# Detection of Grouped and Ungrouped Parts in Visual Patterns by Tufted Capuchin Monkeys (*Cebus apella*) and Humans (*Homo sapiens*)

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The authors investigated perceptual grouping in capuchin monkeys (*Cebus apella*) and humans (*Homo sapiens*). In Experiment 1, 6 monkeys received a visual pattern as the sample and had to identify the comparison stimulus featuring some of its parts. Performance was better for ungrouped parts than for grouped parts. In Experiment 2, the sample featured the parts, and the comparison stimuli, the complex figures: The advantage for ungrouped elements disappeared. In Experiment 3, in which new stimuli were introduced, the results of the previous experiments were replicated. In Experiment 4, 128 humans were presented with the same tasks and stimuli used with monkeys. Their accuracy was higher for grouped parts. Results suggest that human and nonhuman primates use different modes of analyzing multicomponent patterns.

*Perceptual grouping* is the ability to integrate the information that reaches sensory receptors into global representations (Pomerantz, 1985). It has been extensively investigated in human cognition, where most research is focused on the mechanisms allowing our perceptual system to segment an entity into its constituent parts and to integrate these parts into a coherent whole (e.g., Biederman, 1987; Palmer, 1977; Ullman, 1989).

Although variations can be observed in different systems of receptors, it has been suggested that a variety of animal species might share some general principles of perceptual organization, as there are regularities in the habitat and in the general needs of different species that might transcend the peculiarities of specific ecological niches (Vallortigara, Zanforlin, & Compostela, 1990).

This suggestion is consistent with the notion that perceptual organization, and the grouping principles on which it is based, work because they realistically capture essential properties of the physical environment shared by a variety of organisms. However, although the nature of grouping principles is relatively uncontro-

versial (Bruce, Green, & Georgeson, 2003), there is an ongoing and longstanding debate in psychology concerning the reasons why they work. On the one hand, a tradition that can be traced back to von Helmholtz (1909/1962) asserts that perceptual organization favors interpretations of visual stimuli that conform to a realistic state of affairs in the environment. On the other, gestaltists, with their notion of *Pragnanz* or "good shape," emphasize the notion that perceptual grouping principles direct organisms toward the simplest possible interpretation of a stimulus (see Chater, 1996; van der Helm, 2000, for recent theoretical attempts to reconcile these "likelihood" and "simplicity" principles).

Although principles governing the perception of good shapes have been traditionally considered as universal, some recent data suggest that, even among human populations, the perception of good shapes might be linguistically mediated. For example hunter–gatherer people lacking the vocabulary for simple forms such as circles, squares, and triangles do not seem to perceive these figures as good shapes, in contrast with individuals belonging to cultures with verbal categories for these shapes (Roberson, Davidoff, & Shapiro, in press).

Moreover, although perceptual organization was originally conceived as a unitary process based on grouping principles that, although different from each other, have roughly the same importance and operate at the same stage of processing, more recent approaches suggest that this might not be the case. Some researchers have argued that different perceptual grouping principles might have a different weight in determining how perceivers integrate elementary units into wholes and might operate at different stages of visual processing (e.g., Behrmann & Kimchi, 2003).

A comparative approach to perceptual organization can provide important information about the universality of general grouping laws, the extent to which different principles are essential to their operation, and how these principles are related to other cognitive abilities. In fact, recent comparative studies have pointed to im-

portant differences between forms of perceptual grouping ob-
served in humans and nonhuman species. For example, compared
with humans, rats (Kurylo, Van Nest, & Knepper, 1997) and sea
lions (Burke, Everingham, Rogers, Hinton, & Hall-Aspland, 2001)
seem to be able to use only a limited range of visual cues to group
arrays of small geometric shapes into structured visual patterns.
Moreover, species phylogenetically closer to humans, such as
nonhuman primates, when faced with hierarchical visual stimuli
(e.g., a large geometrical shape formed by the spatial arrangement
of smaller geometrical shapes) seem to process the local compo-
nents of the stimuli more proficiently than their global form
(Deruelle & Fagot, 1998; Fagot & Deruelle, 1997; Spinozzi, De
Lillo, & Truppa, 2003). Humans, by contrast, seem to attend faster
and better to the global aspects of the stimuli than to their local
details (Navon, 1977).

The use of hierarchical visual stimuli is particularly suitable for
the comparative study of perceptual organization. Because, in
these stimuli, the same form can be presented at the global and
local levels, the observation of a global or local preference in
different species cannot be easily attributed to the salience or
familiarity of a particular shape, but has to reside in their specific
abilities to assemble a global form on the basis of local elements.

Use of this hierarchical paradigm has made it possible to show
a different sensitivity in human and nonhuman primates to spatial
proximity as a grouping factor. In fact, whereas an increase in the
separation of the elements of hierarchical stimuli disrupts the
ability of nonhuman primates to perceive the global structure of a
figure (Fagot & Tomonaga, 1999; Fagot, Tomonaga, & Deruelle,
2001; Spinozzi et al., 2003), in human adults and children, global
processing is robust across variations in the density of the stimuli
(De Lillo, Spinozzi, Truppa, & Naylor, 2002, 2004; Deruelle &
Fagot, 1998; Fagot & Deruelle, 1997; Fagot & Tomonaga, 1999).

Overall, these studies indicate that human and nonhuman pri-
mates differ in their ability to integrate elementary visual compo-
nents into a unitary percept (for a discussion, see Fagot et al.,
2001).

Considering the similarity of the visual system of humans and
nonhuman primates (Fobes & King, 1982; Walker, 1983), these
results seem to imply that interspecies differences in the mode of
processing visual information must reside in higher cognitive
functions.

However, as pointed out by Kimchi (1992), results obtained
using the global–local paradigm are neutral regarding how an
organism assembles a stimulus on the basis of more elementary
features or segments a complex pattern into more or less structured
sets of component parts. The study of the processing of hierarchi-
cal stimuli is only informative regarding the advantage offered by
one level of globality over the other in the processing of stimuli
specifically constructed so that global and local elements can be
equated in terms of their complexity and in terms of how difficult
it is to recognize and code them.

It seems therefore important to assess, using different experi-
mental paradigms and a wider range of tasks, whether nonhuman
primates, compared with humans, use different mechanisms for the
segmentation of visual scenes into their component parts on the
one hand, and for the integration of these component parts into a
whole figure on the other.

Under a variety of experimental procedures, it has been repeat-
edly found that humans, when required to identify a stimulus part
embedded in a more complex pattern, do not process the pattern as

a collection of local unrelated elements. They form instead a
structural description of the visual stimulus comprising meaningful
component parts—organized in conformity with gestalt laws of
perceptual organization, such as "closure" or "good continuation"
(Koffka, 1935; Kohler, 1947)—and spatial relationships among
the parts (Bower & Glass, 1976; Meinhardt, 2002; Palmer, 1977;
Pomerantz, 1985; Reed, 1974; Reed & Johnsen, 1975; Vecera,
Behrmann, & Goldrick, 2000).

