A test of the generality of perceptually-based categories found in infants: Attentional differences toward natural kinds by New World monkeys

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ABSTRACT

A preference to novelty paradigm used to study human infants (Quinn, 2002) examined attention to novel animal pictures at the subordinate, basic, and superordinate levels in tamarins. First, pairs of pictures representing categories in a stratified manner were presented in phases, starting with a single monkey species (subordinate level) and ending with mammal and dinosaur sets (superordinate levels). After each phase, tests paired novel pictures from the familiarized set with a novel broader category. Look rates toward each picture were coded. Tamarins looked significantly longer at a novel species after being familarized with a single monkey species, a species-specific effect. Subjects attended equivalently to novel primate species after habituation to 4 monkey species, but looked significantly longer at pictures of mammals, marking a more global level inclusion and exclusion. Superordinate testing revealed that more novel and diverse sets were differentiated attentionally. The evidence implies that natural categorical representation occurs at an attentional level in primates in ways similar to human infants, and is effected by recent exposure and category variability.

(171 words)

Key Words: attention, natural kinds, categorical representation, infants, monkeys, preference to novelty.

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Recent research on categorization abilities in infants has focused on the kinds of categories infants can form (for reviews, see Mareschal & Quinn, 2001; Quinn, 2002; Quinn & Eimas, 1986; Younger & Cohen, 1985), and whether perceptual-based categories play a role in conceptual categories used later in life (Mandler, 1988; Mandler & McDonough, 1993; Jones & Smith, 1993; Quinn & Eimas, 2000). Quinn found that 3 – 4 month old infants attended to natural kinds as though they belonged in groups at the basic level because infants looked for a longer duration toward a novel basic-level category (e.g., a dog, a bird, a tiger, or a horse) than at a novel instance of a basic-level category (i.e., novel cat) following familiarization to pairs of pictures from the familiarized category "cat" (for a review, see Quinn, 1999; Quinn & Eimas, 1996; Eimas & Quinn, 1994; Quinn, Eimas & Rosenkrantz, 1993). Behl-Chadha (1996), Quinn and Johnson (2000) and Younger and Fearing (1999) have all found that young infants looked longer at novel categories at the global level as well (i.e., mammals vs. birds, fish and furniture; furniture vs. mammals; animals vs. vehicles). In fact, Quinn and Johnson (1997, 2000) have demonstrated that a connectionist network can learn categorical discrimination at the global level before the basic level based on the use of body size and leg length as cues that differentiated mammals and furniture.

It is clear from this that very young infants react attentionally that they note differences between categories at the basic and global levels based on their experience with certain types of exemplars. What is not clear are the operating principles that allow discriminations at both levels. It has been suggested that the level of categorical representation is based on the variability within the examples shown. For example, Quinn, Eimas and Rosenkranz (1993) found that infants excluded dogs from their "cat" category, but included cats in their "dog" category. Quinn et al. then had adults rate the set of dogs

used in familiarization and the adults coded that group as containing more variability across examples then the set of cats used in familiarization. This asymmetry in categorical discrimination suggested that the category formed is more inclusive of novel items if it is established with examples with a high level of perceptual variability. Global categories clearly contain high variability within them, and in these cases, the distinction made by infants seems based on features which define a difference; in mammals and furniture, the distinction is blurred if legs of mammals and furniture are switched, and similarly, the distinction between animals and vehicles is blurred if wheels and legs are deleted or switched (Rakison and Butterworth, 1998). In sum, highly variable exemplars within a category tend to generate a category more inclusive of novel examples, and thus a more "broad" or more global perceptual category. Prototypical examples or more similar examples tend to generate a narrow more basic level category in infants and young children (see Quinn et al., 1993; Bauer, Dow and Hertsgaard, 1995), potentially because prototypes maximize within-category similarity. With global categories, a defining set of features seems used by infants and connectionist networks to distinguish them from each other.

A point of contention in the literature on infants' attention to categories is whether perceptually-based categories relate at all to later conceptual categories. To answer this question, developmental psychologists have argued that the existence of two systems (a perceptual and conceptual one) causes the cognitive system to lack the parsimony and efficiency one would expect (see Quinn and Eimas, 2000), and that the perceptual categories infants attend to fit in naturally with later conceptual ones anyway(Quinn, 2002). In contrast, there is some evidence to suggest that, at 9 months of age, infants distinguish categories more on conceptual grounds (i.e., dogs and rabbits belong together, and airplanes and birds do not) rather than on perceptual similarities, which would make dogs different from rabbits, and airplanes similar to birds (Mandler & McDonough, 1993). It is unclear through arguments of parsimony or proof that older infants favor conceptual

categories over perceptual similarities that the relative influence of perceptual to conceptual categories will be revealed.

