Can certain stimulus characteristics influence the hemispheric differences in global and local processing?

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Hemispheric processing of global and local form was examined in two experiments in which the size of hierarchical visual stimuli was manipulated in divided-attention tasks. In experiment 1, the subjects were instructed to decide whether or not a symmetrical target (T) was in the visual object presented. In experiment 2, the target to be detected was nonsymmetrical (L). In both studies, global precedence was found depending on stimulus size. When the stimuli subtended about 3° vertically, global dominance was found, but it was not detected when the stimuli subtended about 10°. Experiments 1 and 2 provided evidence against the analytic/holistic dichotomy, presenting the same performance for both hemispheres: the global analysis was much better than the local analysis. When the target was in the global form, both the LH and the RH analyzed the 3° stimuli more efficiently, while both analyzed the 10° stimuli with greater efficiency when the target was in the local form.

Introduction

Navon (1977) provoked a serious controversy about the way in which people perceive the different levels of structure of a visual object. He described experiments in which subjects were presented with stimuli consisting of compound letters – a large letter (global level) made up of small ones (local level) – and suggested that the visual form may be ordered from global to local features, perceptual processes being temporally organized so that they proceed from global structuring towards finer analysis details. This view is known as the
'global precedence hypothesis' or 'global-to-local processing'. Nevertheless, global precedence is not always evident. Other researchers have demonstrated some variables that can affect global versus local dominance and may be summarized as follows. Firstly, stimulus characteristics: size (Antes and Mann 1984; Arnau et al. in press-a; Kinchla and Wolfe 1979; Lamb and Robertson 1989, 1990; Navon and Norman 1983), number of local elements (Arnau et al. in press-b; Kimchi 1988; Martin 1979a; Navon 1983), and quality of stimulus (Grice et al. 1983; Hoffman 1980; Miller 1981a; Ward 1982). Secondly, task parameter: ‘same’–‘different’ judgement tasks (Kimchi 1988). Finally, procedure variables: exposure time (Grice et al. 1983; Luna et al. 1990), location of visual pattern (Grice et al. 1983), and presence of noise in the experimental session (Smith 1985).

Recently, this line of investigation has been transferred to the study of functional hemispheric differences. The hemispheric specialization has frequently been characterized in terms of dichotomous variables. One of these dichotomies suggests that the right hemisphere (RH) is specialized for global or holistic processing, whereas the left hemisphere (LH) is specialized for local or analytic processing. Martin (1979b), using hierarchical visual stimuli in a focused-attention task, found that the local processing of a verbal stimulus was superior in the left hemisphere, while the global feature tended to be responded to more quickly by the right hemisphere. Hellige et al. (1984) examined the effects of stimulus duration, retinal eccentricity and visual noise on the processing of human faces. They discovered that the LH was more efficient when the task required the detection of a specific feature, but the RH was superior when the global attributes of the entire stimulus had to be detected. Versace and Tiberghien (1988) also found that the error rate was lower in the right visual field when local elements had to be discriminated and in the left visual field when the elements were global. This finding was maintained for verbal as well as nonverbal stimuli.

Sergent (1982a) employed hierarchical visual stimuli in a divided-attention task, and observed that the global letters composed of low spatial frequency were processed better by the RH, and the local letters composed of high spatial frequency by the LH. These results were interpreted as revealing a differential sensitivity of the cerebral hemispheres to a particular range of spatial frequency contained in the visual image. Jonsson and Hellige (1986) supported this spatial
frequency model and indicated that the decrease of spatial frequency reduced the performance of LH in relation to RH. Michimata and Hellige (1987) obtained the same data when they repeated this study with nonverbal stimuli, but in another experiment in which they manipulated the size of the visual image, the results did not completely support this hypothesis and the authors pointed out the importance of the judgements demanded by the task for hemispheric differentiation. Other investigators also failed to replicate the findings of Martin (1979b) and Sergent (1982a) (e.g., Alivisatos and Wilding 1982; Boles 1984; Polich and Aguilar 1990; and Arnau et al. 1992).

