield if this was part of a Kanizsa object which extended into the intact hemifield. When the Kanizsa object percept was violated she could no longer indicate any changes in the left hemifield. Davis and Driver (1994) found that search time of Kanizsa objects was independent from the number of distractors in the search display. This ‘pop-out’ effect suggests that Kanizsa objects are constructed preattentively.

Kanizsa objects evoke a rather different pattern in the EEG than the same pacmen placed in a formation in which no illusory object can be formed. Former experiments
(Herrmann and Mecklinger, 2000) focused on differences in potentials evoked by Kanizsa and non-Kanizsa objects. Herrmann, et al. (1999; 2000; 2001) observed that Kanizsa objects evoke larger N1s compared to non-Kanizsa objects, independently of which type of object the subjects had to detect. Therefore, they conclude that the N170 reflects illusory contour detection. Others (Pegna et al., 2002) compared activation of non Kanizsa, Kanizsa and real contours (the illusory edge between the inducing pacman is a real line) of triangles. The ERPs elicited by the Kanizsa triangles and the real contours were similar. They conclude that both processes ‘modulate a common network associated with filling-in and figure-ground segregation’ (p. 965).

Objectives

Several questions have often been addressed. First, where is the locus of processing of objects with respect to the locus of attention? Many authors have argued, conform the Gestalt view, that preattentive stages of perceptual processing also include the formation of object representations (even illusory ones), which in turn can alter attention involuntary (Mattingley, Davis, and Driver, 1997; Davis and Driver, 1994; Duncan, 1984). Others have argued that objects are processed postattentively. For instance, like the zoomlens model, the gradient hypothesis (Downing, 1988; Mangun and Hillyard, 1991) claims that attention is focused first on a location in space and after that on objects and that the efficiency of information processing gradually decreases with the distance to the attended location. Kramer and Jacobson (1991) have shown that when the target information is part of an object which also contains flanker lines, this ‘intra-object’ flanker interference is large compared to interference from flankers which are not part of the same object as the target. Taken together with the literature which states that figural context also alters visuospatial selection (Egly, Driver, and Rafał, 1994; Davis and Driver, 1994) this logic should also apply for the Eriksen paradigm.

In the present study, we used illusory objects to create different figural contexts for a letter array. In focused attention tasks as the Eriksen task, a physical boundary may help subjects to use these cues in an effort to effectively segregate the target from the flankers. In the experiment presented here, there is no physical barrier between the letters. Kanizsa objects also allow changes to the form of the illusory object with simple rearrangements or rotation of the pacmen, without addition or deletion any physical elements in the visual display.

A large illusory object containing the total letter array allows ‘attentional leakage’ (Yantis & Johnston, 1990) from the target to the flankers (i.e. across the object). This would be reflected in large flanker interference effects. To do so, we created a Global Kanizsa object onto which the letter array was presented some time later. On the other hand, when an illusory object is created so that the illusory borders are between the target and the nearby flankers, they may well largely seal off the attentional leak. We did this in two different conditions. First, pacmen were organized so that a small Local object was created on the target position only, so that the target letter was put in a separate context from the flankers. Secondly, we created two Peripheral objects, which placed the flankers instead of the target onto Kanizsa objects, and in which the target was placed between those two illusory rectangles. This condition is comparable with the ‘different’ object condition of Kramer and Jacobsen (1991). Note that in this condition the target is
supposed to appear behind the flankers, whereas in the Local condition the target is supposed to appear in front.

We used ERP measures to pinpoint the processes associated with object-based attention. Few experiments of the massive amount of studies on object-based attention have used ERPs.

The P3 latency is an indicator of perceptual speed of the correct target. When the objects alter selection, the P3 latency also could indicate that object context influence concerns perceptual loci of interference.

4.2 Method

4.2.1 Participants

12 students (7 female, 5 male, age (17-26), M=20.7) were recruited from the Groningen University population and received course credits for their participation. All were right-handed, and their vision was normal or corrected-to-normal.