The aim of the present study was to carry out a comparative
investigation of perceptual grouping processes in humans (*Homo
sapiens*) and tufted capuchin monkeys (*Cebus apella*), using the
same stimuli and comparable testing procedures. We used two
complementary types of task: one, analogous to an embedded
figures task, requiring the subjects to scan a stimulus in search of
some of its component parts, and the other requiring the subjects
to identify the part corresponding to a particular visual pattern.
With this type of task, it is possible to address the issue of what
principles of perceptual organization characterize the visual skills
of an organism. In fact, the stimulus parts can be obtained by
segmenting a stimulus in accordance with particular principles of
organization, or, by contrast, in ways that violate these principles.
The task should be relatively easy to solve when the principles
selected by the experimenter for the segmentation of the experi-
mental stimuli correspond to the laws governing perceptual group-
ing in that particular organism. By contrast, when the organiza-
tional principles chosen to obtain the stimulus parts are in conflict
with the laws governing the perceptual strategies of the organism,
the task should be more difficult to solve. A similar logic has been
applied to investigate how mental images are constructed in human
subjects and, in particular, to address the issue of whether or not
mental representations of visual stimuli are based on structural
descriptions that incorporate the interrelationship between stimu-
lus parts, and not merely a list of unrelated elements (Reed, 1974;
Reed & Johnsen, 1975).

In the experiments presented here, we extended this rationale to
a perceptual task in which the stimulus and its parts were presented
to monkeys (Experiments 1, 2, and 3) and humans (Experiment 4)
as a simultaneous matching-to-sample (MTS) task. By manipulat-
ing the way in which the original stimulus was segmented in order
to obtain the stimulus parts used in different conditions, we aimed
to assess whether the perceptual skills of capuchin monkeys are
facilitated by organizational principles such as closure and good
continuation, as has been reported for humans, or whether, by
contrast, they segment complex visual patterns using principles
different from those used by humans.

## Experiment 1

Experiment 1 was designed to gather information concerning
some of the principles governing perceptual segmentation in ca-
puchin monkeys. In a similarity MTS task, subjects were presented
with a complex visual pattern as the sample and had to choose
which one of two comparison stimuli featured a part of it. Accord-
ing to the different conditions of the experiment, in some trials the
stimulus parts were relatively disconnected, and in some trials they
were grouped in conformity with general rules of organization
such as closure and good continuation. Our assumption was that if
capuchin monkeys segment complex figures hierarchically into
subgroups of interrelated units, they should have found these latter
trials easier.

## Method

*Subjects.* Six (4 males and 2 females) adult tufted capuchins (*Cebus apella*), ranging in age from 11.02 to 21.80 years, were used in this experiment. The monkeys lived in four social groups, each housed in an indoor–outdoor cage (indoor: 3.0 m long × 1.7 m wide × 3.0 m deep; outdoor: 2.5 m long × 1.7 m wide × 3.0 m deep) at the Istituto di Scienze e Tecnologie della Cognizione, Consiglio Nazionale delle Ricerche, in Rome, Italy. Each subject was separated from the group solely for the purpose of testing, just before each daily testing session. The monkeys had food pellets freely available before and after testing; fresh fruit and vegetables were provided after testing. Water was freely available at all times. All the capuchins were already familiar with the MTS procedure, having been previously trained on tasks requiring pattern discrimination (De Lillo et al., 2002, 2004) and categorization problems (Spinozzi, Lubrano, & Truppa, in press), using this procedure (see Spinozzi et al., 2003, for a detailed description of the MTS training). However, they were naive with respect to the specific test featured in this study.

*Apparatus.* The apparatus consisted of a wooden panel (45 cm long × 35 cm high × 2 cm thick) with two square openings (5 × 5 cm), each at 10 cm from the center. The panel was fixed perpendicularly onto a wooden board (45 × 35 cm), which could be moved forward and backward on a support, mounted on a trolley (50 cm long × 50 cm wide × 55 cm high). Three polyvinyl chloride lids (7.0 cm long, 11.0 cm high, 0.3 cm thick) were used for stimulus presentation. Two lids were placed in front of the square openings of the vertical panel. They could be moved laterally in both directions along two parallel metal tracks (45 cm long × 1 cm high), mounted horizontally on the panel, 1 cm above and below the openings. The third lid was fixed at the center of the panel, 5 cm above the two openings and equidistant from them. The apparatus was installed outside the experimental cage (the indoor home cage), behind a transparent Plexiglas panel (45 cm long × 40 cm high) mounted on the front wall of the experimental cage. The Plexiglas panel had two symmetrical lateral arm holes (15 cm long × 5.5 cm high) at the level of the bottom edge of the square openings of the apparatus. The monkey had to insert an arm through one of the two holes and move one of the sliding lids covering the panel square openings in order to reach for a peanut. The square openings of the apparatus were positioned at the subjects' eye level (see Figure 1).

*Stimuli.* The stimulus set comprised 12 different stimuli. It included four complex shapes and, for each of them, 2 stimuli that included isolated patterns representing some of the possible units or parts in which the corresponding complex shape could be divided (see Figure 2).

Regarding the complex shapes, two types of stimuli were used: *closed* stimuli, each resulting from the partial overlapping of three closed shapes (e.g., three overlapping circles and three overlapping squares), and *open*
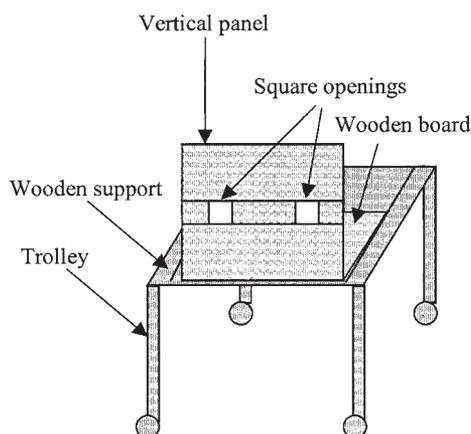
stimuli, each composed by the partial overlapping of three open shapes (e.g., three overlapping vertical crosses and three overlapping horizontal crosses).

Regarding the isolated patterns (i.e., the parts), two types of stimuli were used: *grouped* stimuli, which included a pattern structured on the basis of general laws of organization such as spatial closure, good continuation, or line intersection, producing figures that in humans are regarded as good shapes (e.g., a circle or a cross, Kohler, 1947; see also Lasaga & Garner, 1983; Roberson et al., in press; Tada & Stiles, 1996), and *ungrouped* stimuli, which included a subset of separated segments not organized according to these grouping laws (see Figure 2). Both grouped and ungrouped stimuli were obtained by removing some parts from the corresponding complex shapes.

The overall size of the complex stimuli varied according to the spatial location of the overlapping shapes (height: range = 4.5–5.5 cm; width: range = 3.5–5.5 cm). The size of each of the grouped isolated patterns was as follows: circle and square, 2.5 × 2.5 cm; vertical cross, 3.5 × 2.0 cm; horizontal cross, 2.0 × 3.5 cm. The overall size of each of the ungrouped isolated patterns varied according to the spatial location of segments belonging to the complex pattern; when connected, the overall dimensions of the ungrouped isolated pattern were identical to the corresponding grouped ones. All the stimuli appeared as white shapes on a black background and were created with Microsoft PowerPoint. Each stimulus was printed on paper and was glued onto polyvinyl chloride lids.

*Procedure.* A simultaneous MTS procedure was adopted. At the beginning of each trial, the apparatus was placed in front of the experimental cage, at a distance of 30 cm. A sample stimulus, belonging to either the closed or the open category of complex patterns, was placed at the center of the apparatus, in full view of the subject. Then, the experimenter simultaneously placed the two comparison stimuli (i.e., the parts) in front of the square openings of the panel, approximately 6 cm to the right and 6 cm to the left of the sample: the positive comparison stimulus (S+) was a part of the sample, whereas the negative comparison stimulus (S–) was unrelated to the sample (see Figure 3). The panel was moved forward, bringing it within the subject's arm reach (at a distance of about 15 cm from the cage). The monkey could obtain the reward only if it moved the lid holding the positive stimulus (S+). When the subjects performed a choice, the panel was moved away from the cage, and a new trial was set up. The intertrial interval was approximately 30 s after a correct response and approximately 60 s after an incorrect response.