Polich and Aguilar (1990), as Jonsson and Hellige (1986) and Michimata and Hellige (1987), also assessed the possible contribution of spatial frequency through modification of stimulus size and the influence of the number of local elements which composed the global figure. They constructed square (size: 0.63° and 1.26°) and rectangular (size: 0.32° × 1.26° and 0.63° × 2.37°) stimulus items made up of smaller squares and rectangles and subjects were instructed to identify either the global or local aspect. The results did not support either the local/global or the stimulus spatial frequency theory, since consistent hemispheric differences were not found when the stimulus size or number of elements were varied. However, Kimchi and Merhav (1991) replicated this study but incremented the number of local elements both for few-element patterns and for many-element patterns. They found an LH advantage in the detection of local form and an RH advantage in that of global form, but this was only true for the task which required focused attention.

Alivisatos and Wilding (1982) presented stimuli similar to those of Sergent (1982a) for 100 msec, the subjects being instructed to match the visual pattern either locally or globally. Evidence was not obtained to support the analytic/holistic dichotomy in relation to the hemispheric functional specialization. Nor did Boles (1984), using the letter identification local/global judgement task, find differences between the cerebral hemispheres in the analysis of the global and local features. Van Kleeck (1989) also failed to find any hemifield difference when the subjects were required to classify the stimuli. Nevertheless, he realized a meta-analysis integrating the results of various studies of the theme, and came to the conclusion that both hemispheres carry out global processing much more efficiently than local processing, although the LH analyzed the local information better
than the RH, while the RH was more proficient in the analysis of global information.

Finally, Arnau et al. (1992) in a divided-attention task found that both hemispheres were faster in the analysis of global information than local. The same results were produced with visuospatial stimuli consisting of a meaningless configuration composed of other meaningless configurations. The explanation of these authors was based on the presence of certain stimulus characteristics which might facilitate the extraction of global information, such as the size and number of local elements. In effect, the dimension of visual form appears to determine which processing strategy will be used. Stimuli smaller than 6° are more easily recognized in terms of global processing, whereas this does not happen with stimuli bigger than 6° (Antes and Mann 1984; Arnau et al. in press-a; Kinchla and Wolfe 1979). It is also known that stimuli made up of many local elements (7 × 6) are more easily recognized on the basis of global features (Arnau et al. in press-b; Martin 1979a; Kimchi 198X). In the above study, the stimuli subtended 5° and were composed of a 7 × 6 elements matrix. Both characteristics are optimum for the adoption of a holistic strategy in processing.

The purpose of this study is to find out whether or not the stimulus characteristics can determine the functional dichotomy of the cerebral hemispheres. We have used verbal stimuli similar to those of Arnau et al. (1992) but manipulated their size. This manipulation is known to affect the relative speed of response to local or global level information. Some investigators have suggested that the two hemispheres are equally capable of processing global and local information. If this is true, then the stimulus size should exercise an identical influence on the two visual fields. That is to say, if the stimulus size favours the employment of a global strategy, the two hemispheres will analyze the global information better, whereas if the stimulus size favours the employment of a local strategy, the two hemispheres will analyze the local information better than the global. On the other hand, in accordance with the holistic/analytic dichotomy, if the LH is specialized for local processing, it should respond more quickly and accurately than the RH when the target is in the local level in all conditions of the stimulus size. Conversely, if the RH is specialized for global processing, it should respond faster and more precisely than the LH when the target is in the global level in all conditions of the stimulus size.
Experiment 1

Method

Subjects

A total of 19 right-handed undergraduates, volunteers from the University of Málaga, participated in the experiment (12 females and 7 males). They ranged in age from 19 to 25 years (M = 21.5, SD = 1.57). All subjects had normal or corrected-to-normal vision.

