



Fading perceptual resemblance: A path for rhesus macaques (*Macaca mulatta*) to conceptual matching?



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ABSTRACT

Cognitive, comparative, and developmental psychologists have long been intrigued by humans' and animals' capacity to respond to abstract relations like sameness and difference, because this capacity may underlie crucial aspects of cognition like analogical reasoning. Recently, this capacity has been explored in higher-order, relational matching-to-sample (RMTS) tasks in which humans and animals try to complete analogies of sameness and difference between disparate groups of items. The authors introduced a new paradigm to this area, by yoking the relational-matching cue to a perceptual-matching cue. Then, using established algorithms for shape distortion, the perceptual cue was weakened and eliminated. Humans' RMTS performance easily transcended the elimination of perceptual support. In contrast, RMTS performance by six macaques faltered as they were weaned from perceptual support. No macaque showed evidence of mature RMTS performance, even given more than 260,000 training trials during which we tried to coax a relational-matching performance from them. It is an important species difference that macaques show so hesitant a response to conceptual relations when humans respond to them so effortlessly. It raises theoretical questions about the emergence of this crucial capacity during humans' cognitive evolution and during humans' cognitive development.

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1. Introduction

Cognitive psychologists have long been interested in humans' and animals' capacity to respond to abstract relations like sameness and difference (Wasserman & Young, 2010). James (1890/1950) referred to relational concepts as the keel and backbone of thinking. Relational concepts are one basis for humans' capacity for analogical reasoning and problem solving (e.g., Hummel & Holyoak, 1997). They figure prominently in humans' cognitive-developmental change (Gentner, 2003). They ground theoretical

discussions of language's role in supporting symbolic representation (Gentner & Rattermann, 1991; Goldin-Meadow, 2003). They could represent a pivotal discontinuity between humans' and animals' cognitive system (e.g., Locke, 1690; Penn, Holyoak, & Povinelli, 2008). For these reasons, a full understanding of the phylogenetic emergence of relational concepts is one of comparative psychology's premier goals. That understanding could help explain the emergence of this crucial capacity during humans' cognitive evolution, the timing of that emergence, and perhaps the distinctive character of the human cognitive system.

The issue of relational learning was crucial even in psychology's early behaviorism–cognitivism debates (Kohler, 1918/1958; Spence, 1937). It was realized that relational (e.g., Same–Different) tasks can require a cognitive abstraction beyond the primary stimulus qualities,

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requiring animals to transcend behaviorist response tendencies. From this derives a principal idea in the area that relational concepts like same and different are cognitively sophisticated and phylogenetically restricted (Herrnstein, 1990). In fact, animals find these kinds of relational judgments difficult and their same–different performances are sometimes fragile (Carter & Werner, 1978; Cumming & Berryman, 1961; Farthing & Opuda, 1974; Fujita, 1982; Holmes, 1979; Premack, 1978; Rumbaugh & Pate, 1984; Shields, Smith, & Washburn, 1997; Washburn & Rumbaugh, 1991; Wright, Shyan, & Jitsumori, 1990).

For example, pigeons sometimes have difficulty transferring relational rules from one stimulus domain to another (Zentall & Hogan, 1974, but see Cook, 2002). Premack (1978) concluded that it would be difficult to “talk to a pigeon” because they respond so weakly to relational cues and so strongly to absolute stimulus cues. On a cross-species shopping trip to buy a wall-hanging, for example, the human would be thinking “this will go great with my couch” (a relational judgment). The pigeon would be thinking “red” (a perceptual judgment). The tradeoff between the perceptual and relational levels of processing in matching tasks is crucial to the theoretical and empirical context of the present article (see also Gibson & Wasserman, 2003, 2004). This tradeoff also illuminates by contrast humans’ status as the premier abstract and analogical cognitive system, demonstrating that other cognitive organizations are possible and extant in phylogeny.

