

## Video-Task Assessment of Stimulus Novelty Effects on Hemispheric Lateralization in Baboons (*Papio papio*)

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In a video matching-to-sample task, we examined the effects of stimulus novelty on hemispheric specialization in 6 baboons (*Papio papio*). After familiarization with a set of 8 composite stimuli, baboons were tested with either familiar stimuli paired in a novel way, novel stimuli composed of familiar elements, or novel stimuli differing in structure from the previous stimuli. Analyses focused on visual field differences between initial and later trials in each condition. The findings reflected shorter left than right visual half-field response times for initial but not for terminal trials. With regard to accuracy, scores were smaller for the initial trials than for the later ones, but there was no significant difference between left and right visual half-fields. Overall, this study suggests that hemispheric lateralization changes with practice and that the right hemisphere of the baboon plays a critical role in the processing of novelty.

It has become increasingly evident during the last few years that the left and right halves of the brain of nonhuman primates do not have the same cognitive functions. This finding derives from a variety of studies on motor, cognitive, and perceptual asymmetries in several nonhuman primate species (see Fagot & Vauclair, 1991; Hopkins & Morris, 1989, 1993; MacNeilage, Studdert-Kennedy, & Lindblom, 1987; Ward & Hopkins, 1993, for recent discussions of this issue). Although experimental reports have shown that nonhuman primates do exhibit hemispheric asymmetries, it is difficult at this point to propose an integrated theory on the respective abilities of each hemisphere (Vauclair & Fagot, 1993b). A first difficulty encountered by theoreticians of hemispheric specialization is that lateralization in nonhuman species depends, as with humans, on the nature of the administered tasks. For example, Hamilton and Vermeire (1988) found, within the same group of split-brain rhesus macaques, a left-hemisphere advantage for line-orientation discrimination complementary to a right-hemisphere advantage for the discrimination of monkeys' faces. The task specificity of hemispheric lateralization was also demonstrated in Sanford, Guin, and Ward (1984) and Fagot and Vauclair (1988a). The second difficulty is that hemispheric differences are not necessarily stable over practice

(Fagot & Vauclair, 1991), which complicates the results and their integration in a unified theory.

There is indeed some incidental evidence that patterns of hemispheric lateralization in nonhuman primates may change over the course of a single experiment. For instance, Ettlinger (1961) found in somatosensory discrimination tasks that practice reduces the initial predominance of left-hand preferences to near equality with right. Comparable results were found by Milner (1969). In Milner's study, 58 rhesus monkeys were required to solve two tactile discrimination tasks with whichever hand. For both tasks, there was a higher incidence of preference for the left over the right hand before the training criterion was attained. However, the left-right ratio decreased to near unity after the training criterion was met. Decrease in the left-right ratio was mainly because animals with an initial unestablished hand preference adopted a right-hand preference after repeated testing (Gautrin & Ettlinger, 1970).

Instability of hemispheric lateralization with practice was also found in research with baboons (Fagot & Vauclair, 1988b). Subjects were required to precisely align a window (a sliding Plexiglas panel) with an aperture where a hazelnut was located. In the group as a whole, there was a left-hand preference for the adjustment phase of the task. However, this preference was mostly evident for Trials 1–25 but vanished at the end of the testing (Vauclair & Fagot, 1993b).

Although the aforementioned studies have strong motor components, it is interesting to note that similar effects were observed for visual discriminations. Thus, Hopkins, Washburn, and Rumbaugh (1990) found in 3 chimpanzees a left visual half-field and right-hemisphere (LVF-RH) advantage in accuracy in the first block of trials in a visual discrimination task that required joystick manipulation. Again, no clear asymmetry emerged during final testing. Note, however, that 2 rhesus monkeys tested in situations similar to those used with chimpanzees demonstrated no clear shift in brain lateralization.

