Perception & Psychophysics
2001, 63 (3), 458-463

Asymmetries for Familiar Stimuli and Learned Features

The effect of familiarity on visual-search performance: Evidence for learned basic features

PETER MALINOWSKI and RONALD HÜBNER
Universität Konstanz, Konstanz, Germany

In this study, the effects of familiarity on visual search were investigated. To avoid any confounding between familiarity and visual-feature differences between item pairs, *N*s and mirror-*N*s were presented as target and as distractors to a group of German participants and to a group of Slavic participants. For the Germans only *N* was familiar, whereas for the Slavs both *N* and mirror-*N* were familiar. The results show that search was difficult only when the Germans had to find an *N* among mirror-*N*s. In any other case, search was efficient. Therefore, our results demonstrate that, contrary to earlier suggestions, search for a familiar item among familiar distractors can be easy. This supports the hypothesis that familiarity improves distractor grouping. However, the data are also compatible with the idea that letters are standard or basic features, which implies that basic features can be learned.

It is widely acknowledged that some stimulus features are basic for the human visual system—that is, that they can be processed preattentively and in parallel across the visual field. A frequently applied paradigm for investigating such features is visual search (for a recent overview, see Wolfe, 1998). In corresponding experiments, the participants have to search for a target item among a variable number of distractor items. When the search time for a target is largely independent of the number of distractors, it is concluded that the target differs from the distractors by a unique basic feature. Accordingly, when the search time increases with the number of distractors, it follows that the target item does not have a unique basic feature. Thus, by presenting certain stimuli and inspecting the slopes of the resulting visual-search functions—that is, functions relating search time to the number of distractors—basic features can be determined.

Particularly informative in this respect are *search asymmetries*. For example, a magenta target among red distractors is easier to detect than a red target among magenta distractors. Therefore, it can be reasoned that red items have the feature *red*, whereas magenta contains the features *red* and *blue*. Thus, when a magenta item is the target, it possesses a unique feature such that search is quite effective. On the other hand, a red target does not contain a unique feature that distinguishes it from magenta distractors. Consequently, search is less efficient. One way to interpret this result is to conclude that *blue* is a basic feature (Wolfe, 1998). However, it could also be concluded that *red* items represent a standard or prototype and that magenta items are deviations from that standard. According to this interpretation, deviants among standards are easier to detect than vice versa (e.g., Treisman, 1991; Treisman & Gormican, 1988).

Meanwhile, a number of basic features have been discovered. In his review, Wolfe (1998) lists 8–10 candidates that are accepted, with more or less consensus, as basic features. Examples are orientation, color, and motion. Whereas these features are physical, an important and still unresolved question is to what extent more abstract stimulus properties can act as basic or standard features. An interesting and intensively investigated candidate is *familiarity*. How does the participant's experience with an item affect visual processing? A closely related question is whether basic features can be learned. Unfortunately, the results with respect to these questions are inconclusive. For instance, Treisman, Vieira, and Hayes (1992) had participants learn new arbitrary patterns through extensive practice on a search task. When the new features had become basic through the training, this also should have led to better performance in other tasks with the same patterns. Indeed, the slopes of the search functions decreased with training. However, despite this learning effect, there was no transfer in subsequent tasks. Therefore, Treisman et al. concluded that learning was only task specific. On the other hand, however, Wang and Cavanagh (1993) used Chinese characters as material and found some transfer.

Another line of research has used letters and their inverted counterparts as items and has investigated search asymmetries. In most cases, it turned out that search was more efficient for inverted letters among upright letters than vice versa (Frith, 1974; Reicher, Snyder, & Richards, 1976; Richards & Reicher, 1978). In a recent paper, Wang,

This research was supported by Research Grant Hu 432/6-1 from the Deutsche Forschungsgemeinschaft (DFG) to the second author. Correspondence concerning this article should be addressed to P. Malinowski, Cognitive Neuroscience and Neuropsychology, Department of Psychology, University of Liverpool, Eleanor Rathbone Building, Liverpool L69 72A, England (e-mail: petermal@liverpool.ac.uk).