Each monkey performed 10 daily sessions of 24 trials each, for a total of 240 trials. One half of the trials included closed patterns (e.g., overlapping circles and squares), and the other half included open patterns (e.g., overlapping vertical and horizontal crosses) as sample stimuli. Each complex stimulus was presented six times as the sample in a pseudorandom order, ensuring that 2 consecutive trials could not feature the same stimuli and that the comparison stimuli appeared to the left and right side of the sample with equal frequency. For each sample stimulus, there were three grouped and three ungrouped matching trials, in which the comparison stimuli involved either isolated grouped parts (e. g., a circle and a square) or isolated ungrouped parts (e. g., four arcs and four straight lines), with grouped and ungrouped trials randomly intermixed.

All daily sessions were preceded by nine practice trials that used an identity-MTS procedure and stimuli different from those used in the test (e.g., simple filled shapes such as arrows and hearts). These trials were used to assess the MTS performance level of each subject before each task. Seven correct responses out of nine was the criterion to be reached before the administration of the test session. No physical restriction was imposed on the monkeys during the task.

## Results

Table 1 reports the mean percentages of correct responses performed by each monkey in the test trials for both closed and open complex shapes, in grouped and ungrouped conditions. The
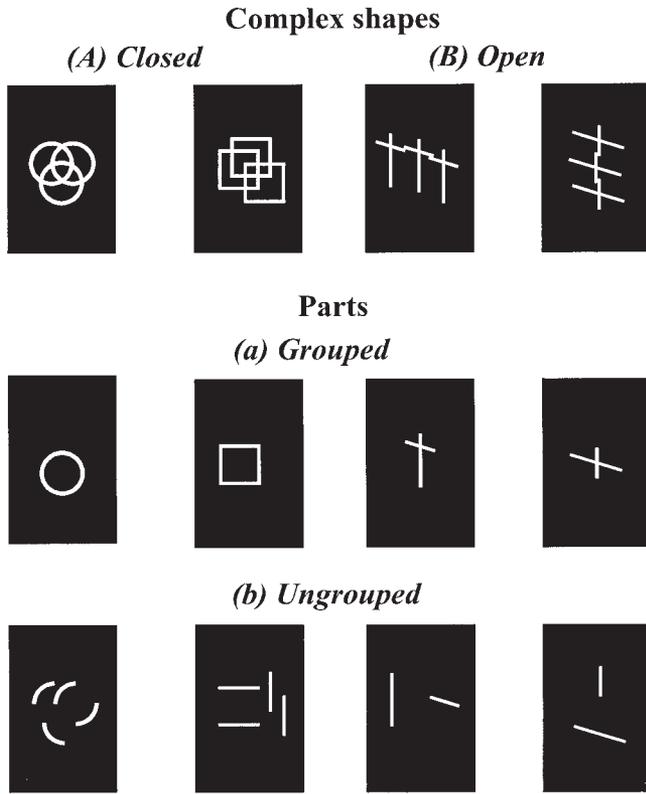


*Figure 1.* Apparatus used with monkeys.

## Complex shapes

### (A) Closed

### (B) Open



## Parts

### (a) Grouped



### (b) Ungrouped



*Figure 2.* Stimuli used in Experiment 1 and Experiment 2 with monkeys, and in Experiment 4 with humans.

overall mean percentages of correct responses ranged from 70.8% to 87.1%.

An analysis of variance (ANOVA) was performed on the percentages of correct responses, with complex-stimulus type (closed vs. open), part type (grouped vs. ungrouped), and session (1–10) as repeated measures factors. A significant main effect was obtained for part type, $F(1, 5) = 12.8$, $p < .05$, partial $\eta^2 = .72$, with a higher percentage of correct responses in the ungrouped trials (81.2%) than in the grouped (73.9%) trials (see Table 1). Moreover, a significant effect of sessions was found, $F(9, 45) = 3.2$, $p < .01$, partial $\eta^2 = .39$. A trend analysis showed that the overall accuracy level increased linearly across sessions, $F(1, 5) = 21.4$, $p < .01$ (Session 1 = 70.8%, Session 2 = 72.9%, Session 3 = 77.0%, Session 4 = 75.7%, Session 5 = 79.1%, Session 6 = 75.6%, Session 7 = 80.5%, Session 8 = 83.3%, Session 9 = 77.7%, Session 10 = 82.6%). No other main effect or interactions proved significant. A one-sample $t$ test carried out to assess the probability of obtaining, in the first testing session, the percentages of correct responses of our sample from a population of scores with a mean of 50% showed that, for the group, the overall accuracy level in the first session of the task (71.0%) was above chance, $t(5) = 9.7$, $p < .001$. Moreover, to evaluate further the extent to which learning was required to achieve an above-chance performance, we verified how subjects responded at the very first presentations of each of the four complex shapes in both the grouped and the ungrouped conditions during the first session of the task. Data for these trials are reported in Table 2. As shown in Table 2, in the grouped condition, five monkeys were correct on three of the initial four trials whereas one monkey was always correct irrespectively of which complex pattern was presented; in
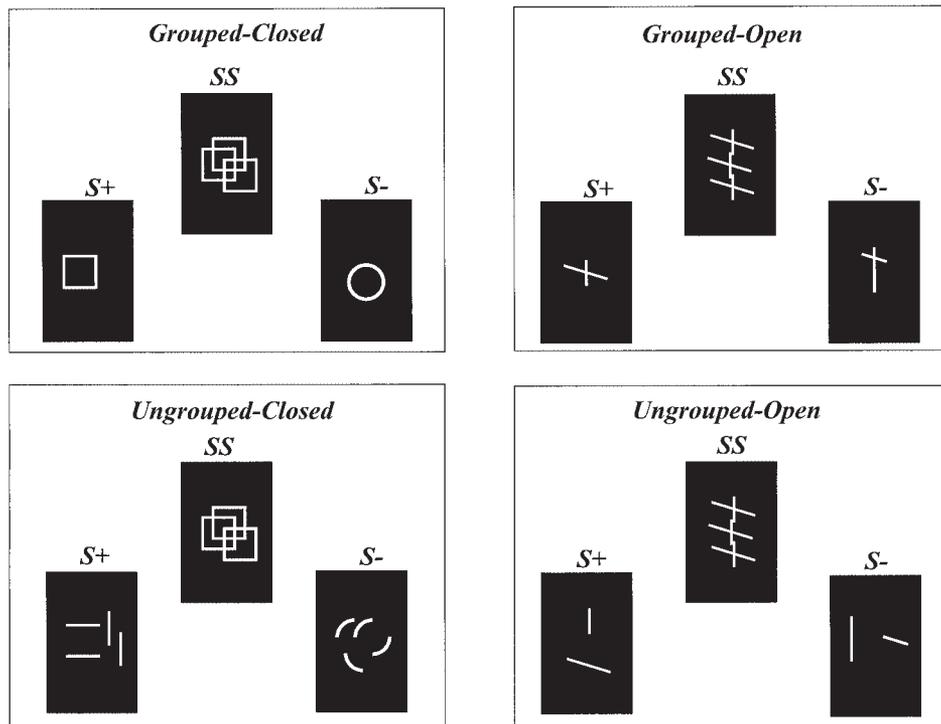


*Figure 3.* Examples of stimulus presentation for each condition. SS = sample stimulus; S+ = positive comparison stimulus; S− = negative comparison stimulus.