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It is worth mentioning that in humans, too, patterns of hemispheric specialization may change with repeated testing. The most commonly reported finding in humans has been a shift from an initial right-hemisphere advantage in early trials toward a left-hemisphere advantage in later ones (but see Kok, Van de Vijver, & Rooijakkers, 1985; Nettleton & Bradshaw, 1983). Such variations have been observed with auditory (e.g., Burton & Wilson, 1990), visual (e.g., Gordon & Carmon, 1976; Hellige, 1976; Streifeld, 1985), and tactile stimuli (e.g., Streifeld, 1985), but other studies reported right-hemisphere advantages for initial but not later trials (e.g., Hallman & Corballis, 1975; Hunt, Edwards, & Quest, 1988). These findings and others have led Goldberg and Costa (1981) to propose that as a consequence of patterns of neural connectivity and anatomical cerebral asymmetries, the right hemisphere excels in the processing of novel tasks and plays a critical role in the initial stages of acquisition. By contrast, the left hemisphere is better in tasks for which there is an already elaborated descriptive set. Hence, this theory explains right-to-left shifts with practice and the fact that changes in population-level asymmetries with increasing familiarization are mostly due to subjects with an initial right-hemisphere advantage (e.g., Kittler, Turkewitz, & Goldberg, 1989).

We proposed a theory about hand preference in nonhuman primates that is relevant in this presentation (Fagot & Vauclair, 1991). Understanding the relation between differential hand use and task characteristics requires a distinction between *handedness*, that is, the differential hand use seen when subjects solve simple, familiar tasks, and *manual specialization*, that is, the differential hand use when the tasks are novel and cognitively or motorically complex. We reported (Fagot & Vauclair, 1991) that simple, familiar tasks (such as reaching for food) lead to an unbiased distribution of hand preferences at the population level.<sup>1</sup> In contrast, studies with novel and complex tasks have provided evidence for population-level hand preferences. We proposed that through extensive practice the initially incompetent hemisphere acquires the ability to solve the task. Then, when both hemispheres can solve the task, hand choices are no more determined by hemispheric lateralization, which results in the appearance of idiosyncratic preferences sensitive to internal or external influences (e.g., differential reinforcement). Contrasted with Goldberg and Costa's (1981) theory, we thus expected a decline in population-level asymmetries with practice rather than a right-to-left shift (Fagot & Vauclair, 1991).

Given such predictions and the fact that in nonhuman primates, changes in hemispheric lateralization with practice have mostly been reported as incidental findings, we deliberately investigated the effects of task novelty on hemispheric specialization in baboons. For that purpose a video-formatted matching-to-sample task that required the manipulation of a joystick was adopted. Novelty effects were assessed by focusing on those aspects of this matching-to-sample task that were related to the choice of the stimuli and their pairing.

## Method

### Subjects

The subjects were 6 wild-born baboons (*Papio papio*), 3 males and 3 females, which ranged from 7.0 to 10.0 kg. On the basis of weight, the baboons were estimated to be 3–5 years of age. Before testing, the subjects had been trained on a psychomotor task that involved the use of a joystick for controlling the displacements of a cursor displayed on a computer monitor (Vauclair & Fagot, 1993a). The subjects were also used in a series of experiments on mirror-image discrimination and rotational invariance problem solving (Hopkins, Fagot, & Vauclair, 1993; Vauclair, Fagot, & Hopkins, 1993). The baboons were housed as a social group of 14 animals reared within the animal facilities at the Centre National de la Recherche Scientifique (Marseille, France). The subjects were isolated from the group during experimental sessions. They received their daily food ration (fruit, monkey chow, and vegetables) at the end of the day.

### Apparatus

The apparatus has been described in detail elsewhere (Hopkins et al., 1993; Vauclair & Fagot, 1993a). Briefly, it comprised a personal microcomputer with a 14-in. color monitor and an analog joystick. The testing environment was the experimental cage (50 cm wide  $\times$  70 cm high  $\times$  68 cm long) depicted in Figure 1. The front of the cage was equipped with a view port (8.7  $\times$  8.0 cm) and two hand ports. The hand ports could be opened or closed with sliding panels in order to restrict joystick manipulation to either the left or the right hand. The distance from the view port to the computer monitor was 47 cm, and the center of the computer monitor was aligned with the center point of the view port. The joystick was positioned 18 cm from the hand ports and was centrally positioned on the horizontal axis of the experimental cage. Also centrally positioned, but 5 cm from the two hand ports, was a touch sensitive pad (11.5  $\times$  10.0 cm). The testing cage was equipped with a food dispenser that provided 190-mg, banana-flavored pellets on the midsagittal axis of the floor of the cage. The experiment was driven by a software program written in Turbo Pascal 5.0. Timing of stimulus presentation and recording of response times were controlled at a 1-ms sampling rate.

