Abstract. This study was designed to examine whether chimpanzees and monkeys exhibit a global-to-local precedence in the processing of hierarchically organized compound stimuli, as has been reported for humans. Subjects were tested using a sequential matching-to-sample paradigm using stimuli that differed on the basis of their global configuration or local elements, or on both perceptual attributes. Although both species were able to discriminate stimuli on the basis of their global configuration or local elements, the chimpanzees exhibited a global-to-local processing strategy, whereas the rhesus monkeys exhibited a local-to-global processing strategy. The results suggest that perceptual and attentional mechanisms underlying information-processing strategies may account for differences in learning by primates.

Keywords Visual perception · Global–local processing · Chimpanzees · Monkeys · Gestalt perception

Introduction

Experimental investigation into the abilities of nonhuman animals to perceive and categorize complex stimuli has enjoyed a long history in comparative psychology (see reviews by Roitblat 1987; Wasserman 1993). In the current study, we addressed a very basic question. How difficult is it for chimpanzees and monkeys to discriminate stimulus patterns that differ on the basis of their local elements, global configuration, or both? Our interest in this comparative question is derived, in part, from animal learning studies as well as studies of human perception and selective attention.

Specifically, several investigators have examined the role of attention and memory in the processing of perceptual elements that comprise compound stimuli (Maki and Leuin 1972; Cox and D’Amato 1982; Riley 1984; Lamb 1988, 1991). For example, in a matching-to-sample paradigm, a red circle with a white horizontal line is presented as the sample stimulus. Subsequently, two comparison stimuli are presented; the positive comparison stimulus is the one that contains one relevant and overlapping characteristic derived from the sample stimulus (e.g., a white horizontal line or a red square) whereas the foil is a stimulus that has no perceptual overlap with the sample stimulus. These types of trials are compared with performance on trials in which the sample stimulus is derived from only one perceptual element such as color or shape. Results indicate that pigeons and monkeys perform significantly better on trials in which the stimuli are derived of a single perceptual element compared to compound stimulus trials. There remains some debate over the interpretation of these results, with some suggesting that the poorer performance on the compound test trials is due to stimulus generalization decrements (Cox and D’Amato 1982; D’Amato and Salmon 1984; Grant and MacDonald 1986) while others have suggested that there is a "limited capacity" for the amount of information that can be encoded within a given time frame by pigeons and monkeys (Riley and Roitblat 1978).

The research on visual perception and attention in animals has typically employed stimuli that differ on the perceptual dimensions of shape and color. Moreover, most of these studies have used pigeons as subjects. These studies have been very important in elucidating basic mechanisms involved in visual processes but there are limitations in the use of pigeons as subjects. For example, the
visual system of pigeons (as in many birds) is organized differently from that of primates in that all visual pathways from the eye to the brain project contralaterally. In contrast, primates have both ipsilateral and contralateral pathways to the brain from each eye. This basic difference could have pronounced effects on how pigeons and primates perceive and attend to different aspects of visual stimuli. Thus, from a comparative perspective, examining aspects of visual perception in nonhuman primates seems warranted on both theoretical and empirical grounds.

In the present study, we examined whether nonhuman primates differentially process compound stimuli that differ on the basis of their global configuration compared to their local elements. Specifically, we were interested in determining whether there is hierarchical processing in the perception of complex stimuli. Studies of perception and selective attention in human subjects suggest that there is a global-to-local precedence in the processing of complex stimuli (Kimchi 1992). Human subjects respond significantly more slowly and with less accuracy when discriminating stimuli on the basis of their local elements compared to their global configuration (Navon 1977). For example, identifying the larger letter “F” constructed of smaller letter “Es” takes longer when asked to identify the local elements rather than the global configuration of the stimulus (herein referred to as the global/local paradigm).

Thus, at one level, we were interested in testing whether monkeys and chimpanzees selectively attend to certain aspects of complex stimuli that are less perceptually prevalent than the dimensions of color and shape. Previous studies in baboons and chimpanzees suggest that species differences may exist. For example, Fagot and colleagues (Deruelle and Fagot 1997; Fagot and Deruelle 1997; Fagot and Tomonaga 1999) reported that baboons show local-to-global precedence in processing compound stimuli whereas chimpanzees show no precedence in hierarchical processing of compound stimuli. In contrast, Hopkins (1997) reported a global-to-local precedence in processing compound stimuli. These results are consistent with the study by Fujita and Matsuzawa (1988), who reported that the chimpanzee Ai typically identified outer features of geometric symbols first compared to inner features.

One limitation in comparing the existing findings between monkeys and apes is that different species have not necessarily been tested using the same stimuli and testing procedures. In addition, some studies in chimpanzees have used very small sample sizes in comparison to sample sizes used with Old World monkeys. The purpose of this study was to assess hierarchical processing of compound stimuli in a sample of rhesus monkeys and chimpanzees using the same stimuli and procedures. If nonhuman primates exhibit global-to-local precedence in the processing of compound stimuli then performance should be better for stimuli that differ on the basis of their global configuration compared to stimuli that differ in their local elements.

Methods

Subjects

Five juvenile chimpanzees (*Pan troglodytes*), three males (Scott, Lamar, and Jarred) and two females (Dara and Katrina), ranging in age from 5 to 6 years, served as subjects. Four of the chimpanzees were raised in the Yerkes Regional Primate Research Center nursery following standard nursery protocol for great apes (see K.A. Bard 1996. Responsive care: behavioral intervention for nursery-reared chimpanzees. Available from Jane Goodall Institute, Ridgefield, CT 06877 USA), whereas Dara was raised by her biological mother at this same facility. Five captive-born male rhesus monkeys (*Macaca mulatta*) were subjects. The rhesus monkeys ranged in age from 3.5 to 14 years of age and were tested at Georgia State University’s Sonny Carter Life Sciences Laboratory. All subjects were skilled in the use of the joystick test system prior to this study and could perform the simultaneous and sequential matching tasks employed here (Rumbaugh et al. 1989; Washburn et al. 1989; Hopkins et al. 1996). However, the stimuli used in the present study were novel to all subjects.

Apparatus

Subjects were tested with computerized test systems, described in detail elsewhere (e.g., Rumbaugh et al. 1989; Washburn and Rumbaugh 1992). Each test system consisted of a personal computer (386 compatible), a 13-inch color monitor, and an analog joystick. For the rhesus monkeys, a Gerbrands 5150 pellet dispenser was used for delivery of 97-mg fruit-flavored pellets (Noyes, Lancaster, N.H., USA). Food reinforcement for the chimpanzees was hand delivered by the experimenter.

Stimuli

Hierarchically structured stimuli (large patterns constructed of smaller elements of the same patterns) were used during training and testing. These stimuli, depicted in Fig. 1, measured 3.5 cm high by 2.5 cm wide and were in white presented on the black background of the computer monitor. Each small element that made up the large stimulus was 7x7 mm in dimension and was

Global-Local Processing in Primates

![Fig. 1 Stimulus libraries 1, 2, and 3](image)