An alternative starting point would be to see if other nonhuman primates show the ability to differentiate basic and global perceptual categories in the same way that infants do. If the discovery of perceptual discrimination in infants is truly a primitive cognitive ability which does not necessarily contribute to the more human-unique ways of categorizing conceptually and functionally, then it should be the case that primates without language training and without conceptual training would show similar perceptual discriminations. Because most apes in captivity have learned symbolic systems and/or been trained on a whole host of tasks in which they learned broader concepts, they may not be ideal primate candidates to tap the natural ability of primates' general categorical representation. Rather, primate groups which are distant relations to humans and other apes, who seem unable to grasp abstract concepts and have not learned a language apart from their own species-specific communication are a better test of the universality among primates of perceptual-based parsing of basic and global categories. The experiment reported here determines whether the perceptual-based parsing of animals based on the variability of familiarized exemplars is an ability shared with a distant primate relation with no extra language learning and no conceptual training, members of a NW monkey species, cotton top tamarins.

There have been few attempts to train monkeys and apes to categorize natural kinds to test for differences at different levels of abstraction (Roberts and Mazmanian, 1988; Phillips, 1996; Schrier & Brady, 1987). The common finding is that OW and NW monkeys discriminate preferentially at the species level rather than at a basic level (Jitsumori and Matsuzawa, 1991; Schrier, Angerella and Povar, 1984; Yoshikubo, 1985; for a review, see Thompson, 1995). When monkeys are trained to respond to obtain a reward and the set of stimuli are specific to a species of animal (i.e. rhesus macaques), monkeys respond to novel examples at the species level (other rhesus macaques) and do not respond to probes outside of the species level but within a basic

level grouping (i.e., other primates). Such a strategy has been coined nonanalytic (Flannagan, Fried, & Holyoak, 1986), by which animals memorize item-specific features or actual examples of the reinforced training stimuli and then generalize to novel stimuli, either by noting specific features or whole items that seem psychophysically similar to the past examples.

So far, there is evidence to suggest that rhesus monkeys (Hopkins and Washburn, 2002) and some tested chimpanzees attend more to local features than to global configurations in visual arrays (Fagot and Tomonaga, 1999), but Hopkins and Washburn found that their chimpanzees showed a global-to-local processing strategy first. Vonk and MacDonald's gorilla Zuri (2002) could more readily discriminate at the concrete level (i.e., gorillas vs. humans) and at the global level (animals vs. nonanimals) than at the intermediate level (primates vs nonprimate animals). This preferential learning of concrete and abstract levels of categorical discrimination was also found in a NW monkey species (Roberts & Mazmanian, 1988). It is possible that under the motivation of food rewards, monkeys and apes can attend to the features most correlated with reward, and thus exhibit a feature-distinctive analysis which might allow for ready learning of both concrete categories, which have low within-category variability, and global categories, which can often be differentiated by a small set of features from other global categories.

Studies of monkeys' preference to attend without reinforcement have shown, on the whole, that monkeys prefer to look at their own kind as compared to other species of monkeys, a consistent conspecific effect (Humphrey, 1974, for rhesus; Demaria & Thierry, 1988 for stumptailed macaques; Swartz and Rosenblum, 1980 for bonnet macaques; Candland & Judge, 1991 for japanese macaques and baboons; Fujita, Watanabe, Widarto & Suryobroto, 1997 for Sulawesi macaques). These studies do not reveal anything about attentional differences in monkeys toward other groupings of animals nor do they confirm that monkeys attend preferentially at the species level when the species is *not* their own kind. In sum, the studies of monkeys thus far confirm that a species level discrimination can be more easily trained with reward and is maintained in testing despite tests of broader levels, and that monkeys prefer to look at their own kind.

An important step in tapping into primates' inclinations to group natural kinds together is to assess how a primate parses its attention when presented with different classes of animals simultaneously. A test of attention to natural kinds requires shifting the local definition of the category in a stratified set, which ranges from concrete (i.e., a single species of monkey pictures, as compared to a novel species of monkey), to basic level (monkeys as a group, as compared to apes) and to superordinate groupings (mammals as a group, as compared to reptiles). Clearly the shifts between phases denote increases in within-category variability, with a single monkey species being least variable, and the class "mammal" being most variable. Such a design is used here, utilizing visual paired comparisons with the dependent variable, attention marked by a preference to novelty look rate.