Stimuli and apparatus

Stimulus presentation was controlled by a 610 Lafayette model tachistoscope, which was connected to a 54045 Lafayette digital chronometer in order to measure the reaction times (RT). The visual field was white, with a black dot in its center as the fixation point. The stimulus display was viewed from a distance of 60 cm. The stimuli were large letters (global level) made up of small letters (local level) organized in a matrix of 7 × 6 local elements, presented either in the right visual field (RVF-LH) or left visual field (LVF-RH). Two sizes of stimuli were employed: large and small. The global letter of the large configuration measured 106 × 66 mm (10.01" × 6.28") and the local letters 10 × 6 mm (0.95" × 0.57"), the separation between two consecutive letters being 6 mm. The global pattern of the small stimulus was 35 × 22 mm (3.33" × 2.10") and the dimension of the local ones 3.3 × 2 mm (0.32" × 0.19"), with a distance of 2 mm between them. These stimuli were constructed of the letters H, T, U, L, E, K, and T was used as the target. Four groups of stimuli were formed: in the first, the target appeared at both global and local level, in such a way that the two levels were relevant (G+L+); in the second, the target only appeared at global level, the local level being nontarget (G+L-); in the third, only the local letter was relevant (G-L+); finally, in the fourth group the target letter did not appear at either global or local level (G-L-). In all conditions, the nonrelevant level had the same number of symmetrical letters (H, U) as nonsymmetrical letters (L, E, K).

A total of 128 stimuli were constructed, of which 32 were for practice purposes. For each of the four conditions of level of appearance of the target 24 stimuli were used. Of these 24, 12 were presented to the left visual field and 12 to the right visual field, 6 of each 12 being small stimuli and 6 large ones.

Design and procedure

All subjects participated individually in a single 20-minute session, in which after a brief introduction to the equipment they read the task instructions silently. These were reiterated by the experimenter and any questions were answered. The subjects were told that in each trial a small black dot would appear in the center of the tachistoscope. They were to fix their vision on the dot and await the stimulus presentation, which occurred randomly to the left or right of the visual field and with the inner edge at 2.19° from the fixation point.

Subsequently, 32 practice stimuli were presented, followed by 96 experimental trials. The subjects were instructed to respond as quickly as possible, 'yes', – by means
of pushing a red button with the index finger – if the target was identical to either the local or global letter presented, or ‘no’ – pressing a yellow button with the middle finger – if the target was not identical to any of the letters presented. Each trial began with the presentation of the fixation dot in the center of the visual field for 3000 msec. It was immediately followed by the stimulus which appeared for 100 msec in the left or right visual field, and the subject had to indicate whether or not it contained the target. In this moment, the experimenter pointed out the reaction time and response accuracy. Next, the fixation dot again appeared and the sequence was repeated for all trials. The stimuli were presented randomly for all subjects and half of the trials were answered with the right hand and half with the left hand.

A repeated measure design followed. The factors were: ‘target level’ with three levels – appearance at both global and local level (G+L+), at global level (G+L-), and at local level (G-L+), ‘stimulus size’ with two levels – small and large, and ‘visual field’ with two levels – left visual field and right visual field. The reaction time and response accuracy were registered. The negative responses (G-L-) were considered separately.

Results and Discussion

The mean RTs and accuracy rate are presented in table 1. Both variables were subjected separately to a repeated measure analysis of variance (ANOVA), with ‘target level’, ‘stimulus size’, and ‘visual field’. The data from the negative responses was subjected to an ANOVA with ‘stimulus size’ and ‘visual field’. Tukey post hoc procedure was applied, in order to determine which specific conditions differed.

Table 1
Latency mean (msec) and response accuracy percentages for target level, visual field and stimulus size factors obtained in experiment 1 (for affirmative responses).