### Procedure

**Training.** Before this experiment the subjects were trained to manipulate the joystick under the procedure outlined in Vauclair and Fagot (1993a). They were then trained on a matching-to-sample task similar to the one used by Hopkins et al. (1990). The details of the training procedure are described in Hopkins et al. (1993). ASCII characters or simple geometric forms (e.g., star, cross, circle, etc.) were used as visual stimuli during training.

**Testing procedure.** Each subject was removed from its social group and was individually placed into the experimental cage (Figure 1). A trial was started by having the subject place one hand on the touch pad. This action led to the immediate display of a cursor (a green circle, 0.5 cm in diameter) and a fixation stimulus (a 0.5  $\times$  0.5 cm white square) on the monitor. The cursor appeared

<sup>1</sup> In a set of 41 studies of simple reaching with a sufficient data basis, Fagot and Vauclair (1991) observed that only 4 studies revealed asymmetries in hand use whereas the remaining studies showed symmetrical distributions of hand use.

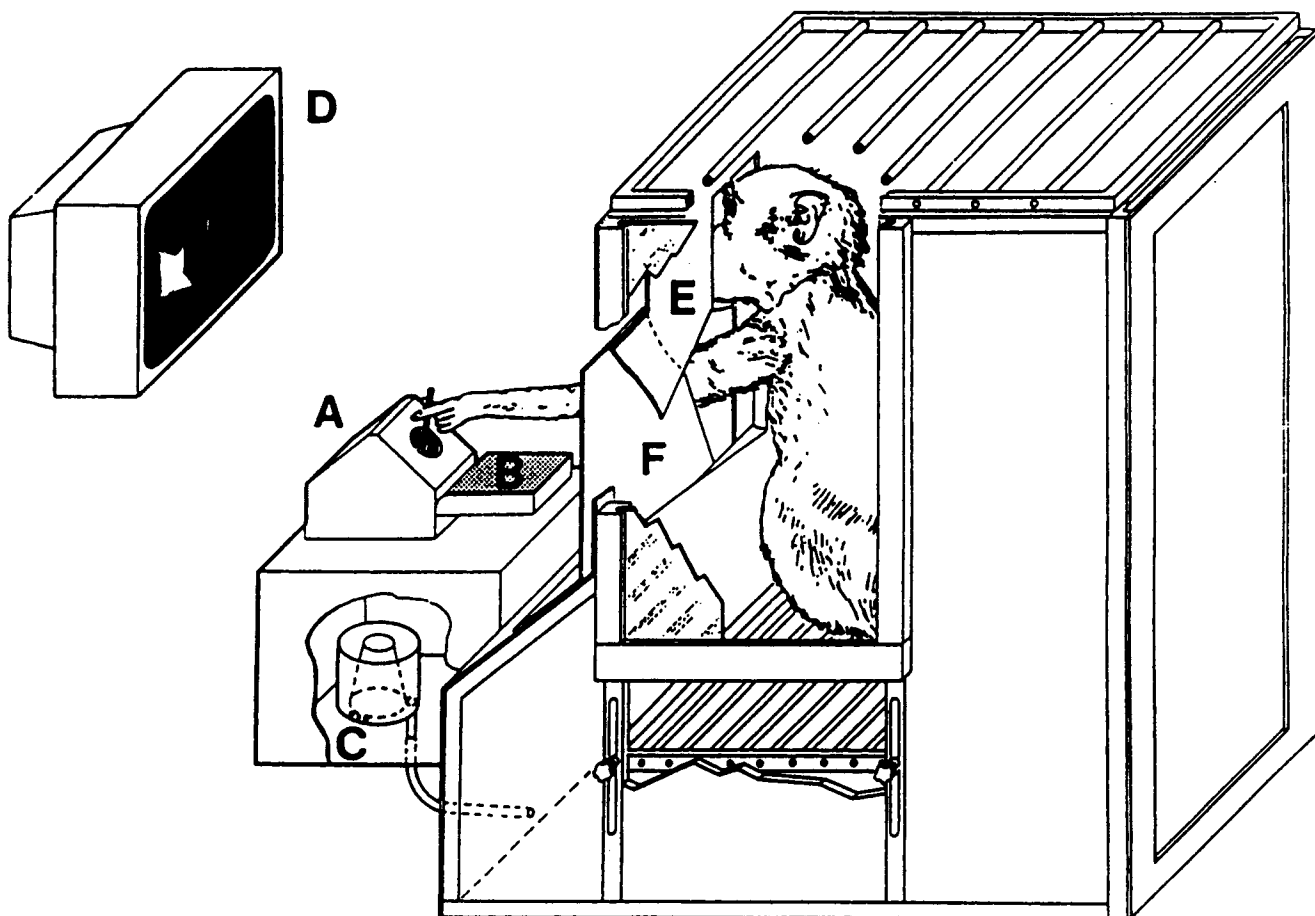


Figure 1. Test apparatus: A. joystick; B. touch pad; C. food dispenser; D. computer monitor; E. view port; F. hand port.