Table 1
*Experiment 1: Percentage of Correct Responses by Each Monkey for Each Type of Complex Shape and Matching Part*

| Subject | Complex shape (sample) | Part (comparison stimulus) | |
|---|---|---|---|
| | | Grouped | Ungrouped |
| Narciso | Closed | 73.3 | 83.3 |
| | Open | 75.0 | 81.7 |
| Patè | Closed | 58.3 | 73.3 |
| | Open | 76.6 | 80.0 |
| Brahms | Closed | 65.0 | 80.0 |
| | Open | 78.3 | 78.3 |
| Gal | Closed | 85.0 | 90.0 |
| | Open | 85.0 | 88.3 |
| Pepe | Closed | 70.0 | 73.3 |
| | Open | 56.7 | 83.3 |
| Pippi | Closed | 83.3 | 80.0 |
| | Open | 80.0 | 83.3 |
| *M* | | 73.9 | 81.2 |

the ungrouped condition, four monkeys were correct three out of four times and the remaining two were always correct. One sample *t*-test carried out on these data revealed that the observed mean of correct responses for the sample of monkeys on these four initial trials was significantly different from the value expected on the basis of random responding (i.e., 2 correct responses) for both the grouped ($M = 3.17$), $t(5) = 7$, $p < .01$, and the ungrouped condition ($M = 3.33$), $t(5) = 6.33$, $p < .01$. Altogether, the level of success shown by the monkeys on the first occasion that they were faced with a particular combination of stimuli suggests that their matching performance could not be exclusively based on the gradual development of associations between a particular sample and the corresponding S+.

*Discussion*

This experiment demonstrates that capuchins are able to perform an efficient analysis of a complex pattern in search of its constituent parts as shown by the very high level of accuracy observed across the different conditions of the experiment. Although performance level improved significantly across sessions, capuchins' ability to solve the matching problem was evident by the first trials of the task. This suggests that the monkeys were not using a simple associative strategy (i.e., learning a conditional discrimination by trials and errors) to choose the rewarded stimulus, but that they were instead attending to the particular matching relation between the sample and the comparison stimuli to solve the task.

Moreover, we found that the level of performance was higher when the parts to be detected were ungrouped elements. Thus, notwithstanding the fact that the monkeys had the parts and the whole stimulus available at the same time, and no time constraints were imposed on their responses, they were less accurate in identifying parts obtained by segmenting the stimulus as three overlapping geometric shapes, such as a circle or a cross. It seems therefore that capuchin monkeys, at least within the scope of the stimuli and the tasks featured in this experiment, find it more difficult to decompose a multipart shape into substructures based on principles of perceptual organization such as closure, good continuation, or line intersection, which are normally strong

grouping cues in humans (Bower & Glass, 1976; Lasaga & Garner, 1983; Palmer, 1977; Reed, 1974; Reed & Johnsen, 1975).

With the procedure adopted here it is impossible to establish whether (a) the subjects segmented the sample stimulus in its component parts first and then tried to match these parts with the comparison stimuli, (b) they used the opposite strategy of attending to one of the comparison stimuli first and then searching for the presence of the subpattern featured in the sample stimulus, or (c) they alternated these two strategies before making a choice.

However, because the complex shape (i.e., the sample) was always presented before the parts (i.e., the comparison stimuli), it is possible that this particular order of presentation influenced the way in which our subjects approached the problem. It is therefore important to assess whether the same results would have been obtained in a task where the subjects received the stimulus parts as the sample and the whole complex figures as the comparison stimuli. We addressed this issue in Experiment 2.

Experiment 2

It has been shown that humans, when required to judge whether one pattern is part of another presented successively, find the task easier when the part is presented before the whole stimulus. It has been suggested that this effect might be the expression of two different cognitive processes taking place with regard to the order of presentation of the stimulus and their parts (Reed & Johnsen, 1975). If the whole stimulus is presented first, participants would engage in an active segmentation of the representation of the stimulus. By contrast, if the parts are presented first, a search procedure would enable their detection in the visually presented stimulus and segmentation of the mental image of the stimulus would not be required.

The aim of Experiment 2 was to evaluate whether the same pattern of results obtained in Experiment 1 would have been observed in a situation where the sample featured the stimulus parts and the comparison stimuli featured the complex figures.

*Method*

*Subjects, apparatus, stimuli, and procedure.* Subjects, apparatus, and stimuli were the same as used in Experiment 1. However, in Experiment 2, the monkeys were presented first with the stimulus part as the sample stimulus and then with the two complex patterns as comparison stimuli. The subjects had to identify which of the two comparison stimuli included

Table 2
*Experiment 1: Trial 1 Responses to Each Complex Pattern for Grouped and Ungrouped Conditions of Session 1*

| Subject | Grouped | | | | Ungrouped | | | |
|---|---|---|---|---|---|---|---|---|
| | 3Cr | 3X | 3C | 3S | 3Cr | 3X | 3C | 3S |
| Narciso | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Patè | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| Brahms | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 |
| Gal | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Pepe | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 |
| Pippi | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 |

*Note.* 3Cr = 3 overlapping vertical crosses; 3X = 3 overlapping horizontal crosses; 3C = 3 overlapping circles; 3S = 3 overlapping squares. 1 = correct response; 0 = erroneous response.

the sample. In this case, grouped and ungrouped trials were defined on the basis of the type of segmentation proposed in the sample stimulus (see Figure 2).

Testing occurred immediately after the completion of Experiment 1. Each subject performed 10 daily sessions of 24 trials each, for a total of 240 trials. Each session included all the eight isolated parts, with each part being presented three times as the sample within each session. There were 12 grouped and 12 ungrouped trials, in which the sample stimulus involved either isolated grouped parts (e.g., a circle or a vertical cross) or isolated ungrouped parts (e.g., four arcs or one short oblique line and one long vertical line) with grouped and ungrouped trials pseudorandomly intermixed so that identical trials could not appear consecutively.

### Results

The overall mean percentages of correct responses ranged from 77.5% to 89.2%. A repeated measures ANOVA (Isolated Part [grouped vs. ungrouped] $\times$ Complex Stimulus [closed vs. open] $\times$ Session [1–10]) did not reveal a significant main effect of isolated-part type (grouped, $M = 81.4\%$; ungrouped, $M = 83.9\%$; see Table 3), complex-stimulus type (closed, $M = 81.5\%$; open, $M = 83.7\%$), or sessions (mean range: 79.2%–84.0%). Likewise, no interactions proved significant.

In order to compare the pattern of results obtained in Experiment 1 and Experiment 2, an ANOVA was carried out on the percentage of correct responses observed in the different conditions of the two experiments. The overall performance level observed in Experiment 2 (82.6%) was significantly higher than that observed in Experiment 1 (77.6%), $F(1, 5) = 16.8$, $p < .01$, partial $\eta^2 = .77$. Moreover, there was a significant main effect of stimulus part, $F(1, 5) = 16.0$, $p < .05$, partial $\eta^2 = .76$, with an overall higher accuracy for ungrouped (82.6%) than for grouped (77.6%) parts. No other main effect or interactions proved significant (see Figure 4).

### Discussion

The results of Experiment 2 show that capuchin monkeys also perform at a very high level of accuracy in conditions where, in analogy with a standard embedded figures task, stimulus parts are presented first as the sample, and the complex patterns that have to

be searched for their presence are subsequently presented as the comparison stimuli. However, in contrast with the results of the previous experiment, we found that the subjects were equally successful in trials featuring grouped and ungrouped parts.

One possible explanation of the fact that Experiment 2 failed to replicate the difference in performance observed between the conditions featuring grouped stimuli and the condition featuring ungrouped stimuli of Experiment 1 is that different processes underpinned task solution in the two experiments.