<table>
<thead>
<tr>
<th>Visual field</th>
<th>Target level</th>
<th>G+L+</th>
<th>G+L-</th>
<th>G-L+</th>
</tr>
</thead>
<tbody>
<tr>
<td>LVF Small</td>
<td>RT</td>
<td>646</td>
<td>619</td>
<td>880</td>
</tr>
<tr>
<td></td>
<td>Accur.</td>
<td>99</td>
<td>96</td>
<td>30</td>
</tr>
<tr>
<td>LVF Large</td>
<td>RT</td>
<td>634</td>
<td>780</td>
<td>762</td>
</tr>
<tr>
<td></td>
<td>Accur.</td>
<td>97</td>
<td>84</td>
<td>87</td>
</tr>
<tr>
<td>RVF Small</td>
<td>RT</td>
<td>668</td>
<td>616</td>
<td>987</td>
</tr>
<tr>
<td></td>
<td>Accur.</td>
<td>95</td>
<td>96</td>
<td>30</td>
</tr>
<tr>
<td>RVF Large</td>
<td>RT</td>
<td>587</td>
<td>736</td>
<td>736</td>
</tr>
<tr>
<td></td>
<td>Accur.</td>
<td>99</td>
<td>89</td>
<td>88</td>
</tr>
</tbody>
</table>
In the analysis of the negative responses (G^-L^- condition), visual hemispheric differences were not found (for RT, $F(1, 18) = 0.47$, $p = 0.50$, and for correct responses, $F(1, 18) = 1.90$, $p = 0.18$). The RVF-LH as well as the LVF-RH had similar latencies (900 vs. 918 msec, respectively) and a similar ratio of correct responses (84% vs. 88%, respectively). The 'stimulus size' factor was only significant for accuracy rate ($F(1, 18) = 6.99$, $p = 0.02$), showing that the subjects make fewer errors when they analyze the 10° stimuli (93% vs. 79%).

With regard to the affirmative responses, neither 'stimulus size' nor 'visual field' was significant for the RT. However, the percentage of exact responses was significantly superior when the stimuli subtended 10° vertically (91% vs. 74%), with $F(1, 18) = 43.34$ and $p < 0.001$. The main effect of the 'target level' was significant for RT ($F(2, 36) = 57.18$, $p < 0.001$) and for accuracy ($F(2, 36) = 65.85$, $p < 0.001$). In accordance with previous investigations with visual hierarchical stimuli, global precedence was manifested in two senses. Firstly, the global information was more quickly analyzed than the local information (688 vs. 841, $p = 0.01$) and, secondly, there was a greater number of correct responses in the G^+L^- condition than in the G^-L+ condition (92% vs. 59%, $p = 0.01$). However, when both levels were target (G^+L+), the latency was the shortest and the major accuracy was found, the differences in the two dependent variables not being statistically significant between this condition and G^+L-, though it was with respect to G^-L+ (RT: 634 vs. 841, $p = 0.01$; accuracy: 97% vs. 59%, $p = 0.01$). These findings seem to support the idea of Navon (1977) that the visual system realizes a global processing and afterwards a local processing of the visual pattern, since the search of the target in G^+L+ may finish with the identification of the global letter. In any case, however, the interpretation of these data cannot be carried out without taking into account the influence of the 'stimulus size'.