4.2.2 Stimuli

Subjects were seated 1 m from a computer screen and placed their head in a chin-rest. A fixation sign (‘+’) was presented at the beginning of a trial. After 850 ms a figure display was presented. This display was constructed in the following manner. Four rows of 6 circles were presented, in total 4.82° high and wide. The outer and inner two circles of each row were 0.74° in diameter, the second and fifth were 0.57° in diameter. The horizontal distance between the circles was 0.11°, see Figure 4.1.

From the top row to the bottom row the distance was the same for each figure. When an illusory object was presented between two rows, the distance between these rows was 0.74°, else it was 0.11°. Illusory objects were 1.55° high, irrespective of the position they were presented (above, at, or below fixation). The illusory objects were configured by two aligning rows of half circles and four pacman inducers (two on each row). These pacman inducers were placed on the inner two positions, on the outer two (facing each other to induce a Local and a Global illusory object, respectively) or placed on the inner position facing outward and on the outer position facing inward to produce two objects peripheral of the target position.

The object was either 4.13° (Global) or wide 0.86° (Local). The Peripheral objects were 1.55° wide each. The ‘strength’ of the illusory object percept is indexed by the length of the edge of the object which is aligned with the pacman inducers divided by the total length of the edge of the object (see Ringach and Shapley, 1996). This index was 0.5 for the height and 0.87 (Local) and 0.86 (Global) and 0.86 (for each Peripheral) for the width. Only when the illusory object(s) was presented on fixation the ‘+’ sign disappeared.

In a period of 350-600 ms (with 50 ms steps) after presentation of the Kanizsa object, a row of five letters was presented within the rows of circles which contained the illusory object. The outer two and the central (third) letter could differ or not and were either an ‘H’ or an ‘E’. These were chosen because they cannot be discriminated by simple featural differences. The distance between the letters was 0.29°. The target for the
subjects was the central letter. When presented on a Global illusory object all five letters just fitted into this display. When presented on a Local illusory object only the central of the five letters (i.e. the target) just fitted within the object. Peripheral objects parsed the flanker letters from the target letter which was not placed on an object.

After 150 ms the display disappeared and the fixation sign appeared. Subjects had 1000 ms time to respond after appearance of the letters. Half of the subjects had to respond with their left hand when the target was an ‘E’, and with their right hand when the target was an ‘H’. The other half of the subjects had to respond with their left hand when the target was an ‘H’, and with their right hand when the target was an ‘E’. Responses had to be made by releasing the left or right index finger from a release button on a response box. The response boxes were placed on a comfortable distance on a table in front of the subject. It was stressed to the subject that it was important to fixate and keep their eyes at the fixation spot during presentation of the entire trial.

There were 18 categories (compatible or incompatible, and with Local, Global or Peripheral objects, and on, above or below fixation) which were presented with equal probability. Each block contained 4 of each category, which comes to 72 trials in each block of 160 s. Subjects completed 17 blocks in total.

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Figure 4.1

Schematic representation of the task. See text for further explanation.
After 150 ms the display disappeared and the fixation sign appeared. Subjects had 1000 ms time to respond after appearance of the letters. Half of the subjects had to respond with their left hand when the target was an ‘E’, and with their right hand when the target was an ‘H’. The other half of the subjects had to respond with their left hand when the target was an ‘H’, and with their right hand when the target was an ‘E’. Responses had to be made by releasing the left or right index finger from a release button on a response box. The response boxes were placed on a comfortable distance on a table in front of the subject. It was stressed to the subject that it was important to fixate and keep their eyes at the fixation spot during presentation of the entire trial.

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4.2.3 Procedure

Subjects were instructed to respond only to the central letter. Their gaze could be checked both visually (a camera registered their gaze) and electrophysiologically (their vertical and horizontal electro-oculogram was registered online). Importantly, no instruction was given about the objects other than that it predicted the location of the letter array. They were also told that there was no relation between one trial and the next. After this instruction they exercised blocks of 36 trials until their performance was satisfactory (8 errors or less). Subjects received feedback after each block about average accuracy and their reaction time on compatible letter combinations and incompatible letter combinations, averaged across all figural contexts.