Old World primates have had more success on relational tasks (Katz, Wright, & Bachevalier, 2002; Shields et al., 1997; Wasserman, Young, & Fagot, 2001; Wright, Cook, & Kendrick, 1989; Wright, Rivera, Katz, & Bachevalier, 2003; Wright, Santiago, & Sands, 1984; Wright et al., 1990). However, their Same–Different (SD) concepts are also limited. In Shields et al. (1997), macaques responded persistently to absolute stimulus cues in an SD task before achieving successful performance. In D’Amato and Colombo (1989), monkeys failed to transfer an SD concept from static to dynamic stimuli. Monkeys have also failed to show robust, transferable SD performance when small training-item sets led them to favor response strategies based on specific-item associations (D’Amato et al., 1985; Katz et al., 2002).

These limitations set the stage for the discovery of species differences across the primates in higher-order tasks of relational judgment, especially the relational matching-to-sample (RMTS) task. In this task, given a pair of same objects (AA) as a sample, subjects should choose a second pair of same objects (BB) instead of a pair of different objects (CD). Or, given a pair of different objects (AB), they should choose another pair of different objects (CD) and not a pair of identical objects (EE). Thompson, Oden, and Boysen (1997) found evidence using this paradigm of relational matching in four of five chimpanzees (*Pan troglodytes*). The chimpanzee Sarah also performed successfully in relational-cognition tasks that required her to complete and even create functional analogies (Gillan, Premack, & Woodruff, 1981; Premack, 1976, 1986).

Thus arose the influential idea that apes are *analogical* (Thompson & Oden, 2000) in the sense of dealing fluently with analogies and abstract relations. However,

it is important that Thompson et al. (1997) chimpanzees had a history of learning conditional discriminations involving tokens matched to object pairs, a kind of pair naming or symbol training that might have facilitated their RMTS performance. The chimpanzee Sarah had received extensive training with plastic tokens symbolizing “same” and “different.” (Premack (1976, 1986), Gillan et al. (1981) and Thompson and Oden (1996) all acknowledged the critical role of her symbols for *same* and *different* in fostering her relational cognition. Therefore, these apes might have been analogical as a result of symbolic pre-exposure or as a result of some aspect of their biology such a large brain size. (The story of the emergence of humans’ analogical capacity could be very different depending on which of these explanations turned out to be correct).

For one or both of these reasons, the case for non-apes is different. Fagot, Wasserman, and Young (2001) presented RMTS tasks to baboons. Given 16-icon arrays as sample and choices, baboons demonstrated successful relational matching. However, additional studies showed that they were not responding purely relationally, but in a manner correlated with the visual-entropy or information-theoretic complexity of the stimulus arrays. When the strength of the visual-entropy cue was weakened, by reducing the sizes of the stimulus arrays, baboons’ performance fell sharply to reveal a constraint on their abstract conceptual ability. In another experiment, however, these baboons successfully matched 2-item choice arrays to 16-item sample arrays. Perhaps the detection of visual entropy in the sample arrays primed conceptual processing as a correct relational choice was made. In a very recent study, Flemming, Thompson, and Fagot (2013) also showed that one could not explain baboons’ matching performances based solely on the cues of perceptual variability or visual entropy. To the contrary, it appears that some conceptual processes add in along with perceptual processes in comparisons of four-item arrays. In a sense, Flemming et al. (2013) may be thought of as foreclosing the possibility that primates’ array-matching performances only reflect the use of a visual-entropy cue.

Findings like these ground the idea in the literature that Old World monkeys are on the verge of true relational-matching performances if only the appropriate facilitating conditions were found. This article joins others in trying to establish these facilitating conditions.

For example, Fagot and Parron (2010) used a spatial fostering paradigm. Their RMTS task used adjacent color-patch stimulus elements that initially were spatially conjoined. Thus, both RMTS samples and the choices could initially be considered as single to-be-matched stimuli. Later, gaps between the color blocks were introduced to foster relational comparisons—now between spatially separated pairs of stimuli. Baboons’ performance collapsed to chance with a spatial gap of just 30 pixels. Fagot and Parron (2010) suggested that the contiguous stimuli gave baboons a way to successfully complete the task using a local mode of processing. By contrast, to group the elements separated by gaps into a higher-order structure proved difficult or impossible for monkeys (Fagot & Deruelle, 1997; Spinuzzi, De Lillo, & Truppa, 2003).

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