Indeed, the interaction between 'target level' and 'stimulus size' was found in RT ($F(2, 36) = 15.02$, $p < 0.001$) as well as in response accuracy ($F(2, 36) = 61.28$, $p < 0.001$). As other investigators (Antes and Mann 1984; Arnau et al. in press-a; Kinchla and Wolfe 1979; and Lamb and Robertson 1989, 1990) have demonstrated, the effect of global precedence observed depends on the dimension of the stimuli (see fig. 1). If we compare the latencies in G^+L^- and in G^-L+, there was a mean advantage in the first condition for the small stimuli (618 vs. 934, $p = 0.01$), but this advantage disappeared for the large stimuli (758 vs. 749, $p > 0.05$). This demonstrates that the stimuli of about 10° tend to increase the difficulty of global processing, whereas the 3° stimuli tend to favour it. That is to say, the effect of global precedence is only shown in the small stimuli and not in the large ones. This finding may be explained on the basis of the 'grouping' notion (Pomerantz 1986). Small hierarchical stimuli may be grouped with more facility into whole configurations, their decomposition into isolated elements being more difficult, thus permitting a holistic analysis. On the other hand, the large hierarchical stimuli make the separation of their components possible, thus favouring local processing. If we consider the responses on the basis of stimulus size, it can be observed that in the small stimuli no significant differences exist between G^+L+ and G^-L- either in RT (657 vs. 618, $p > 0.05$) or accuracy rate (97% vs. 96%, $p > 0.05$), though they do exist between G^+L+ and G^-L+ (RT: 657 vs. 934, $p = 0.01$; correct responses: 97% vs. 30%, $p < 0.01$). This may show that in the G^+L+ condition the response is realized on the basis of the global features, which are
analyzed before the local ones. With respect to the large stimuli, significant differences are detected among G+L+, G+L- and G-L+ neither in RT (610, 758 and 749, respectively) nor in the percentage of correct responses (98%, 87%, 88%, respectively), which may suggest that both levels of information are analyzed and contribute in equal measure in the elaboration of the response. Therefore, the global level is not invariably processed prior to the local one in the temporal sequence, rather the global aspect as well as the local one may be available in the same period of time (Hoffman 1980; Miller 1981a, 1981b) and the subject pays attention to one or the other depending on the characteristics of the stimuli.

Against the analytic/holistic dichotomy, neither the interaction 'target level' x 'visual field' nor 'target level' x 'visual field' x 'stimulus size' was found. Both the RVF-LH and the LVF-RH obtained shorter RTs and a lower error rate in G+L+, followed by G+L- and G-L+, indicating that the two hemispheres are better in the analysis of global than of local information. In relation to stimulus size, the respective performances of the RVF-LF and the LVF-RH were again the same. When the target was in the global form, the two hemifields worked better with the 3' stimuli, but when the target was presented in the local pattern their achievement was greater with the 10' stimuli. However, the results do not support our hypothesis that the LH processes the local features more efficiently than the RH, and the RH processes the global ones more efficiently than the LH. Rather, the characteristics of the stimulus, such as size, seem to determine which processing strategy will be adopted by each cerebral hemisphere.

Experiment 2

Palmer (1985) suggested that some aspects of shape perception take place within a perceptual reference and emphasized the importance of the local and global axes of
symmetry. Departing from this assumption, we want to find out if the above results could be extended to the identification of a nonsymmetrical target. In the previous study the subjects were instructed to decide whether or not the character ‘T’ was in the stimulus presented. In this case, the subjects are told to identify the character ‘L’, and to decide whether or not the target is included in the stimulus, following the same experimental procedure as in experiment 1.

Method

Subjects
Nineteen right-handed undergraduate volunteers from the University of Málaga participated in the experiment (11 females and 8 males). They ranged in age from 18 to 25 years ($M = 20.9, SD = 1.03$). All subjects had normal or corrected-to-normal vision.

Stimuli and apparatus
The stimuli were constructed in the same way as for experiment 1, except that the target was the letter L. The nonrelevant level had the same number of symmetrical letters ($H, U, T$) as nonsymmetrical letters ($E, K$).

Design and procedure
The procedure and the experimental design were the same as in experiment 1. The factors of the repeated measure design were: ‘target level’ with three levels – appearance at both global and local level ($G+L+$), at global level ($G+L-$), and at local level ($G-L+$), ‘stimulus size’ with two levels – small and large, and ‘visual field’ with two levels – left visual field and right visual field. The reaction time and response accuracy were registered. The negative responses were considered separately.

Results and Discussion
Mean reaction time and correct response proportion for ‘target level’, ‘visual field’ and ‘stimulus size’ are shown in table 2. An ANOVA was performed on these variables and the Tukey post hoc procedure was applied in order to determine which specific conditions differed.

In the analysis of the negative responses ($G \ L$), only the ‘stimulus size’ factor was significant for latency ($F(1, 18 = 5.78, \ p = 0.03$). The 10° stimuli tended to produce shorter RTs than the 3° stimuli, indicating that the subjects were better at processing the large stimuli.