in the center of the screen, and the fixation stimulus was shown vertically 1.5 cm above or below the cursor. The subject had to manipulate the joystick so as to place the cursor on the fixation stimulus for 35 ms. In order to perform that action, the subject had to look at the fixation stimulus. That behavioral constraint allowed for control of eye fixation. Once the cursor was in the location of the fixation stimulus, a sample stimulus appeared for 150 ms in either the left or the right part of the screen. The inside edge of the sample stimulus was laterally displaced from the center of the fixation stimulus by a visual angle of  $6^\circ$ . Hence, the sample stimulus was presented in one visual half-field at a time, because it was displayed for a duration (150 ms) shorter than the time required to perform saccadic eye movements (200–250 ms; Fuchs, 1967) and at a retinal eccentricity of  $6^\circ$ , which ensures a contralateral projection of the visual input (Leventhal, Ault, & Vitek, 1988).

Immediately after the display of the sample stimulus, two comparison forms appeared 4 cm above or below the cursor on the vertical axis of the computer screen. By way of joystick manipulation, the subject was then required to touch with the cursor the comparison stimulus that matched the sample. A correct response was recorded if the subject chose the matching comparison form. An incorrect response was recorded if the subject chose the form different from the sample stimulus. Correct responses were reinforced with food pellets and were accompanied by a tone. Incorrect

responses were never reinforced. They were followed by a low raucous tone and a time-out of 3 s.

During the time-out the computer screen turned green. At the end of the time-out, the screen turned black. If a subject was either moving the joystick or holding its hand on the touch pad before the end of the time-out period, the initiation of the next trial was delayed until the baboon removed its hand from the touch pad and the joystick returned to the central position. During testing, each subject used one hand only to manipulate the joystick. Three subjects (1 male and 2 females) used their right hand, and the remaining 3 (2 males and 1 female) used their left hand. Distal hand movements, that is, those produced in manipulating the joystick, are predominantly under the control of the hemisphere opposite to the hand used (Brinkman & Kuypers, 1973).

The experiment was composed of four different phases, over 14 consecutive days of testing and 1,792 trials per animal. The subjects were first familiarized with a set of stimuli initially novel to them (*familiarization condition*). The stimuli used for familiarization were combinations of simple forms selected from a limited pool of possible forms. After familiarization, the subjects were tested with the same stimuli paired in a different way (*pairing condition*). Finally, the subjects were tested with two new sets of visual patterns. In one condition (*recombination condition*), the stimuli were novel recombinations of the simple forms used to draw the stimuli in the familiarization and pairing conditions. In

another condition (*structure condition*), the set of visual patterns was composed of polygon-shaped stimuli with both an external and internal structure different from the structure of the composite stimuli used in other conditions. The familiarization and pairing conditions were run first and consecutively for all baboons. Then, 3 baboons received the recombination condition before they received the structure condition. The other 3 baboons received the recombination condition after they completed the structure condition.

*Familiarization condition.* The subjects were familiarized with a set of eight composite stimuli. Examples of those stimuli are depicted in Figure 2. The composite stimuli comprised geometric forms made of 3 elements selected from among 11 possible elements: horizontal, oblique, wave, snake, block, dot, lozenge, circle, square, vertical, and triangle (see Figure 2). The stimuli were

yellow in color and up to  $4.0 \times 4.0$  cm in size. They were adapted from Tomonaga and Matsuzawa (1992).

For the familiarization condition, five sessions of 128 trials each were run with each animal, one session a day. Within a session each stimulus was always paired with the same stimulus, which resulted in four different pairs. The sample stimulus was presented 64 times to either the left or the right of the fixation point. For half of the trials with each visual half-field, the correct comparison form was displayed at the top of the screen, and the correct stimulus was located on the bottom part of the screen for the remaining trials. Each stimulus served an equal number of times as the sample and comparison form. The order of presentation for trials was randomized within each test session and thus varied from session to session as well as from subject to subject.