Cavanagh, and Green (1994) tried to minimize perceptual differences between target and distractors by using specific letters and their mirror images. For example, *N* and *Z* differ from their mirror images only in the orientation of the oblique line. Nevertheless, even with these stimuli, search asymmetries were found. Search was more efficient for a mirror letter among regular letters than vice versa (1.5 vs. 46 msec/item). That is, an unfamiliar target popped out between familiar distractors, whereas a familiar target between unfamiliar distractors did not. Wang et al. concluded from this result that familiarity can be regarded as a basic feature.

How does familiarity affect visual search? Specifically, how does it produce search asymmetries? Wang et al. (1994) compared two possible accounts. It has been stated that familiar distractors or background items group better than novel items (Karni & Sagi, 1991) and that better grouping leads to better target detection (Treisman, 1982, 1993). As an alternative account, Wang et al. proposed that novel items elicit more activation and, consequently, attract more attention. Thus, when novel items serve as distractors, search is slower, since they have to be processed first. By examining their data, Wang et al. came to the conclusion that the first account cannot explain their results. Rather than merely contrasting familiar targets with novel distractors and vice versa, they also included a condition with 5 and 2 as items and assumed that both forms were equally familiar. In the case of distractor grouping, search should be efficient in either case. However, it turned out that search time increased considerably with set size (31 msec/item) for both target–distractor combinations. Therefore, Wang et al. concluded that with equally familiar items, attention has to be voluntarily directed to each item in turn.

However, this conclusion can be questioned, because it is based on a comparison between different stimuli—that is, the variation of familiarity relations between the different pairs of items was confounded with a variation of the stimuli. Therefore, it cannot be ruled out that stimulus differences are responsible for the observed effect. One candidate is the similarity between 5 and 2, which might be greater than that between the other letters and their mirror images. For instance, between *N* or *Z* and their respective mirror images there is an orientation difference that is absent between 5 and 2. In the latter case, there is merely a difference in the relative position of the vertical lines. Given that this leads to a large target–distractor similarity, it could explain why search is difficult with these items (see Duncan & Humphreys, 1989, 1992).

To exclude the interpretation that visual factors are responsible for the observed differences in the Wang et al. (1994) study, it would be necessary to use the same stimuli and to vary familiarity. This approach has been realized in our study. We presented the same stimuli to two groups of observers who differed with respect to their experience with this material. One group consisted of German students, and the other group consisted of students from Slavic countries. They all had to search for *N*s among mirror-*N*s, and vice versa. The participants in the two groups were differently familiar with these items. Whereas *N* is a letter in the Latin alphabet, the mirror image of *N* is a letter in the Cyrillic alphabet, which is used in several Slavic languages. Thus, for the German group we had a novel target among familiar distractors (mirror-*N* among *N*s), and vice versa (*N* among mirror-*N*s). For this group, the same search asymmetry was expected as that in the Wang et al. study. On the other hand, for the Slavic participants, both target–distractor combinations should have a familiar target among familiar distractors, because they had experience with both the Latin *and* the Cyrillic alphabet.

If Wang et al.'s (1994) interpretation is correct, for the Slavic group, the search functions should be steep irrespective of the target–distractor combination. For the German group, only searching an *N* among mirror-*N*s should produce steep search functions. On the other hand, when an increased distractor grouping is responsible for the familiarity effect, the slopes for conditions with familiar distractors should not differ between the German and the Slavic groups.

A further question addressed with the present experiments was the effect of the spatial arrangement of the items on absent-responses. Humphreys, Quinlan, and Riddoch (1989) showed, with *T*s as distractors and an inverted *T* as a target, that absent-responses can be faster than present-responses when the items are arranged in a regular manner—for instance, on an imaginary circle. On the other hand, Wang et al. (1994) also used such an arrangement but did not find a consistent absent-advantage. To explain this discrepancy, Hübner and Malinowski (2001) suggested that an absent-advantage occurs only when regular and irregular item patterns are mixed. In this case, the decision criteria might be adjusted in such a way that fast absent-responses result for regular patterns. By also using *T*s as items, Hübner and Malinowski could show that this is indeed the case. When regular and irregular item patterns were blocked, no absent-advantage was observed. However, when both arrangement types were mixed within a block of trials, there was an absent-advantage for regular patterns. To show that the hypothesis holds also with items other than *T*s, regular and irregular displays also were mixed in the present experiment.