Because in our procedure the presentation of the sample always precedes the presentation of the comparison stimuli, it is reasonable to conjecture that the subjects attend to this particular stimulus first and use it for subsequent comparisons with S+ and S–. If so, in order to select the correct stimulus, in Experiment 1 subjects had to segment it into its constituent parts in order to match it with one of the comparison stimuli. A difficulty in solving the task would be experienced here when the product of the perceptual segmentation operated by the subject differed from the actual segmentation proposed (by the experimenter) in the comparison stimuli.

By contrast, in Experiment 2, in which the proposed segmentation was presented as the sample stimulus, the subject might not necessarily have engaged in a similar process. It would suffice here to "search" for the elements (or the grouped subunit) in each of the comparison stimuli without necessarily having to segment them. When a correct match is found, the response to the appropriate stimulus is emitted. Should this explanation apply, given the absence of active stimulus segmentation by the subject, the problems deriving from a potential conflict with the proposed segmentation would not emerge.

Although the above explanation could account for the results, it is still possible that the disappearance of the effects observed in Experiment 1 was due to general task practice, which produced the observed improvement in the grouped trials in Experiment 2. Experiment 3 was designed to assess the extent to which this latter possibility is plausible.

## Experiment 3

In order to assess whether the different pattern of results obtained in the first two experiments could be accounted for merely in terms of an improvement in the grouped condition in Experiment 2 that was due to task practice, the design of Experiment 3 featured the tasks presented in Experiments 1 and 2, counterbalanced across subjects for order of presentation. Novel stimuli were used for this experiment. The use of new stimuli in Experiment 3 also enabled the assessment of the generality of the results obtained in the previous experiments.

### Method

*Subjects, apparatus, and stimuli.* Subjects and apparatus were the same as used in the previous two experiments. However, the monkeys were tested with a different stimulus set. It comprised 12 new stimuli, which included four complex shapes and, for each of them, two stimulus parts (see Figure 5). As in the previous experiments, the complex stimuli featured three closed or three open overlapping shapes, and the isolated patterns included both grouped and ungrouped parts.

The overall size of both complex shapes and grouped isolated patterns was similar to that of the stimuli used in the previous experiments. As in Experiments 1 and 2, the overall size of the ungrouped isolated patterns varied according to the spatial location of segments belonging to the

Table 3

*Experiment 2: Percentage of Correct Responses by Each Monkey for Each Type of Part and Complex Matching Shape*

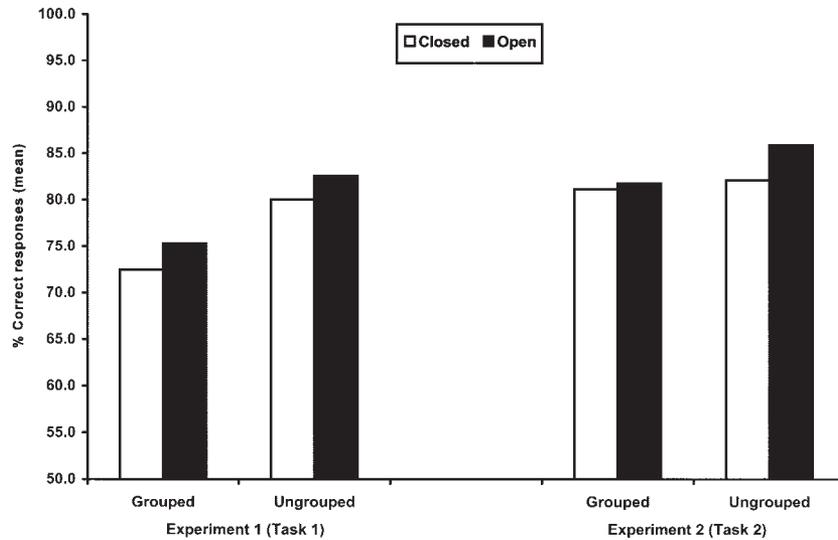| Subject | Complex shape (comparison stimulus) | Part (sample) | |
|---|---|---|---|
| | | Grouped | Ungrouped |
| Narciso | Closed | 75.0 | 78.3 |
| | Open | 81.7 | 83.3 |
| Patè | Closed | 73.3 | 70.0 |
| | Open | 78.3 | 88.3 |
| Brahms | Closed | 78.3 | 86.7 |
| | Open | 75.0 | 85.0 |
| Gal | Closed | 93.3 | 88.3 |
| | Open | 86.7 | 88.3 |
| Pepe | Closed | 78.3 | 78.9 |
| | Open | 83.3 | 81.7 |
| Pippi | Closed | 88.3 | 90.0 |
| | Open | 85.0 | 88.3 |
| *M* | | 81.4 | 83.9 |

*Figure 4.* Mean percentage of correct responses by capuchins in each condition featured in Experiment 1 (Task 1) and Experiment 2 (Task 2).

corresponding complex shapes. All the stimuli were created with Microsoft PowerPoint and appeared as white shapes on a black background.

*Procedure.* In the present experiment, we used the same MTS procedure used in the first two experiments. However, here, 3 subjects were presented with the task used in Experiment 1 (labeled Task 1), in which a complex shape was used as the sample and the stimulus parts were

## Complex shapes

### (A) Closed        (B) Open



### Parts

#### (a) Grouped



#### (b) Ungrouped



*Figure 5.* Stimuli used in Experiment 3 with monkeys and in Experiment 4 with humans.

presented as the comparison stimuli, and then with the task used in Experiment 2 (labeled Task 2), in which the sample featured the stimulus parts and the comparison stimuli depicted the complex shape. The other 3 monkeys received Task 2 first, and then Task 1.

For both Task 1 and Task 2, each subject performed 10 sessions of 24 trials each, one session a day, for a total of 240 trials per task. As in the previous experiments, each session included 12 grouped and 12 ungrouped trials, randomly intermixed.
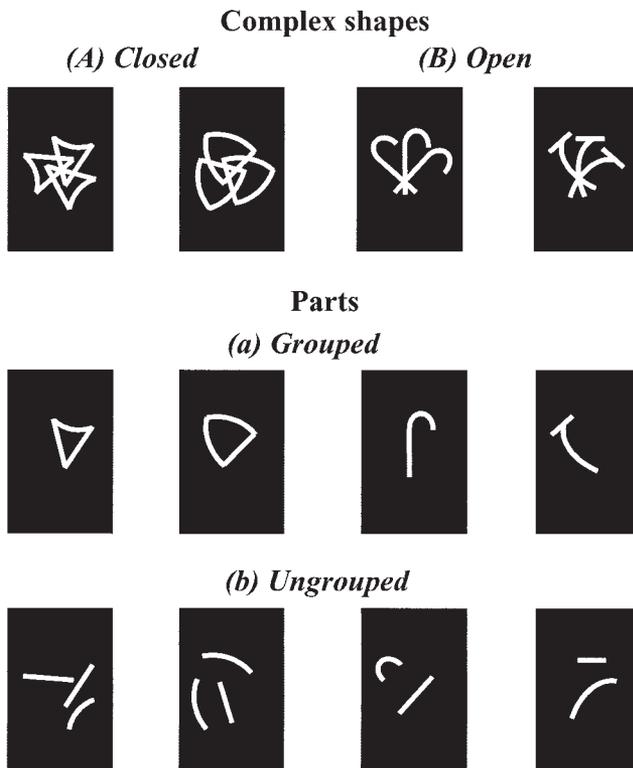
### Results

Table 4 reports the individual percentages of correct responses for each task, in the different experimental conditions.

Two separated three-way (Complex Stimulus × Isolated Part × Session) ANOVAs were carried out to analyze the percentage data obtained in each task.