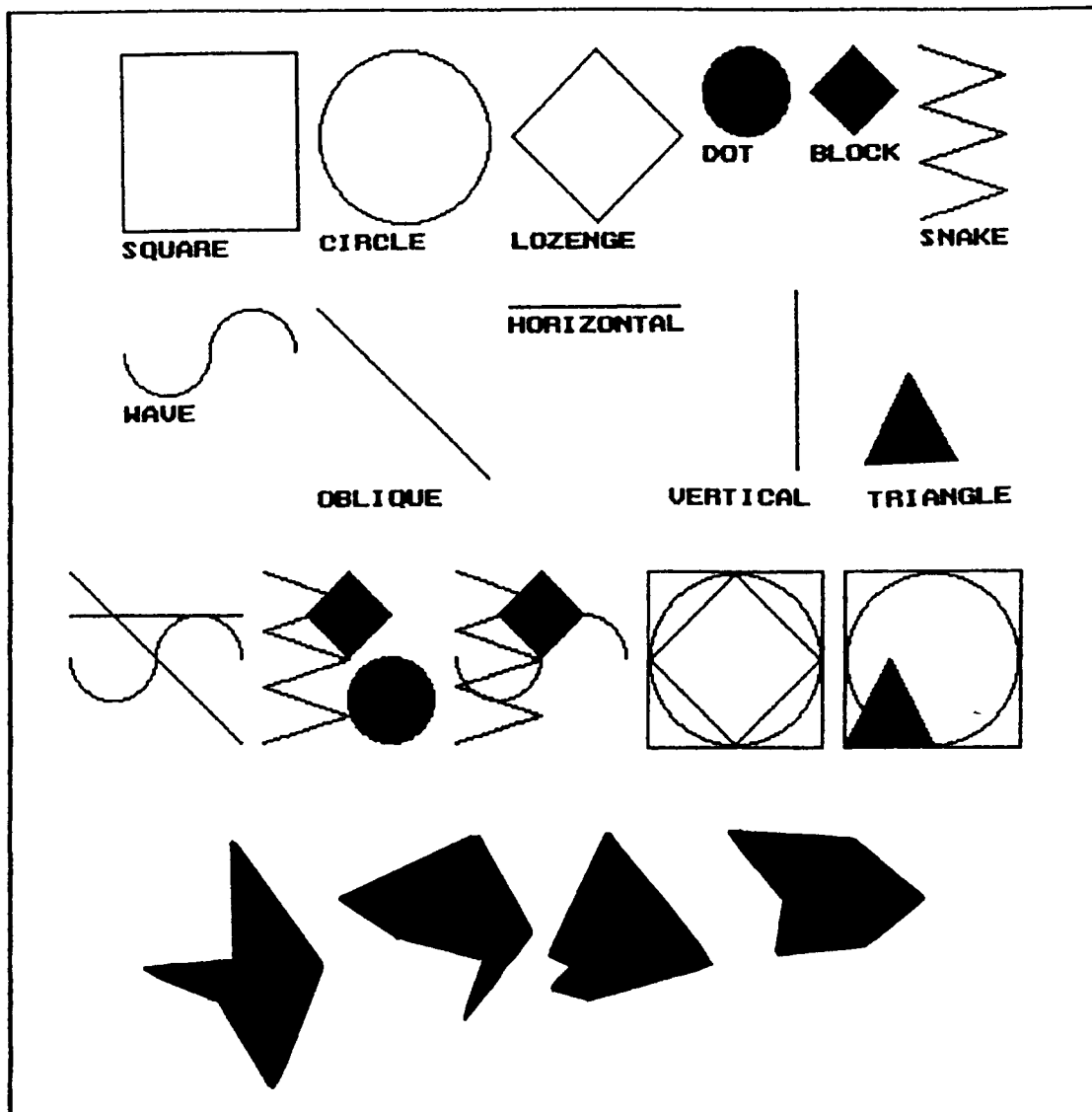


Figure 2. Visual forms used in the experiment. (The top two rows show the 11 elements used to construct the composite stimuli for the familiarization, pairing, and recombination conditions. The third row shows examples of the composite stimuli made of 3 of the 11 basic elements. In the fourth row are examples of polygons used in the structure condition.)