4.2.4 Recording

The electroencephalogram (EEG) was measured with an electrodecap (Electro-Cap International) using 29 Sn electrodes placed at positions FP1, FP2, F7, F3, Fz, F4, F8, FC5, FC3, FC4, FC6, T7, C3, Cz, C4, T8, CP5, CP6, P7, P5, P3, Pz, P4, P6, P8, PO9, PO7, O1, O2, PO8, and PO10 (Sharbrough et al., 1991). All electrodes were referenced to the right and left mastoid. Horizontal electro-oculogram (hEOG) was measured with Sn electrodes on the outer canthi. Vertical EOG was measured with Sn electrodes, above and below the left eye. The impedance of the electrodes was kept below 5 KΩ. EOG and EEG were amplified with a time constant of 10 s and a 200 Hz low-pass filter, sampled at 1000 Hz, digitally lowpass filtered with a cut-off frequency of 35 Hz, and on-line reduced to a sample frequency of 100 Hz.

4.2.5 Performance Analysis

The mean reaction times (RT) on hits were analyzed as well as the error levels. Correct responses within 200-700 ms after target presentation were considered as hits. A repeated measures analysis (ANOVA) was performed on the performance data, with FIGURE (Global, Local, or Peripheral objects), COMPAT (compatible or incompatible letter combinations), and POS (at, above or below fixation) as within-subject factors. In order
to account for violation of sphericity assumption in application of the univariate approach, we used the Huynh-Feldt correction (Huynh and Feldt, 1976) in case of an Huynh-Feldt epsilon $\geq 0.75$, and the Greenhouse-Geisser correction (Greenhouse and Geisser, 1959) in case of an epsilon $<0.75$ (Quintana and Maxwell, 1994).

4.2.6 ERP Analysis

ERPs were averaged off-line. Artifacts (out-of-range, movements or saccades) were rejected automatically and ocular correction was performed (Gratton, Coles, & Donchin, 1983). Averages reported here were corrected with a baseline of 100 ms preceding stimulus onset. Two types of ERPs were of special interest. The first is the OBJECT-ERP. Kanizsa objects usually evoke enhanced N1s compared to non-Kanizsa objects (see Introduction). To investigate this effect, we analyzed the pooled activity of visual evoked potentials on electrodes O1/O2. The time range uncontaminated by letter array presentation is until 350 ms after object presentation. The factors in this analyses were POS (at, below, or above fixation), and FIGURE (Global, Local, and Peripheral objects). We analyzed the OBJECT-ERP from 50 ms to 350 ms in 50 ms bands.

Second, the ERP evoked by the letter array (ARRAY-ERP) gives us insight in how the compatible and incompatible letter arrays are processed and whether this information is differently processed in different object contexts. These averages were also corrected with a baseline of 100 ms preceding the onset of the letter array. We calculated the lateralized readiness potential (LRP) to test whether the different objects have a differential effect on the build-up of readiness of a response. For calculation of the LRP, electrodes C3/C4 were analyzed. Visual effects were expected to be most pronounced at posterior electrodes (O1/O2). Nine bands of 50 ms each were analyzed from 50 ms to 500 ms. Testing many intervals increases Type I errors. The chance of one band being significant on basis of chance is $(1-0.95^9)=0.37$. Therefore, we report significant F values if there is a significant effect of a factor on at least two adjacent intervals. In this case, the probability for a type I error in two consecutive significant intervals is reduced to 0.02. In consecutive significant bands the largest F-value is reported. Furthermore, the individual P3 latencies were established by automatic scoring of the most positive peak on electrode Pz between 300 – 700 ms postarray. The factors were the same as in the OBJECT-ERP, with an additional factor COMPAT. For calculation of the LRP, electrodes contralateral or ipsilateral to the response hand were pooled. LRP values were calculated by amplitude subtraction of electrodes contralateral from electrodes ipsilateral to the response hand. The different ERP components were analyzed with 3 factors (POS, FIGURE, and COMPAT). Violations of sphericity for the ERPs were treated in the same way as for the performance data.