For Task 1, the analysis revealed, once again, a significant main effect of isolated-part type, $F(1, 5) = 22.6$, $p < .01$, partial $\eta^2 = .82$, with a higher level of accuracy for ungrouped trials ($M = 87.9\%$) than for grouped trials ($M = 81.9\%$, see Table 4). Thus, as in Experiment 1, the monkeys found it easier to identify parts of a stimulus presented as a disconnected set of elements than to identify parts presented as a group of interrelated elements. The effects of complex-stimulus type and sessions were not significant. Likewise, none of the interactions were significant.

For Task 2, the ANOVA failed to reveal any significant main effects or interactions.

### Discussion

Overall, the results of Experiment 3 confirm those obtained in the first two experiments, showing that the difference in the pattern of results obtained in the previous experiments has to be attributed to the type of tasks used there. Moreover, because novel stimuli were used in Experiment 3, the observed results do not seem to be specifically related to the particular stimuli used in Experiments 1 and 2.

Table 4

*Experiment 3: Percentage of Correct Responses by Each Monkey in Each Task for Each Type of Part and Complex Shape*

| Subject | Complex shape | Task 1 part[a] | | Task 2 part[b] | |
|---|---|---|---|---|---|
| | | Grouped | Ungrouped | Grouped | Ungrouped |
| Narciso[c] | Closed | 78.3 | 85.0 | 86.7 | 81.7 |
| | Open | 95.0 | 90.0 | 86.7 | 91.7 |
| Patè[c] | Closed | 75.0 | 86.7 | 78.3 | 86.7 |
| | Open | 90.0 | 91.7 | 83.3 | 73.3 |
| Brahms[c] | Closed | 86.7 | 88.4 | 76.6 | 88.3 |
| | Open | 86.7 | 95.0 | 86.7 | 81.7 |
| Gal[d] | Closed | 90.0 | 86.7 | 98.3 | 95.0 |
| | Open | 80.0 | 98.4 | 93.3 | 96.7 |
| Pepe[d] | Closed | 73.3 | 86.7 | 81.7 | 91.7 |
| | Open | 81.7 | 85.0 | 86.7 | 88.3 |
| Pippi[d] | Closed | 73.3 | 83.4 | 83.4 | 85.0 |
| | Open | 73.3 | 76.7 | 90.0 | 86.7 |
| M | | 81.9 | 87.9 | 86.1 | 87.2 |

[a] In Task 1, the parts featured the comparison stimuli. [b] In Task 2, the parts featured the sample stimulus. [c] Subjects receiving Task 1 first. [d] Subjects receiving Task 2 first.

However, scrutiny of Table 4 reveals that individual subjects' accuracy scores were higher than those observed in the previous experiments, showing that learning can improve task performance. Such improvement was mainly evident in Task 1. This notwithstanding, the monkeys continued to solve the two tasks in a different way. As in Experiment 1, a clear advantage for ungrouped trials was still evident in Task 1, in which the complex pattern was presented as the sample and the parts as comparison stimuli. This advantage did not emerge in Task 2, in which the sample featured the stimulus parts and the comparison stimuli the complex figures. Here, the monkeys performed equally well in both the grouped and the ungrouped conditions, as in Experiment 2. Thus, the disappearance of the effects observed in Experiment 2 and in Task 2 of Experiment 3 cannot be accounted for merely by task practice.

## Experiment 4

There is considerable evidence from experimental psychology that humans, when required to identify the parts of a complex stimulus, typically segment visual stimuli hierarchically into highly organized units (Bower & Glass, 1976; Palmer, 1977; Reed, 1974; Reed & Johnsen, 1975). However, with some of the paradigms adopted with humans (see Reed, 1974; Reed & Johnsen, 1975), subjects do not have the complex stimuli and their parts available at the same time during a trial, and because the retention of at least one of the stimuli is required in these tasks, inferences can be drawn about how the patterns are coded in a mental image. Our previous results with monkeys are neutral concerning the issue of the way our subjects code the stimuli in memory. They only provide evidence that capuchins, faced with a perceptual task not necessarily relying on the retention of a visual image, find the task easier to solve when the parts are presented as elements in spatial isolation. Considering the variety of tasks adopted in different studies with human participants, inferences concerning differences

between humans and capuchin monkeys are not warranted on the basis of the above-cited literature.

The aim of Experiment 4 was to collect data on humans, which enabled meaningful comparisons with data collected on tufted capuchin monkeys. To this end, we used the same stimuli and paradigms as those used with monkeys, and comparable testing procedures. The design of the present experiment was similar to that adopted in Experiment 3, featuring two tasks (Task 1 and Task 2) counterbalanced across subjects for order of presentation.

### Method

*Participants.* The group of human (*Homo sapiens*) participants was composed of 128 (17 men and 111 women) psychology undergraduates at the University of Leicester. They had normal or corrected-to-normal vision and were naive about the experimental hypothesis.

*Apparatus and stimuli.* The experimental setup was composed of Pentium III, 800 MHZ, PCs with 15-in. SVGA monitors with a resolution of 1024 × 768 pixels. The software used to run the experiments was developed at the University of Leicester, using E-prime (Psychology Software Tools Inc.). It enabled the recording of the frequency of correct responses and of the response time (RT) with an accuracy of 1 ms.

Bitmaps of the stimuli used in Experiments 1, 2, and 3 with monkeys were used for stimulus presentation on the computer screen. The whole set of stimuli used with monkeys (see Figure 2 and Figure 5) was used in the present experiment. Therefore, the stimulus set was composed of 24 stimuli, which included eight complex figures (four from Set 1 and four from Set 2) featuring closed and open overlapping shapes and, for each of them, two stimulus parts featuring both grouped and ungrouped patterns. The size of each stimulus was the same as the size used with monkeys.

*Procedure.* Each participant sat in front of a computer at a distance of approximately 30 cm from the screen. Trials started with a stimulus sample displayed centrally at the top of the screen. After a brief, randomly generated interval, lasting between 2 and 3 s, the two comparison stimuli appeared at the bottom left and right corners of the screen, respectively. The subject's task was to indicate, by pressing the "1" or the "2" key, respectively located on the left and right of the computer keyboard, which of the two patterns (the one presented on the left or the one presented on the right of the screen) resembled most closely the centrally presented pattern. All the three stimuli remained present on the screen until a response was made.

Half of the participants received Task 1, in which a complex shape was used as the sample and the parts were presented as the comparison stimuli, and then Task 2, in which the sample featured the stimulus parts and the comparison stimuli depicted the complex shape. The other half received Task 2 first and then Task 1.

For both Task 1 and Task 2, each participant performed a session of 48 trials, which included the four conditions (closed–grouped, closed–ungrouped, open–grouped, open–ungrouped) featured in the previous experiments. In each task, each condition comprised 12 trials. For Task 1, each complex stimulus (open, closed) was presented six times as the sample, and for Task 2, each isolated part (grouped, ungrouped) was presented three times as the sample. For both tasks, the trials were presented in a pseudorandom order so that two identical trials could not appear consecutively.

The analysis of the performance shown by humans was based on both accuracy scores and RTs.

### Results

*Accuracy.* The mean percentages of correct responses performed by the participants in each task (Task 1 and Task 2) are reported in Table 5. The overall mean percentages of correct responses ranged from 75.0% to 100.0% in Task 1, and from

Table 5

*Experiment 4: Mean Percentages of Correct Responses by Humans in Each Task for Each Type of Part and Complex Shape*

| Complex shape | Task 1 part[a] | | | Task 2 part[b] | | |
|---|---|---|---|---|---|---|
| | Grouped | Ungrouped | *M* | Grouped | Ungrouped | *M* |
| Closed | 98.7 | 95.8 | 97.3 | 99.4 | 94.0 | 96.7 |
| Open | 93.4 | 90.2 | 91.8 | 94.1 | 90.8 | 92.5 |
| *M* | 96.1 | 93.1 | | 96.7 | 92.4 | |

[a] In Task 1, the parts featured the comparison stimuli.  [b] In Task 2, the parts featured the sample stimulus.