**Pairing condition.** This phase used the same set of composite stimuli as for familiarization. The only difference with the previous phase was the pairing of the stimuli. In this phase each of the eight stimuli could be paired with any other stimulus. The number of trials, the number of sessions, stimuli presentation, and procedure were in all respects identical with those of the familiarization condition.

**Recombination condition.** This phase used 128 different stimuli that were recombinations of 3 of the 11 elements (Figure 2). These stimuli differed from the eight used in the familiarization and pairing conditions. Two sessions of 128 trials were run with each animal on 2 consecutive days. During a session each stimulus was used once as the sample stimulus and served one time as the comparison stimulus. Other aspects of the test sessions were in all respects identical with those of the previous test sessions.

**Structure condition.** Stimuli used in this phase were 128 yellow polygons randomly generated with Attneave and Arnoult's (1956) method. Each polygon was approximately 14 cm<sup>2</sup> in surface and contained six angles (see Figure 2). Two sessions of 128 trials each were run with each animal. Stimuli presentation and procedure was the same as for the recombination condition.

**Data reduction.** Because of the possibility that subjects could respond by anticipation or could be distracted while giving their response (e.g., because of a noise), a data reduction was performed. Table 1 provides the frequency of trials and the percentage of correct responses as a function of response times. From that table it can be inferred that mean accuracy scores were at their lowest both for the minimal and maximal response times. Given the pattern of results reported in Table 1, trials in which response times were shorter than 150 ms or greater than 800 ms were omitted for the analyses. This reduction procedure, which resulted in a removal of 9.1% of the data, provided more conservative estimates of response time and accuracy measurements.

An analysis of motor behaviors showed that in the structure condition 4 of the 6 baboons adopted stereotypies, such as pulling the joystick regardless of the location of the correct comparison form. These responses gave rise to low accuracy scores (correct responses,  $M = 56.5\%$ ,  $SD = 5.4\%$ ). Data from this condition were thus omitted for statistical analyses of response times and accuracy scores.

## Results

### Response Times

Response time was defined as the time elapsed between the offset of sample stimulus presentation and the detection

of a collision between the cursor and one of the two comparison stimuli. For statistical analyses we focused on differences in response time between the first 70 trials and the remaining trials in each condition.<sup>2</sup> For this purpose an analysis of variance (ANOVA) was performed. Independent variables were the condition (familiarization, pairing, or recombination), the hand (left or right) used by the animal for joystick manipulation, the type of trial (first or last), and the visual half-field (left or right). The only significant result concerned the interaction between the type of trial and the visual half-field,  $F(1, 4) = 64.43$ ,  $p < .001$ . This interaction is depicted in Figure 3. Tukey's honestly significant differences post hoc comparisons ( $p < .05$ ) indicated that LVF-RH response times were shorter than response times for the right visual half-field and the left hemisphere (RVF-LH) when the first trials are considered. Differences between fields were not significant when considering the last trials only.

Given the LVF-RH advantage observed in initial trials, we verified if this advantage was evident in each animal. Table 2 reports mean correct response times for each animal and for each condition. It appears that 5 of the 6 baboons exhibited the shortest initial response times for LVF-RH trials. The remaining subject (Subject 3; see Table 2) had equal mean response times for both fields of stimulus presentation. Table 2 also shows that on average for the 6 subjects, the LVF-RH advantage was present in the three testing conditions.

We also compared the last correct trials performed during the familiarization with the first 70 correct trials of the pairing condition. This analysis failed to reveal any significant main effect or interaction. We note, however, that the Type of Trial  $\times$  Visual Half-Field interaction was close to significance ( $p < .1$ ) and corresponded to shorter LVF-RH response times for the first trials and to shorter RVF-LH trials for last trials. We compared the last correct trials of the pairing condition with the first correct trials of the recombination condition. This comparison considered, among the aforementioned variables, the order of testing condition, that is, that 3 subjects received the structure condition after the paired condition and the remaining 3 were tested in the reversed order. This ANOVA revealed no significant main effect or interaction.