METHOD

Participants

Two groups of participants, matched for gender and approximately for age, took part in the experiment after giving informed consent. The first group consisted of 8 German students (4 male, 4 female), who ranged in age from 19 to 24 years (mean, 22.3 years). They had no experience with the Cyrillic alphabet. The second group consisted of 1 Ukrainian and 7 Bulgarian students (4 male, 4 female). Their ages ranged from 18 to 27 years (mean, 21.8 years). All the members of this Slavic group reported that they came to Germany only recently for the purpose of studying. They became accustomed with the Latin alphabet between their 8th and 14th years (mean, 10.6 years). All the participants reported normal or corrected-to-normal vision.

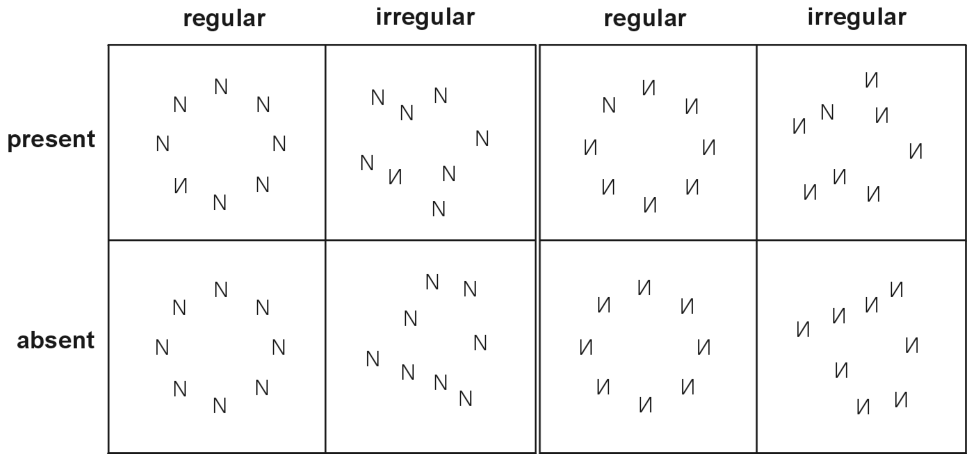

Figure 1. Stimulus examples. The two left columns show stimuli with *N*s as distractors, whereas the two columns on the right show stimuli with mirror-*N*s as distractors.

Stimuli

The elements were *N*s and their mirror images. The stimuli were white and appeared on a black background. Depending on the condition, *N*s or mirror-*N*s served as the target or the distractors, respectively. Three set sizes of 6, 8, and 10 elements were used. In the regular conditions, the elements were arranged with equal spacing on the circumference of an imaginary circle. In the irregular condition, each element was jittered randomly around the position it would have had in a regular pattern. See Figure 1 for stimulus examples.

Procedure

Each trial started with a fixation cross that was presented centrally on the screen for 300 msec. Immediately afterward, the stimulus display appeared and remained present until a response was given. After the response, a blank interval of 1,000 msec was inserted before the next trial began. Errors were signaled by a tone. The participants responded with the index and middle fingers of their right hands for target-present and target-absent judgments, respectively, where the response-to-finger mapping was balanced across participants. For each group, there were 24 conditions (distractor-*N*/distractor-mirror-*N* × target-present /target-absent × regular/irregular pattern × 3 set sizes) with 72 trials each. They were run in two 1-h sessions. Half of the participants of each group started with the *N*s as distractors in their first session and the mirror-*N*s in the second session; for the other half, this order was reversed. In each session, there were nine blocks of 96 trials, with 4 additional warm-up trials at the beginning of each block. Each condition (except distractor type, which was blocked) occurred eight times in each block in random order. At the beginning of each session, a training block was administered.

RESULTS

Response Times

Because the variance of the response times increased systematically with their means, the data were logarithmically transformed for each participant before they were entered (correct responses only) into an analysis of variance (ANOVA). Target presence (present, absent), regularity (regular, irregular), and distractor type (*N*, mirror-*N*) were within-subjects factors, whereas group (German, Slavic) was a between-subjects factor. Set size was not included as a factor in this first analysis, because the slopes of the search functions were analyzed separately (see below). The mean latencies are displayed in Figure 2.