4.3 Results

4.3.1 Performance

RT data are presented in Figure 4.2, left panel. As expected, compatible trials were faster than incompatible trials (COMPAT: $F(1, 11)=99.9, p<.001$). Furthermore, POS was significant ($F(1.41, 15.46)=16.52, p<.001$), which indicated that responses were much
Flanker interference and Kanizsa Figures

faster when the array was presented at fixation than when they were presented elsewhere (RT did not differ for arrays presented in the lower and upper visual field (F(1,11)=1.28, p>.05)).

Our aim was to alter the flanker interference under influence of the object context. However, the factors FIGURE and COMP did not interact (F(1.43, 15.70)=.07, ns.). Although they did interact with different positions (F(2.70, 29.64)=2.77, p<.05), this could not be explained in fruitful manner for our questions.

Accuracy data are presented in Figure 4.2, right panel. COMPAT also was significant on errors. Error levels were elevated for incompatible trials compared to compatible trials (F(1,11)=98.4, p<.001). An COMPAT and POS interaction was found which reflected that incompatible arrays resulted in lowered accuracy, especially when the array was presented off fixation (F(1.96, 21.51)=3.92, p<.05). Also, an effect of FIGURE was found on accuracy (F(1.85, 20.33)=3.66, p<.05). The contrast between the different objects revealed that only arrays presented in Local objects showed elevated error scores compared to Peripheral objects (F(1,11)=10.25, p<.01). The factors FIGURE and COMPAT again did not reach a significant level, as our a priori hypothesis would predict (F(1.86, 20.43)=.36, ns.).

![Figure 4.2](image)

Performance data. In the left panel the RTs of compatible and incompatible letter arrays in the different figural contexts are presented, in the right the error percentages. Error bars indicate the standard error of mean.

### 4.3.2 ERPs

**OBJECT-ERPs**

In Figure 4.3 the OBJECT-ERPs are shown. The factor POS was significant from 100-350 ms (F(2,22)=31.9, p<.001). As can be seen in Figure 4.3, the amplitude is more positive as the object is presented higher in the visual field.

Also, FIGURE was significant from 150-350 ms (F(2,22)=6.83, p<.005). As can be seen in Figure 4.3, the Global object evoked larger amplitudes than the other object, although Peripheral and Local objects differed from 300-350 ms, (F(1,11)=12.93, p<.005).

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2 Contrast analysis showed that this interaction was because of a 7 ms larger compatibility effect for Peripheral objects than for Local objects when they are presented in the lower visual field only.
From early stages onward (100 ms) these factors also interacted (F(4,44)=11.68, p<.001). In an early stage of this effect it could be determined by post-hoc comparison, that the FIGURE effect was larger in the LVF, as can be seen in Figure 4.3. In a later stage (200-350 ms) the different figures also evoked different signals on fixation (as well as in the LVF). Remarkably, the different figures had no effect on the ERP pattern when they were presented in the UVF (F(2,22)< 2.88, ns.).

ARRAY-ERP

O1/O2

The location of presentation of the array resulted in different amplitudes on O1/O2 from 150-350 ms postpresentation (F(2,22)=41.27, p<.001, see Figure 4.4). Within this period, contrasts revealed that N1 amplitude was largest when the array was presented in the Lower Visual Field (LVF) compared to the Upper Visual Field (UVF, F(2,22)=74.03, p<.001), which was less negative than when the array was presented on fixation (F(2,22)=26.96, p<.001). Also within this period (150-350 ms), the posterior N1 (O1/O2) also depended on the type of figure the array was presented on (F(2,22)=21.53, p<.001). Arrays presented on Local objects showed a stronger N1 compared to Global object context (F(1,11)=29.51, p<.001) and also compared to Peripheral object context (with the remark that from 200-300 this was marginal, 3.85≤ F(2,22)≤11.22, p≤ .076), as revealed by contrasts. A Global object context tended to evoke smaller N1s than Peripheral object context: a later part of the N1 (200-300 ms) showed marginally significant effects (4.14≤ F(2,22)≤27.11, p≤.067). The effects of POS and FIGURE interacted from 100-250 ms (3.55≤ F(4,44)≤4.87, p≤.013). As can be seen in Figure 4.3, the FIGURE N1 effect between Peripheral and Local objects was absent when the array was presented at fixation, which was confirmed by the contrasts.