### Scores

Accuracy scores were analyzed with the same statistical approach as that for response times. An ANOVA was thus

Table 1  
Frequency Trials and Percentage of Correct Responses  
As a Function of the Duration of Response Times

Response time (in milliseconds)	Frequency	% correct responses
<150	2.0	51.8
150–200	2.2	57.0
200–300	16.4	69.4
300–400	34.8	76.4
400–500	19.4	74.5
500–600	9.3	69.6
600–700	5.3	64.7
700–750	1.9	63.8
750–800	1.6	64.7
800–850	1.2	55.4
>850	5.9	52.8

<sup>2</sup> In the human literature novelty effects are generally evaluated on series of 20–90 trials (e.g., Hellige, 1976; Kittler, Turkewitz, & Goldberg, 1989). In the present experiment, we have selected the first 70 trials to assess novelty, because this number falls within the range of previous experiments and it corresponds to half of the smaller number of correct trials per subject in the recombination condition, for which there were only 256 trials per subject. Hence, the use of this value allowed for a balanced comparison between the first and the remaining trials for those subjects that had the smaller number of correct trials.

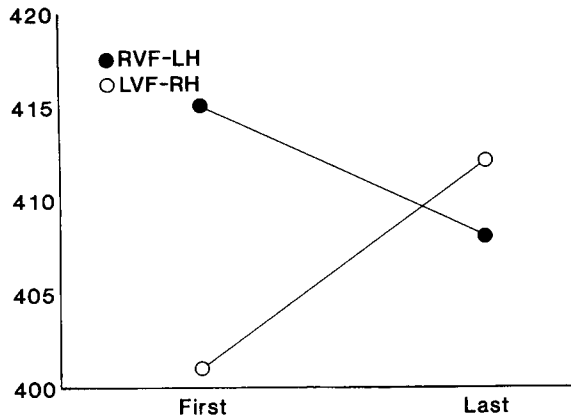


Figure 3. Type of Trial (first or last)  $\times$  Visual Half-Field (right or left) interaction for response times (in milliseconds).

performed on accuracy scores with the condition (familiarization, pairing, or recombination), the hand (left or right), the type of trial (first 70 and remaining trials), and the visual half-field (left or right) as the independent variables. Two interesting main effects emerged from this analysis. First, the effect of condition was significant,  $F(2, 8) = 11.41, p < .005$ . Tukey's honestly significant differences post hoc comparisons ( $p < .05$ ) showed that accuracy scores in the pairing condition were greater than in the familiarization and recombination conditions. The second main effect concerned the type of trial,  $F(1, 4) = 7.35, p = .053$ . Note that this effect was marginally significant. On average, mean accuracy scores were higher for last trials ( $M = 76.2\%$ ) than for the first ( $M = 68.7\%$ ).

The Hand  $\times$  Visual Half-Field  $\times$  Condition third-order interaction was significant,  $F(2, 8) = 8.16, p < .02$ . For the 3 subjects that used their left hand, LVF-RH presentations led to greater accuracy scores than RVF-LH presentations in the familiarization condition only. The subjects that used their right hand showed greater accuracy scores for RVF-LH presentations in the familiarization and pairing conditions. This advantage was opposite in the recombination condition. Finally, the Hand  $\times$  Visual Half-Field  $\times$  Condition  $\times$  Type of Trial fourth-order interaction was

significant,  $F(2, 8) = 14.26, p < .002$ . For this interaction, no simple interpretation suggests itself.

## Discussion

This experiment was designed to test the effects of stimulus novelty on hemispheric lateralization in a visual matching-to-sample task in 6 baboons. The analysis of response times revealed a significant interaction between the type of trial (first or last) and the visual half-field of stimulus presentation. On average, response times for initial trials were shorter for the left visual half-field than for the right visual half-field presentations. No such effect was found for later trials. Using the same type of video-formatted matching-to-sample task with novel visual stimuli, Hopkins et al. (1990) found in 3 chimpanzees an initial LVF-RH advantage in accuracy. In that same study, LVF-RH response times were also shorter in the first two blocks of trials, but the difference was significant for the second block only. Contrasted with chimpanzees, two rhesus monkeys tested in the same conditions failed to show shorter response times for LVF presentations (Hopkins et al., 1990). Our finding of an LVF-RH advantage in initial trials in baboons is thus in agreement with the results obtained in chimpanzees.