The analysis revealed a significant effect of regularity [$F(1,14) = 76.54$, $p < .001$]. Responses to regular patterns were faster than those to irregular ones (719 and 751 msec, respectively). Also, distractor type had a significant effect [$F(1,14) = 20.00$, $p < .005$]. The search time for a mirror-*N* among *N*s was faster than vice versa (614 vs. 855 msec). However, the significant interaction between group and distractor type [$F(1,14) = 27.55$, $p < .001$] shows that this holds mainly for the German group (*N*, 542 msec; mirror-*N*, 1,049 msec; Slavic group: *N*, 686 msec; mirror-*N*, 661 msec).

Furthermore, the presence factor interacted significantly with group [$F(1,14) = 6.81$, $p < .05$] and with distractor type [$F(1,14) = 22.76$, $p < .001$]. However, there was also a significant three-way interaction between group, distractor type, and presence [$F(1,14) = 22.18$, $p < .001$]. This interaction reflects the fact that there were extremely slow absent-responses for the German group when mirror-*N*s served as distractors (see Figure 2). Finally, there was a reliable interaction between regularity and presence [$F(1,14) = 12.96$, $p < .005$]. Absent-responses to irregular patterns were more slowed down (present, 714 msec; absent, 788 msec) than absent-responses on regular trials (present, 701 msec; absent, 737 msec). Inspecting the relation of absent- and present-responses to regular patterns in more detail, it becomes obvious that, in all conditions in which the distractors were familiar, an absent-advantage occurred. With *N* as distractor in the German group, absent-responses (523 msec) were 21 msec faster than present-responses (544 msec). In the Slavic group, there was an absent-advantage of 28 msec with *N* as distractor (present, 681 msec; absent, 653 msec), and of 22 msec with mirror-*N* as distractor (present, 656 msec; absent, 634 msec). On the other hand, absent-responses were much slower than present-

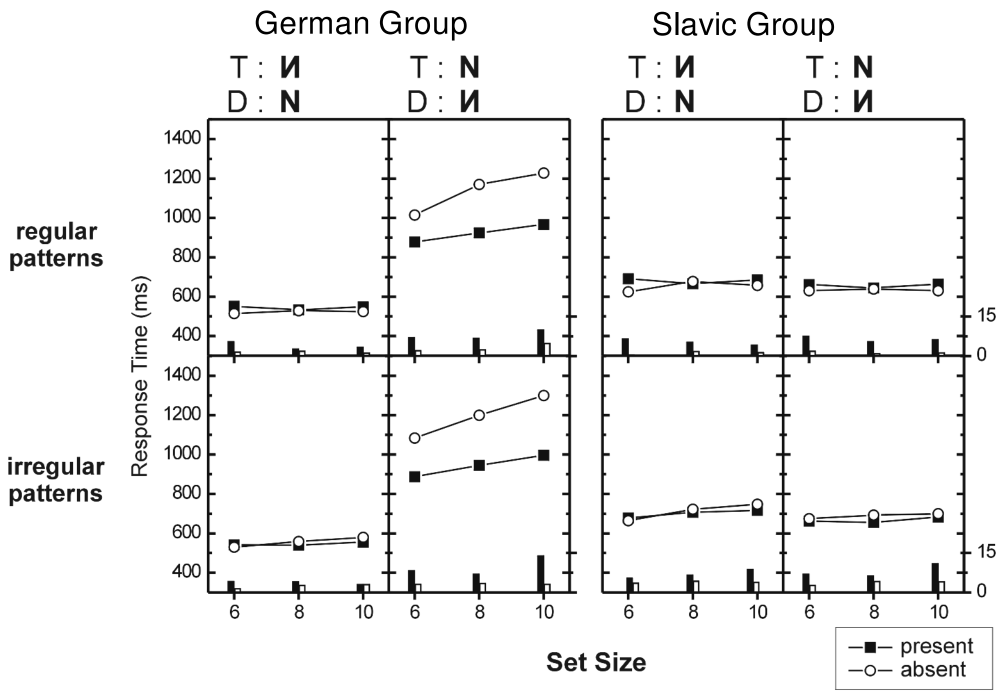

Figure 2. Mean response times and error rates. The target (T) and the respective distractor type (D) are indicated at the top of each column. The black bars represent misses, and the white ones false alarms.

responses (present, 923 msec; absent, 1,137 msec) when the distractors were unfamiliar (mirror-*N*, German group).