In relation to the analysis of affirmative responses, the ‘stimulus size’ was marginally significant for accuracy ($F(1, 18 = 4.22, \ p = 0.054$). The correct responses were most frequently found with the 10° stimuli (87% vs. 79%). Consistent with the previous findings, the ‘target level’ was statistically significant (RT: $F(2, 36) = 24.85, \ p < 0.001$; accuracy rate: $F(2, 36) = 11.75, \ p < 0.001$). Again, global precedence was detected, the visual analysis in the $G^+L^-$ condition being faster than in $G^-L^+$ ($705 \text{ vs. } 811, \ p = 0.05$). However, in this case global precedence is also closely connected with the
Table 2
Latency mean (ms.ec) and response accuracy percentages for target level, visual field and stimulus size factors obtained in experiment 2 (for affirmative responses).

<table>
<thead>
<tr>
<th>Visual field</th>
<th>Target level</th>
<th>G+ L+</th>
<th>G+ L-</th>
<th>G- L+</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>692</td>
<td>709</td>
<td>875</td>
</tr>
<tr>
<td></td>
<td>RT</td>
<td>640</td>
<td>764</td>
<td>770</td>
</tr>
<tr>
<td></td>
<td>Accur.</td>
<td>624</td>
<td>635</td>
<td>878</td>
</tr>
<tr>
<td>LVF Small</td>
<td></td>
<td>96</td>
<td>91</td>
<td>58</td>
</tr>
<tr>
<td>LVF Large</td>
<td></td>
<td>582</td>
<td>711</td>
<td>722</td>
</tr>
<tr>
<td>RVF Small</td>
<td></td>
<td>99</td>
<td>76</td>
<td>91</td>
</tr>
<tr>
<td>RVF Large</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

stimulus dimension, as is shown by the interaction ‘target level’ x ‘stimulus size’ in RT (F(2, 36) = 6.55, p = 0.003) and in correct response rate (F(2, 36) = 25.40, p < 0.001). Global precedence only appeared for the small stimuli, since the target was more rapidly and more precisely identified in the G+ L+ condition than in G- L+ (RT: 672 vs. 876, p = 0.01; accuracy rate: 94% vs. 52%, p = 0.01). If we consider the large stimuli, we can observe similar latencies in G+ L- and G- L+ (738 vs. 747, p > 0.05) and a similar number of correct responses (72% vs. 89%, p > 0.05), meaning that global precedence has not been found either in RT or response accuracy. As in experiment 1, differences can be detected in the small stimuli between G+ L+ and G- L+ (RT: 658 vs. 876, p = 0.01; accurate: 92% vs. 52%, p = 0.01), but not between G+ L+ and G+ L- (RT: 658 vs. 672, p > 0.05; accurate: 92% vs. 94%, p > 0.05). In the large stimuli, there are similar latencies among the three conditions in RT, although there is a different proportion of correct responses between G+ L+ and G+ L- (98% vs. 72%, p = 0.05). These results support the findings of the previous experiment and reinforce the idea that with a small hierarchical pattern the global aspect is the information level that contributes more in the elaboration of the response, while with the large stimuli both levels interact to provide information in equal measure.