Our results from this study are also in agreement with those obtained in different perceptual-motor tasks. For instance, for either visual or tactile two-choice discrimination tasks, Ettlinger (1961), Milner (1969), and Gautrin and Ettlinger (1970) have found that there were more left-handed than right-handed macaques that reached training criterion. In other words, left-handers were more efficient than right-handers in the acquisition phase of the discrimination tasks. Similarly, we reported (Vauclair & Fagot, 1993b) a significant left-hand preference in baboons for the initial trials of a visuomotor task that required the adjustment of a Plexiglas panel. Hence, in spite of differences in the perceptual and motor components in the limited set of studies that have examined practice effects, the reported data have shown consistent results. These results suggest (a) a stronger lateralization for tasks with some novel components in comparison with familiar tasks and (b) an advantage of the right hemisphere for initial trials of a novel task.

Table 2  
Correct Response Times for Initial Trials

Subject	Familiarization		Pairing		Recombination		Mean	
	LVF	RVF	LVF	RVF	LVF	RVF	LVF	RVF
1	477	551	464	473	496	489	479	504
2	368	404	336	342	351	357	352	368
3	337	268	515	525	382	439	411	411
4	542	530	484	527	372	378	466	478
5	311	316	306	313	303	320	307	316
6	408	456	364	376	408	408	393	413
<i>M</i>	407	421	412	426	385	399	401	415

Note. LVF = left visual half-field; RVF = right visual half-field. Data are given in milliseconds.

Goldberg and Costa (1981) proposed that when existing well-routinized codes are unsuccessfully applied to processing some stimuli, subjects must develop novel modes of representation for which the right hemisphere excels. The LVF-RH advantage we observed for initial trials supports this theory. Moreover, the overall right hemisphere advantage observed for initial trials only, regardless of the experimental conditions, indicates that subjects perceived changes in stimuli identity or pairing when changes were made in the testing procedure. Stimulus-related factors, such as the composition of the stimuli or their pairing, can thus fruitfully be experimentally manipulated to assess novelty effects. Note, however, that in humans, even if all stimuli within a block of trials are novel, shifts toward RVF-LH superiority can still occur (e.g., Kinsbourne & Bruce, 1987).

Although our work supports the advantage of the right hemisphere for novelty processing, it does not seem to provide a clear support for the right-to-left shift with practice postulated by Goldberg and Costa (1981). For last trials, RVF-LH response times were smaller on average than LVF-RH response times, but the difference between the two presentation modes was not significant. The failure to observe such a shift can be explained in at least two different ways. One hypothesis implies that the number of trials or the number of sessions was insufficient to elicit the expected inversion in hemispheric asymmetry, although subjects performed a large number of trials (246 or 640) in each condition. The second possibility is that, because of inter-hemispheric transmissions, each hemisphere acquired with practice the basic abilities to solve the task (Fagot & Vauclair, 1991). This acquisition may have masked the initial LVF-RH advantage. It is of note that none of the studies that have shown an initial right-hemisphere superiority in nonhuman primates gave rise to a clear lateralization in favor of the left hemisphere in final trials (Ettlinger, 1961; Gautrin & Ettlinger, 1970; Hopkins et al., 1990; Milner, 1969; Vauclair & Fagot, 1993b). Moreover, highly practiced manual activities, such as reaching for food, rarely provide evidence for population-level lateralization in nonhuman primates (see Fagot, Drea, & Wallen, 1991; Fagot & Vauclair, 1991; see also footnote 1). However, generalization from these results is difficult because the method, the stimulus set, and the procedures differed between studies. Further experiments are needed to determine if extensive practice produces a right-to-left shift or a decline in overall lateralization. This research, nevertheless, constitutes a clear warning that we can no longer assume that because a given task has demonstrated a left- or right-hemispheric superiority, this indicates that this task will permanently produce the same lateralization bias.

In terms of accuracy, the significant results showed differences in overall scores between initial and terminal trials and between conditions. On average, scores were lower in the first than in the last trials, which suggests a training effect. Scores in the pairing condition were also greater than in the recombination condition. We can assume that this difference is because stimuli were presented only once in the recombination condition, whereas in the pairing condi-

tion each stimulus was presented 16 times as the sample stimulus.

More generally, this work clearly increases the existing body of evidence that points to the reality of hemispheric lateralization in nonhuman primates. Additionally, it does suggest that hemispheric lateralization is not necessarily a stable phenomenon, because it can disappear or even shift over trials. If this is the case, then the systematic inclusion of the variable of change over time may lead to a better understanding of the role of each hemisphere in various stages of the information processing.

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