Search-Function Slopes

The effects of familiarity were analyzed by examining the slopes of the search functions. For compatibility with the data of Wang et al. (1994), only the data corresponding to the regular stimulus arrangements were included in the analysis. After calculating the individual slopes by means of linear regression, they were subjected to an ANOVA, with target presence (present, absent) and distractor type (*N*, mirror-*N*) as within-subjects factors and group (German, Slavic) as a between-subjects factor. The mean slopes are given in Table 1.

The analysis revealed significant main effects of group [$F(1,14) = 8.04$, $p < .05$] and distractor type [$F(1,14) = 7.82$, $p < .05$] factors. However, there was an interaction between these factors [$F(1,14) = 11.04$, $p < .01$], which reflects the fact that slopes for the German group with mirror-*N*s as distractors were much larger (37.73 msec/item) than those for the Slavic group (3.47 and 0.31 msec/item for *N* and mirror-*N* distractors, respectively) and those with *N*s as distractors for the German group (1.05 msec/item). Also, the slopes for present-trials were significantly smaller than those for absent-trials [$F(1,14) = 17.05$, $p < .005$]. However, there was a significant interaction between presence and group. This interaction shows that slopes were similarly small for present- and absent-trials in the Slavic group (−0.36 vs. 4.14 msec/item), whereas they were larger and different in the German group (10.88 msec/item vs. 27.90 msec/item). Finally, the three-way interaction between group, distractor type, and presence also was significant [$F(1,14) = 11.04$, $p < .005$]. Obviously, this is due to the diverse present–absent differences across the individual conditions.

Error Rates

The mean error rate was 4.65%. Since the two groups produced similar error rates (German, 4.56%; Slavic, 4.75%) and since no speed–accuracy tradeoff was visible, they were not further analyzed. However, they were included as bars in Figure 2.

DISCUSSION

The aim of this experiment was to investigate the effects of familiarity on visual search performance. Since in former studies familiarity was often confounded with visual-feature differences between the stimuli (e.g., Wang et al., 1994), here, the same stimuli were presented to two groups of participants who differed in their experience with the items. Specifically, *N*s and mirror-*N*s were presented to a group of German participants and to a group of Slavic participants. Each form served as target and as distractor in corresponding conditions. Whereas for the German group only the *N*s were familiar, both *N*s and mirror-*N*s were familiar for the Slavic group. Thus, irrespective of which form served as the target, the distractors as well as the target were familiar for the Slavic

Table 1
Slopes (in Milliseconds/Item) of the Search Functions for Regular Stimulus Patterns

	German Group		Slavic Group	
Distractors	*N*	Mirror-*N*	*N*	Mirror-*N*
Present	−0.6	22.3	−1.2	0.5
Absent	2.7	53.1	8.2	0.1

group. On the other hand, for the German group, depending on the target item, either the target was familiar and the distractors were novel, or vice versa.

Our results show that search was efficient in all the conditions except when the target was familiar and the distractors were novel. That is, the German participants found it difficult to search for an *N* among mirror-*N*s, whereas the Slavic group produced flat search functions with both target/distractor combinations. The latter result is at odds with the conclusion of Wang et al. (1994) that familiar targets among familiar distractors are difficult to find. However, as was mentioned in the introduction, they varied familiarity by presenting different item pairs. They found search to be more effective for a mirror-*Z* and a mirror-*N* among *Z*s and *N*s, respectively, than when the target and distractor roles were exchanged. This indicates that it is easier to detect novel items among familiar distractors than vice versa. To examine what would happen when participants had to search familiar targets among familiar distractors, they used 5 and 2 as items, both of which were assumed to be familiar. Because they found steep slopes for both target/distractor combinations with these items, Wang et al. concluded that it is difficult to detect a familiar item among familiar distractors. However, a critical aspect of the Wang et al. study is that the variation of familiarity was confounded with a variation of visual features. Therefore, these differences might also account for the observed effects. That this was indeed the case is suggested by our data. By using the same items as in the other conditions, we found efficient search also for familiar targets among familiar distractors.