LRP

LRPs are presented in Figure 4.5. COMPAT was significant in the periods 250-350 (F(1,11)=15.70, p<.005), and 400-500 ms (F(1,11)=8.12, p<.05). In the early episode, stronger lateralization in compatible arrays was observed than in incompatible arrays. There was still lateralization in the later epoch when arrays were incompatible, while compatible arrays did not evoke lateralization any more.

P3 Latency

See Figure 4.6 for the P3 latencies. P3 latency showed large effects of compatibility (F(1,11)=26.3, p<.001). Compatible array displays resulted in earlier P3 peaks than incompatible arrays. Although FIGURE also resulted in significant effects on P3 latencies (F(2,22)=3.83, p<.05), this did not interact with COMPAT. Arrays presented in a Global object resulted in relatively early P3 peaks, whereas Peripheral objects resulted in late peaks, with arrays in a Local object resulting in intermediate P3 peak latencies.
**Figure 4.3**

Grand Averages ERPs evoked by the presentation of the different objects. The upper panel shows the potentials evoked by the different objects presented in the upper visual field, the middle objects presented on fixation, and the lower the objects presented in the lower visual field.
Figure 4.4

Grand Averages ERPs evoked by the presentation of letter arrays. The upper panel shows the potentials evoked by letter arrays presented on the different objects which were presented in the upper visual field, the middle panel when the letter array was presented onto objects presented on fixation, and the lower when letter arrays were presented onto objects presented in the lower visual field.
Figure 4.5

The Laterialized Readiness Potentials of the letter arrays presented on the different objects. Shown are the LRP s pooled for letter arrays presentation fixation, upper and lower visual field. The LRP of compatible and incompatible letter arrays in the upper panel are compared when the letter array was presented on Global objects, on Local objects in the middle panel, and on Peripheral objects in the lower panel.
Figure 4.6

P3 latencies of compatible and incompatible letter arrays are compared for when the letter array was presented on the different objects. Error bars indicate the standard error of mean.

4.4 Discussion

The present results indicate that visual processing of the letter array was altered by the figural context. The N1, evoked by presentation of the letter array, was enhanced (by several microvolts) when it was presented on a Local object. The early components P1 and N1 are known to vary as a function of focused visual attention. The P1 is modulated by spatial attention (Mangun and Hillyard, 1991) and the N1 especially when visual discriminative processes come into action (Vogel and Luck, 2000; Mangun and Hillyard, 1991). The spatial allocation of visual attention was argued to depend on the figural context. However, we did not find any modulation of the P1 by the figural context that might suggest differences in spatial attention. Instead, the present evidence suggests that the Local objects created a context in which discriminative processes are enhanced.