The effect of ‘visual field’ was significant only for latency (F(1, 18) = 9.66, p = 0.006), the right visual field being quicker than the left visual field (692 vs. 742) in the detection of the target. Nonetheless, in this experiment, unlike the preceding study, the interaction ‘target level’ x ‘size stimulus’ x ‘visual field’ was found for the precision of response (F(2, 36) = 3.42, p = 0.04) (see fig. 2), though this interaction demonstrated a similar performance in both hemifields. With regard to the G+ L-
condition, the LVF-RH analyzed the 3° stimuli better than the 10° (p = 0.01) and the
same happened with the RVF-LV (p = 0.05). If we compare the rate of correct
responses between the two hemispheres, there are no significant differences either in
the small or large patterns. That is to say, both process the visual stimuli with the
same accuracy when the target appears at the global level. With respect to the G-L+
condition, the RVF-LH was more accurate in the analysis of large stimuli (p = 0.01)
the same as the LVF-RH (p = 0.01). Nor, in this case, were significant differences
found between them. Thus, both hemispheres carry out either global or local process-
ing depending on which of the two is favoured by the stimuli, and not according to the
shape of the target. These findings reveal the importance of the stimulus characteris-
tics in the analysis of the visual pattern by the cerebral hemispheres and suggest that
the two hemifields can adopt a global as well as a local strategy in visual processing.

**General discussion and conclusion**

In the two experiments carried out it was observed that the visual
angle of the stimulus is an important factor in visual information
processing. The large stimuli (10.01° × 6.28°) were analyzed better
than the small stimuli (3.33° × 2.10°) in negative as well as in affirma-
tive responses. This may suggest that the visual system favours the
processing of stimuli of a specific size (Kinchla and Wolfe 1979).
However, this result is not consistent with other studies. For example,
Lamb and Robertson (1990) found that the optimal size was around 6°
when the stimulus set they displayed to subjects ranged in size from 3°
and 12°. Arnau et al. (in press-a) also discovered that the more
accurate and faster responses were in the visual pattern which subtended 5.04° vertically, while differences were not found between the stimuli whose dimensions were 3.33° and 10.01°, pointing out that the figures which were too big or too small impaired the visual processing. Therefore, supporting the hypothesis of Lamb and Robertson (1990), the results obtained here may suggest that the optimal size is a function of the context. That is to say, it depends on the set of visual angle experienced by the subject. However, in this case, it is also possible that the advantage obtained with large stimuli may be explained on the basis of the relative accessibility of the global and local levels, as we will now see.

In accordance with other investigations (Antes and Mann 1984; Arnau et al. in press-a; Kinchla and Wolfe 1979; Lamb and Robertson 1989, 1990), the present findings confirm the importance of stimulus characteristics in the analysis of global and local information. Comparing the G+L+, G+L− and G−L+ conditions in the different size of the stimuli, it can be concluded that the global aspect is not always analyzed prior to the local, rather that this depends on the characteristics of the stimuli. In the two experiments realized, global precedence was observed in the stimuli which subtended about 3° vertically, but not in the 10°. It is probable that this relationship may be controlled by the grouping or nongrouping of the parts into whole forms. Small hierarchical stimuli can be organized into whole figures more easily than large ones, allowing the employment of global processing. Large hierarchical stimuli favour the separation of their elements, permitting the analysis of the local letters. But why do the small stimuli favour their grouping into whole forms? We think that it is a function of the relative qualities of the global and local levels. In the small size, the reduction of the visibility of the local letters is greater than that of the global letters and, consequently, it is logical that the time employed in their recognition was longer. On the other hand, in the large size, the visibility of the local level is enhanced, whilst the quality of the global level diminishes because its exterior edge is seen with greater eccentricity than in the small stimuli. Thus, the grouping of the 3° stimuli is facilitated by the limited visibility of the local letters, the global level being that which offers more information in the transmission of the response. It is also possible to decompose the hierarchical pattern into isolated elements when their size is bigger, permitting the analysis of local features. In any case, this is a
possible hypothesis that must be tested. A possible way of doing this might be by means of including a set of stimuli in which simple letters are as big as local letters and by comparing the performance of the subjects while the eccentricity is controlled in the center, inner or exterior edge of the stimulus. It is also important to find out the size limit within which a visual pattern is recognized with relative speed and accuracy. In conclusion, we think that the different levels of structure of a visual form become available in the same period of time and the possibility of grouping will determine whether the subjects direct their attention to the global or local level, selecting their response on the basis of one or both of them.