Because Wang et al. (1994) interpreted their data to mean that familiar targets are difficult to find among familiar distractors, they rejected the hypothesis that the effect of familiarity is due to a superior grouping of familiar distractors. Rather, they proposed that novel items elicit more activation than do familiar ones and, therefore, attract more attention. When both target and distractors are familiar, there are no activation differences, and attentional search has to proceed in a serial manner. Our results indicate the opposite. Although they contradict the hypothesis that familiar targets and distractors produce the same activation, they are compatible with the idea that familiar distractors show superior grouping, as compared with novel ones, and that this improves search performance (a possible specific mechanism can be found in Wolfe, 1994).

However, our results are also compatible with the hypothesis that letters are standard features or prototypes (e.g., Treisman, 1991; Treisman & Gormican, 1988). For the German participants, *N* is a standard feature, whereas a mirror-*N* is a deviant from that standard. Therefore, it is easier for them to find a mirror-*N* among *N*s than vice versa. On the other hand, the Slavic participants code each form as a different unique standard feature, which leads to efficient search in either case.

In his review, Wolfe (1998) pointed out that flat search functions are not sufficient for determining basic features, because various studies have found slopes near zero even when the items were defined by a conjunction of features. He suggested that two conditions must hold before it can be concluded that a basic feature is involved: A stimulus must lead to flat search functions *and* to effortless texture segmentation. Interestingly, Meinecke and Steininger (2000) have provided evidence that these criteria are fulfilled for our items. They found that texture segmentation was more efficient when the background items were *N*s and the foreground items mirror-*N*s than vice versa. As in our experiment, this asymmetry was absent for a group of Slavic participants, who were familiar with both forms. Thus, together, these results support the hypothesis that letters are basic features. Moreover, they imply that basic features can be learned. If such learning can take place, letters probably belong to the most prominent candidates, at least in our culture. Presumably, no other specific patterns of feature conjunctions are used as often and in as many different situations as letters. And no other conjunction of a few simple features carries as much information as they do.

Why, then, was search not effective for the 5 and 2 used by Wang et al. (1994)? As has already been mentioned, the target–distractor similarity between those items might be larger than that between *N* and mirror-*N*. Given that this leads to stronger grouping, it could explain the finding that search is difficult with these items (see Duncan & Humphreys, 1989, 1992). An alternative explanation would favor the basic-feature account: Whereas the *N*s (and mirror-*N*s) are typical versions of the letter, the 5 and 2 are rather atypical versions—made up of horizontal and vertical lines, instead of curved lines. If letters really are standard features, it is reasonable to assume that such a deviation from the standard impairs search performance.

Although the oblique line is the only physical difference between *N* and mirror-*N*, it can be ruled out that the search asymmetry occurred only because the Germans are able to process one of these obliques more effectively. The asymmetry that was observed for *N*s and mirror-*N*s was found with *Z*s and mirror-*Z*s, too (Wang et al., 1994). Whereas for the *N* the \ is the "familiar oblique," in *Z*s the / is the familiar one. This means that both orientations can lead to efficient search, but only when they are part of a letter—even without knowing the Cyrillic alphabet. Obviously, the asymmetry evolves *because* the elements are perceived as letters and not as oblique lines.

A similar observation was made by Shen and Reingold (2001, Experiments 2 and 3). When Chinese participants had to search for the mirror image of a Chinese character among several of the original characters and vice versa, a corresponding search asymmetry occurred. This asymmetry was larger when the character and its mirror image differed with respect to the orientation of one component line than when they differed only with respect to the arrangement of their parts. That is, orientation differences can further facilitate search for an unfamiliar item among familiar distractors, although the main source of the asymmetry is the distractor familiarity.

It should be pointed out that there might be situations in which the familiarity of the elements is irrelevant. For illustration, consider the case of searching for *X* among *O*s. There, observers can rely on an extreme difference in low-level features, resulting in efficient search whether they are familiar with these letters or not. On the other hand, for other combinations, as for *N* and mirror-*N*, this is not the case.

It would be desirable to replicate these findings with different letter stimuli. Unfortunately, there are only a few letters in our alphabet whose inverted images belong to other alphabets. A possible candidate is the capital *R*. But although its mirror image belongs to the Cyrillic alphabet, the problem here is that both letters differ with respect to several low-level features that can facilitate visual-search processes.

Would Slavs who are not familiar with the Latin alphabet display a search asymmetry opposite to that of the Germans in our experiment? To conduct the corresponding experiment would be rather difficult because nowadays, even in Slavic countries, it would not be easy to find people who had never had contact with the Latin alphabet. In any case, having shown the clear asymmetry for the German group, there seems to be no reason to assume that the opposite should not hold for a "pure" Slavic group.