79.2% to 100.0% in Task 2. It is worth noting that in only 6 of 128 individuals (4.7%) was performance always correct (i.e., 100%) in all conditions of both tasks.

A 2 × 2 × 2 (Task × Part × Complex Stimulus) ANOVA comparing the percentage of correct responses observed in the two tasks did not reveal any significant main effect of task: The overall performance level was similar in both tasks (Task 1: 94.5%; Task 2: 94.6%). However, the effects of part type, $F(1, 127) = 71.3$, $p < .001$, partial $\eta^2 = .37$, and complex stimulus, $F(1, 127) = 63.9$, $p < .001$, partial $\eta^2 = .34$, were significant. The overall accuracy scores were higher for grouped (96.4%) than for ungrouped (92.7%) parts, and for closed (97%) than for open (92.1%) shapes (see Figure 6). None of the interactions between factors was significant.

*RT analysis.* This analysis could only be carried out on the human sample, as RTs could not be collected in the experiments with monkeys. As here we were interested in a measure of the time required to process the stimuli featured in the different task conditions, and because only when subjects respond correctly is it possible to assume that stimulus processing has actually taken place, RTs for incorrect responses were not included in the analysis. The mean response latencies are reported in Table 6.

A 2 × 2 × 2 (Task × Part × Complex Stimulus) analysis revealed a significant effect of task, $F(1, 127) = 11.9$, $p < .001$, partial $\eta^2 = .09$. The participants responded faster in Task 2 (1,454.6 ms) than in Task 1 (1,634.2 ms). In addition, there were significant effects of part, $F(1, 127) = 445.1$, $p < .001$, partial $\eta^2 = .77$, and of complex stimulus, $F(1, 127) = 307.1$, $p < .001$, partial $\eta^2 = .71$. The overall mean RTs for the ungrouped parts were significantly slower (1,873.3 ms) than those for the grouped (1,215.4 ms) parts. Responses to open shapes were slower (1,762.0 ms) than responses to closed shapes (1,326.7 ms). Finally, the interaction between the task variable and the part variable proved statistically significant, $F(1, 127) = 13.8$, $p < .001$ partial $\eta^2 = .10$. Post hoc comparisons (Tukey's test) revealed that, within each task, the mean RTs for grouped conditions were significantly faster than the mean RTs for ungrouped conditions (Task 1: grouped = 1,260.5 ms, ungrouped = 2,007.8; Task 2: grouped = 1,170.4, ungrouped = 1,738.7; all $ps < .001$). Moreover, intertask comparisons revealed that, for the trials featuring grouped parts, the mean RT recorded in Task 1 was significantly longer than the mean RT recorded in Task 2 ($p < .05$). Similarly, for the trials featuring ungrouped parts, the mean RT was significantly longer in Task 1 than in Task 2 ($p < .001$, see Figure 7). An inspection of the pattern of means observed in the different conditions suggests that this interaction could be explained by the fact that the difference between the mean RT for Task 1 and Task 2 is smaller for the grouped trials than for the ungrouped trials. Neither the Task × Complex Stimulus interaction nor the third-order interaction between the three factors was significant.

## Discussion

The results of Experiment 4 indicate important differences between the perceptual strategies deployed by humans and capuchin monkeys when detecting component parts of complex patterns. Unlike monkeys, humans find it easier to detect parts of a complex figure when these are sets of units organized according to grouping principles rather than unconnected elements. Moreover, humans,
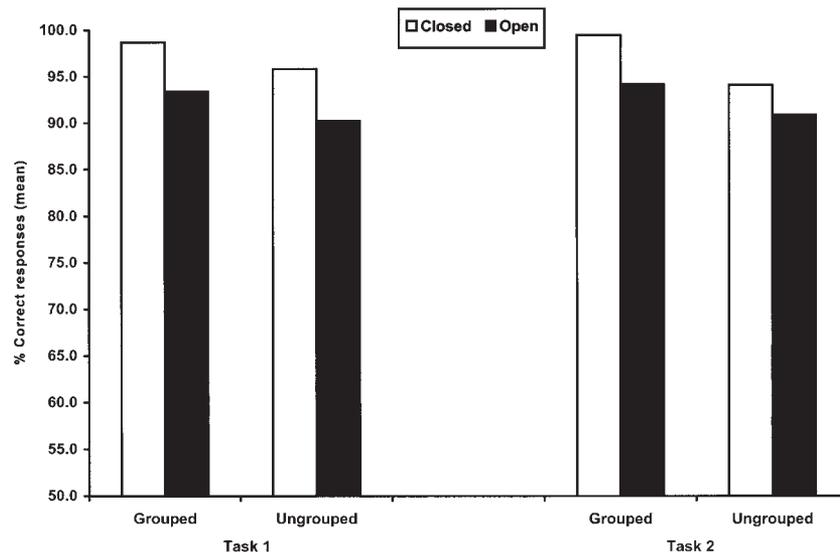


*Figure 6.* Mean percentage of correct responses by humans for each condition and task (Task 1, Task 2) featured in Experiment 4.

Table 6
*Experiment 4: Mean Latency (in Milliseconds) Scores by Humans in Each Task for Each Type of Part and Complex Shape*

| Complex shape | Task 1 part[a] | | | Task 2 part[b] | | |
|---|---|---|---|---|---|---|
| | Grouped | Ungrouped | M | Grouped | Ungrouped | M |
| Closed | 1,015.4 | 1,811.5 | 1,413.5 | 945.5 | 1,534.4 | 1,240.0 |
| Open | 1,505.5 | 2,204.2 | 1,854.9 | 1,395.2 | 1,943.1 | 1,669.2 |
| M | 1,260.5 | 2,007.8 | | 1,170.4 | 1,738.7 | |

[a] In Task 1, the parts featured the comparison stimuli.   [b] In Task 2, the parts featured the sample stimulus.

in contrast with monkeys, showed the same pattern of results when the subjects had to judge which one of two stimuli featured a part of the complex pattern (Task 1), and when they had to judge which one of two complex patterns contained its component part (Task 2). In addition, in humans, the detection of parts of a complex figure was carried out more efficiently when the figure featured closed overlapping units versus open overlapping components, suggesting that closure is a strong cue for the visual processing of multipart stimuli in humans, a finding in agreement with evidence from other studies (Elder & Zucker, 1993; Kovacs & Julesz, 1993).

The RT analysis confirmed the findings obtained with accuracy measures and provided further information concerning the effect of stimulus presentation on humans' matching performance. Participants proved faster in responding correctly when the parts were presented as sample stimuli (Task 2) than when they were presented as comparison stimuli (Task 1), a result comparable to that obtained by Reed and Johnsen (1975) using a different experimental paradigm.