The major purpose of this work was to include stimuli in such a way that both analytic and holistic processing were possible, in order to test whether or not the hemispheres adopted one processing strategy or the other. According to the analytic/holistic dichotomy, if the LH is specialized for local processing, it is expected to respond more quickly and with fewer errors when the target appears at the local level, while if the RH is specialized for global processing, it is expected to respond faster when the target appears at the global level. Nevertheless, experiment 1 provided evidence against this hypothesis. The subjects were instructed to detect a vertically symmetrical target (T), but no indication was obtained that each hemisphere is specialized in a particular processing mode. The RVF-LH as well as the LVF-RH presented shorter RTs and a lower error rate when the target appeared in the global letter, indicating that both carry out global processing much more efficiently than local processing. Likewise, the influence of the stimulus size was the same for the two hemispheres. When the target was in the global form, they analyzed the 3° stimuli more efficiently, but when the target was in the local pattern both visual fields offered a more efficient analysis of the 10° stimuli. This provides evidence that the two cerebral hemispheres can adopt a global or local strategy, and that this strategy may be determined by the perceptual factors inherent in the stimuli used.

In the second experiment, a non-symmetrical target (L) was included with the intention of finding out if the symmetry of the letter to be detected had any influence on the hemispheric specialization in visual processing. The principal effect of visual field was significant, demonstrating that the RVF-LH was quicker than the LVF-RH. The explanation of this fact cannot be based on the verbal–nonverbal
dychotomy, because if this were true the superiority of the RVF-LH would have been found when the target 'L' was included. Neither can the explanation be based on the differential capacity for feature detection of a visual pattern (straight or curved) as Polich et al. (1986) suggested. These authors found that the LH produced a superior performance for the detection of the straight stimuli (T) and the RH in the curved stimuli (O). But in this case, both types of target had a straight pattern and the superiority of LH should have been found in the two experiments. However, only the target 'L' demonstrated a more rapid processing with RVF-LH presentations. It is possible, therefore, that the nonsymmetry of the letter to be detected may provoke a better performance of the LH, indicating that the symmetry of the visual form is an important factor in determining hemispheric differences. However, there is not sufficient evidence to confirm this idea and we should await further research for understanding such functional differences.

On the other hand, as in the first experiment, the two hemispheres were more precise in the global analysis for stimuli which subtend 3°, and more precise in the local analysis for stimuli which subtend 10°. If the achievement of the two hemifields is compared, it can be appreciated that the RVF-LH had the same performance as the LVF-RH in the analysis of the local and global information. The fact of not finding hemispheric differences when the target was 'L' may suggest that the symmetry of the target is not a factor that influences the detection of different levels of a visual form by the cerebral hemispheres.

These findings corroborate previous investigations which have not obtained hemispheric differences for local and global processing with letter stimuli (Alivisatos and Wilding 1982; Arnau et al. 1992), and do not support the studies in which differences were found (Sergent 1982a). However, there exists an important difference among these experiments. In effect, Alivisatos and Wilding (1982) displayed the stimuli between 2.20° and 3.3° from the fixation point, and Arnau et al. (1992), at 2.5°, while Sergent (1982a) included an eccentricity of 1.40. Thus, it is possible that there exists an optimal eccentricity, around 1° from the fixation point, in which the differences between the two hemispheres is maximum. For example, although it was with visuospatial stimuli, Hellige et al. (1984) demonstrated hemifield differences in the stimuli presented at 1°, whereas these were not found
in stimuli at 4° and 9° presented to the left or right of the fixation point. Thus, it is necessary to repeat these investigations manipulating the retinal eccentricity with the aim of finding out how this factor affects visual processing of the local and global features in order to detect hemispheric differences. In any case, the results of both experiments taken together show that the two hemispheres carry out global processing with more effectiveness than local processing, depending on the perceptual factors inherent in the stimuli, such as the visual angle that they subtend, and confirm the importance of organization of the stimuli with respect to the adoption of a global or local strategy, emphasizing the need to control the physical attributes of the stimuli in the investigation of hemispheric specialization.

References