Another question addressed with our experiment was that of fast absent-responses. They were reliably faster for regularly arranged items than for irregularly arranged ones. With familiar distractors, even an absent-advantage occurred. Such a result was not obtained by Wang et al. (1994), who used only regular item patterns. Therefore, our results provide further evidence for the hypothesis that an absent-advantage depends on the experimental context and does not rely on regularity alone (see Hübner & Malinowski, 2001). Regular and irregular patterns must be mixed within a block of trials. This allows adjusting the decision criteria in such a way that an absent-advantage occurs for regular patterns. As our results also show, familiarity of the distractors is a further important condition for obtaining an absent-advantage.

REFERENCES

Duncan, J., & Humphreys, G. W. (1989). Visual search and stimulus similarity. *Psychological Review*, **96**, 433-458.

Duncan, J., & Humphreys, G. W. (1992). Beyond the search surface: Visual search and attentional engagement. *Journal of Experimental Psychology: Human Perception & Performance*, **18**, 578-588.

Frith, U. (1974). A curious effect with reversed letters explained by a theory of schema. *Perception & Psychophysics*, **16**, 113-116.

Hübner, R., & Malinowski, P. (2001). How to produce an absent-advantage in visual search. *Perception & Psychophysics*, **63**, 258-271.

Humphreys, G. W., Quinlan, P. T., & Riddoch, M. J. (1989). Grouping processes in visual search: Effects with single- and combined-feature targets. *Journal of Experimental Psychology: General*, **118**, 258-279.

Karni, A., & Sagi, D. (1991). Where practice makes perfect in texture discrimination: Evidence for primary visual cortex plasticity. *Proceedings of the National Academy of Sciences*, **88**, 4966-4970.

Meinecke, C., & Steininger, S. (2000). *Memory contact in early vision: The familiarity effect in texture segmentation tasks*. Manuscript submitted for publication.

Reicher, G. M., Snyder, C. R. R., & Richards, J. T. (1976). Familiarity of background characters in visual scanning. *Journal of Experimental Psychology: Human Perception & Performance*, **2**, 522-530.

Richards, J. T., & Reicher, G. M. (1978). The effect of background familiarity in visual search: An analysis of underlying factors. *Perception & Psychophysics*, **23**, 499-505.

Shen, J., & Reingold, E. M. (2001). Visual search asymmetry: The influence of stimulus familiarity and low-level features. *Perception & Psychophysics*, **63**, 464-475.

Treisman, A. (1982). Perceptual grouping and attention in visual search for features and for objects. *Journal of Experimental Psychology: Human Perception & Performance*, **8**, 194-214.

Treisman, A. (1991). Search, similarity and integration of features between and within dimensions. *Journal of Experimental Psychology: Human Perception & Performance*, **17**, 652-676.

Treisman, A. (1993). The perception of features and objects. In A. Baddeley & L. Weiskrantz (Eds.), *Attention: Selection, awareness, and control: A tribute to Donald Broadbent* (pp. 5-35). Oxford: Oxford University Press, Clarendon Press.

Treisman, A., & Gormican, S. (1988). Feature analysis in early vision: Evidence from search asymmetries. *Psychological Review*, **95**, 15-48.

Treisman, A., Vieira, A., & Hayes, A. (1992). Automaticity and preattentive processing. *American Journal of Psychology*, **105**, 341-632.

Wang, Q., & Cavanagh, P. (1993). Acquired familiarity effects in visual search with Chinese characters [Abstract]. *Investigative Ophthalmology & Visual Science*, **34**, 1236.

Wang, Q., Cavanagh, P., & Green, M. (1994). Familiarity and pop-out in visual search. *Perception & Psychophysics*, **56**, 495-500.

Wolfe, J. M. (1994). Guided Search 2.0: A revised model of visual search. *Psychonomic Bulletin & Review*, **1**, 202-238.

Wolfe, J. M. (1998). Visual search. In H. Pashler (Ed.), *Attention* (pp. 13-73). Hove, U.K.: Psychology Press.

(Manuscript received April 4, 2000;
accepted for publication May 31, 2000.)