It could be argued that differences between humans and capuchins observed in this study might be related to the differences in the testing procedure that we used with the two species. For example, whereas humans were instructed verbally to select the comparison stimulus that was most similar to the sample stimulus, capuchins received several identity MTS trials before each testing session to ensure comprehension of the MTS task. It is, however, difficult to envisage how such a procedural difference could explain the fact that humans performed better in particular conditions
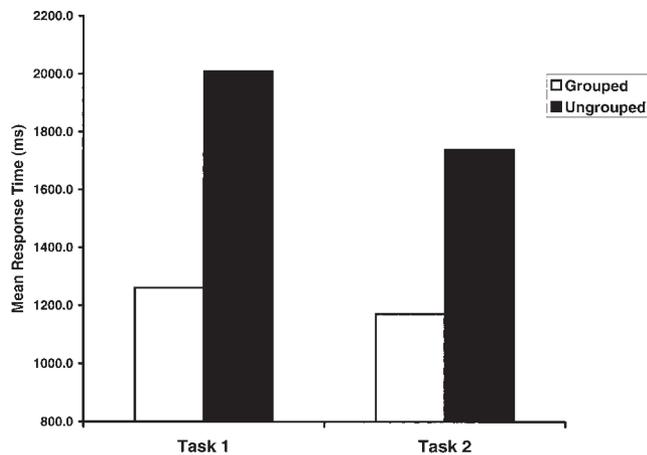
and monkeys performed better in others, especially considering the overall high level of accuracy shown by the two species. Moreover, if the MTS trials presented to the monkeys before each daily testing sessions had biased their responses in the experimental trials, it is difficult to argue that this bias would have favored the processing of ungrouped parts because the stimuli featured in the pretest were simple filled shapes.

Another difference in the testing procedure used with humans and capuchins concerned the reinforcement schedule. Humans were never told whether they responded correctly, whereas capuchins were reinforced for every correct response. This variable may have differentially affected overall performance, but it cannot explain why grouped and ungrouped conditions were processed differently in the two species.

## General Discussion

Overall, the findings of the four experiments presented here indicate clear differences between humans and nonhuman primates in their mode of analyzing multicomponent patterns in order to detect their component parts.

The results of Experiment 1 show that the performance of capuchin monkeys is facilitated when the stimulus parts are relatively disconnected compared with conditions in which they are presented as units grouped on the basis of organizational principles.

In Experiment 2, however, where the task resembled a standard embedded figures paradigm (Gottshaldt, 1926) and required a visual scanning of complex forms, presented as comparison stimuli, in search for the presence of their parts, presented as the sample, the performance level of monkeys in the grouped conditions became indistinguishable from that observed in the ungrouped conditions.

The results of Experiment 3 allowed us to rule out that the differences between the results of Experiment 1 and Experiment 2 were due to mere task practice. In fact, when the same tasks were presented again in Experiment 3 and counterbalanced across subjects for order of presentation, the same pattern of results observed in Experiment 1 and 2 emerged. As Experiment 3 featured novel stimuli, moreover, it seems that the observed results are not restricted to the particular stimuli featured in Experiment 1 and 2. It seems, therefore, reasonable to conclude that the subjects were differentially affected by the task procedures used in the two experiments.

One possible interpretation of these findings is that capuchins deployed two different strategies in Experiments 1 and 2. It is possible that whereas in Experiment 1 they were actively seg-



*Figure 7.* Mean response time by humans for each condition and task (Task 1, Task 2) featured in Experiment 4.

menting the complex stimulus into its component parts, in Experiment 2 they were simply scanning the comparison stimuli in order to recognize the stimulus parts, presented as the sample, without necessarily having to segment them. As a consequence, the subjects were not negatively affected when the particular type of segmentation proposed by the experimenters did not match the way they spontaneously analyze a visual stimulus.

The results of Experiment 4 clearly show that monkeys' performance differs from that of humans. Unlike capuchin monkeys, humans were, on average, better at identifying stimulus parts when they were grouped according to general principles of perceptual organizations, compared with conditions in which the parts were presented as relatively disconnected elements. This difference is confirmed by the analysis of RT performed on humans' data. Although RTs were overall shorter when the parts were presented as the sample (Task 2), the participants were, on average, faster at detecting grouped parts than ungrouped parts in both Task 1 and Task 2.

Moreover, humans, in contrast with monkeys, showed an advantage for processing closed shapes over the processing of open shapes, as shown by the analysis of both accuracy of responding and latencies in both tasks of Experiment 4. Thus, for humans, the holistic property of closure seems to be a stronger grouping cue than line intersection. This finding is consistent with results obtained with humans using other tasks and stimuli (Lasaga & Garner, 1983). This latter finding also points to differences in the perceptual grouping processes used by capuchin monkeys and humans and can possibly be related to a different sensitivity to the grouping cues used in this study.

As such, the perceptual mode of humans differs from that of capuchin monkeys, which, by contrast, find it easier to identify parts of complex patterns when they are segmented into relatively disconnected features rather than organized on the basis of these grouping principles. Considering the similarity of the visual system of human and nonhuman primates (Fagot & Deruelle, 1997; Fobes & King, 1982; Walker, 1983), differences between humans and monkeys in the extent to which structural descriptions are used in stimulus segmentation raises the question of which cognitive functions might give rise to them.

It has been proposed that verbal coding may play an important role for pattern recognition in humans (McKinney, 1966; Reed, 1974). For example, it has been found that human subjects are limited in their ability to detect a part of visual image when they cannot utilize a verbal concept to describe it (Reed, 1974; Reed & Johnsen, 1975). Recent findings even emphasize the role played by the presence of a linguistic code for the perceptual categorization of good forms. Hunter–gatherer people who lack the vocabulary for simple forms such as circles, squares, and triangles do not seem to perceive these figures as good forms. This is not true for individuals belonging to cultures with verbal categories for these shapes (Roberson et al., in press).

Because these results challenge the universality of the perception of good forms even among human populations, they seriously raise the question that nonlinguistic species might lack the critical competences that make organized patterns so salient to the majority of human populations.

Overall, our results support previous research carried out with other stimuli and paradigms, showing that monkeys, in contrast with humans, somehow identify more easily the shape of the local elements of a configuration rather than their global spatial arrangement (De Lillo et al., 2002, 2004; Fagot & Deruelle, 1997; Spinozzi et al., 2003). To that literature, the present study adds the finding that monkeys seem to rely less than humans do on laws of organization such as closure, good continuation, and line intersection for the segmentation and grouping of visual stimuli.

Considering the potential advantages, in terms of information management, that can be obtained by storing a complex visual pattern into hierarchically organized groups, it would be surprising if monkeys did not possess such an ability and instead had a tendency to analyze visual stimuli as a collection of relatively disconnected local elements. Our results do not indicate that this is the case. In fact, if monkeys were processing the stimuli on the basis of isolated elementary features, they should have been completely insensitive to the type of segmentation proposed. In other words, they should have found grouped and ungrouped parts equally easy or difficult to identify. The fact that, by contrast, they found the grouped parts less easy to detect seems to indicate that the particular form of organization that we imposed on the parts of the stimuli, and that facilitated visual processing in humans, may not be the type of segmentation used by capuchin monkeys.

We are currently in search of organizational principles that might facilitate perceptual integration and segmentation in monkeys. On the basis of the comparative results presented here and elsewhere (De Lillo et al., 2002; Fagot & Deruelle, 1997; Spinozzi et al., 2003) this seems to be a worthwhile pursuit. It has been claimed that it is very difficult to highlight noteworthy differences between the physiological bases of visual perception of monkeys (chiefly studied in rhesus monkeys), chimpanzees, and humans (Walker, 1983). As such, on the one hand, the characterization of the cognitive underpinnings of the interspecies differences observed here could reveal important details concerning fundamental differences in the way in which human and nonhuman primates use the organizational possibilities that a variety of stimulus material afford.

On the other hand, should the differences in perceptual grouping processes, such as those observed here, prove to be attributable to lower level sensory processes, they would highlight differences between the visual system of humans and nonhuman primates that have so far gone undetected.

In particular, comparisons between humans and nonhuman species on perceptual tasks featuring stimuli for which humans do not have a verbal label available, and which allow the assessment of other organizational principles to which different species might be selectively sensitive could, in our opinion, prove particularly fruitful within a comparative context.

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