In spite of the sizable effect on the N1 amplitude, figural context did not have an appreciable effect on performance, or response selection (reflected in the LRP). One would expect, when discrimination of a central target letter in a letter array is enhanced in a Local object context, that that context would have at least some beneficial effect on post-discrimination processing. In fact, we failed to find any evidence for the hypothesized role of figural context in modulating interference effects in the Eriksen flanker task. Though this outcome is perhaps somewhat disappointing, the often fragile nature of object-based effects on performance in the Eriksen flanker task has been established before (Kramer, Tham, and Yeh, 1991; Berry and Klein, 1993). Importantly, no such effects were obtained in the present study even when the letter array was presented off fixation, requiring attentional shifts, which Lamy and Egeth (2002) have suggested to be important for objects to influence spatial attention. This pattern of results,
clear effects of figural context on the N1 amplitude coupled with a complete absence of figural context effects on overt performance (and on LRP latencies), suggests that figural context affected perceptual processes involved in discriminating the target from flanker letters, but that this perceptual effect may have been too subtle to cause significant changes in subsequent processing in the Eriksen flanker task. Consequently, the present results suggest that early ERPs may sometimes provide more sensitive indicators of object effects on perceptual processing than indicators based on overt behavior measures. Such superior sensitivity of ERPs have been suggested before; for instance, groups which tend to differ in daily life (extraverts vs. introverts) show similar performance in a go/no-go task, but have remarkable differences in information processing indicated in the N1/P3 (Rammsayer & Stahl, 2004).

Egly et al. (1994) suggested that the context of objects can alter the spatial distribution of attention. Using Kanizsa objects as a figural context resulted in similar results (Moore, Yantis, and Vaughan, 1998). It has been suggested that such figural context as in the Egly paradigm alter the preference to search for target preferably on the cued object, although discriminability of stimuli presented in the cued object context is not higher than stimuli presented elsewhere (McCarley, Kramer, and Peterson, 2002). Alternative target locations seem to be preferably searched along the object context. In the experiment presented here, with only one relevant target location, Kanizsa figural context failed to influence overt performance in the flanker interference task. This suggests that with no alternative locations to search, contextual objects do not have an effect on performance.

These effects of object context seem to differ from experiments of Duncan (1984) and the experiments of the object effects in the Eriksen paradigm described in the Introduction (Kramer and Jacobson, 1991; Driver & Baylis, 1989) in which objects have a large effect on performance and the target locations is known. In those experiments, a target feature is element of an object. When multiple features have to be reported, they are more easily detected when they belong to the same object as compared to when they are element of different objects (Duncan, 1984). When only one feature has to be identified, flanker interference is enhanced when the target features are element of an object also containing the flankling features, whereas it is reduced when the target feature is element of another object than those containing flankling features (Kramer and Jacobson, 1991; Driver and Baylis, 1989).

Another important result is the OBJECT-ERP. First, the P1 was enhanced for Global objects as compared to other objects. Former experiments (Herrmann and Mecklinger, 2000) focused on differences in potentials evoked by Kanizsa and non-Kanizsa objects (objects in which the inducing pacmen do not create an illusory object). Herrmann, et al. (1999; 2000; 2001) observed an N170 (N1) enhancement by Kanizsa objects compared to non-Kanizsa objects, which was independent of the task. Therefore, they concluded that the N170 reflects illusory contour detection. Others (Pegna et al., 2002) compared activation of non Kanizsa, Kanizsa and real contours (the illusory edge between the inducing pacmen is a real line) of triangles. The activation of the Kanizsa triangles and the real contours was comparable. They conclude that both processes ‘modulate a common network associated with filling-in and figure-ground segregation’ (p. 965).
To our knowledge, no one has compared different sizes of illusory objects (with a constant visual input). Furthermore, perception of the form of the illusory object is completely irrelevant in this experiment. In our experiment, larger illusory objects evoked larger P1 components. This resembles the effects which are found when the visual system is presented with larger objects, such as checkerboard size (Pike & Polich, 1988), which evoke larger early visual components. Our experiment suggests this is also true for illusory objects. This shows that different illusory object forms result in different visual cortical representations.

Second, former reports suggest that occluded surfaces, such as Kanizsa objects, are better perceived when they are presented in the lower visual field, possibly because depth is a more important cue when stimuli are close (Rubin, Nakayama, & Shapley, 1996). The differences we report with the OBJECT-ERP suggest that the Kanizsa objects were indeed identified more quickly when they were presented in the LVF.

To conclude, different contextual objects were processed into different cortical representations, and although this perceptual reorganization had an effect on the perceptual processing of the letter array (reflected in N1 modulation), the objects failed to influence flanker interference performance.