Method

Subjects

A group of 6 cotton top tamarins (Saguinus oedipus), ages ranging from 1 to 13, participated. Subjects were housed as 3 pairs, with 2 females (Oprah, Fozzy) and 4 males (Mac, Zhivago, Rolo, and Yohoo) in the study. All subjects had been nursery-peer reared in laboratory settings, and had been socially housed in pairs in three 0.85 X 1.5 X 2.3 m pair cages, with the cages visually separated by opaque sheets. The subjects were on a 12-hour light/dark cycle and had free access to water. All animals were maintained on a complete diet consisting of a yogurt & applesauce breakfast, a lunch of Zupreem Marmoset chow, Mazuri New World Monkey dry chow, fruits and vegetables, and a protein snack (e.g., eggs, hamburger, mealworms) daily. Subjects had been exposed to mirrors and to digitized pictures of themselves, to digitized pictures of other cotton top tamarins from the colony, and of buildings on campus. All digitized images were displayed on a computer monitor placed next to their cages. None of the animals had been exposed to pictures or live examples of other types of monkeys, mammals, reptiles, or dinosaurs before this study. They had observed humans who cared for them.

Stimuli

The stimuli were a set of 212 14 cm X 10.5 cm digitized color pictures of animals obtained from several web sites of zoos (i.e., the National Zoo), research organizations (i.e., the Wisconsin Regional Primate Research Centers), or data bases of pictures (i.e., Corbis.com). Dinosaurs were contrived full color photographs obtained from various web sites (including Disney). The relative luminosity of the stimuli was controlled by presenting each picture in digitized form on the same television monitor. Pictures were chosen to represent a wide variety of positions of animals, numbers and ages of animals, background types, and relative sizes. In most pictures, a frontal face orientation was displayed.

The subordinate level set included 40 unique pictures of a single monkey species, the golden lion tamarin. There were 12 examples of a different monkey species, the pygmy marmoset, used in a test of the subordinate set.

The basic level monkey set included pictures of the former two species and of capuchin monkeys, rhesus monkeys, spider monkeys, drill monkeys and goeldi tamarins. The primate class included the former species and examples of humans, gorilla, orangutan, gibbons, and chimpanzees. The mammal set included all the primate species and examples of lions, dogs, squirrels, elephants, cows, bears, llama, hippopotamii, moose, leopords, tigers, kangaroo, rabbits, horses, goats, ox, and deer. The reptile set included examples of reptiles (i.e.various monitors, iguana, and so forth). The dinosaur set included pictures of dinosaurs including examples standing on 4 legs, some on 2 legs, and some with wings. A subset of pictures from each set were used in each familiarization phase, with novel examples of the familiarized species and novel examples of other species within each category reserved for preference tests.

Apparatus

The digitized pictures were presented in a Power Point slide show (Microsoft application) on a G3 Power Macintosh through a Focus Enhancements L-TV portable pro scan converter to a 27" Sony Trinitron television, placed 1 m in height above the floor on a

Wilson mobile television cart. The monitor attached to the computer remained off throughout the experiment. The television and cart were moved against the exterior of the front of each cage. The television screen was approximately 4 cm away from the cage mesh. In all phases of the experiment, two digitized pictures were presented simultaneously during each trial. The digitized pictures were of equal sizes, 14 cm X 10.5 cm high, and were presented as pairs on the screen such that the left and right exterior vertical edges of the pictures matched the left and right vertical exterior edges of the screen, respectively. A distance of 13.5 cm separated the interior vertical edges of the pictures. The distance between the center of the pictures and the floor was approximately 1.3 meters. The background area of the television screen was white in color.

Procedure

There were 6 daily 40-minute sessions in each familiarization phase, followed by a preference test conducted in two consecutive 70-minute daily sessions. Throughout all familiarization and testing, every trial lasted 70 seconds total. Each trial began with an 8-s presentation of a "green" screen, or the screen fully filled with a green color, followed by a 2-s presentation of a "blue" screen, and then a 60-s presentation of a pair of pictures. Three levels of category inclusion, subordinate, basic, and superordinate levels, were tested. For each level tested, there was a familiarization phase followed by a preference test phase. (See Figure 1 for examples of each type of test).

Insert Figure 1 about Here

Subordinate Level. A total of 17 pairs of pictures of golden lion tamarins, a single monkey species, were shown per session in the familiarization phase. Within each session, the pairs were shown twice, once with the locations reversed, so that the location of each picture (left of center or right of center) was counterbalanced across each session. A total of 34 trials were conducted per session.

The subordinate test consisted of 20 pairs of pictures of golden lion tamarins, and 6 presentations of a **Monkey** test, in which a novel picture of a new species, the pygmy marmoset, was paired with a novel picture of the familiarized species, the golden lion tamarin for each presentation. All trials were repeated twice in each test session, with the second presentation reversing the location of the pictures in the pairs, for a total of 52 trials per session[1].

Basic Level. A total of 18 pairs of pictures of monkeys comprised the basic level familiarization set, and they included pictures of golden lion tamarins, pygmy marmosets, capuchins, and goeldi tamarins. The pairs were constructed of two different monkey species, and each pair was repeated twice per session such that the locations of the pictures were counterbalanced. The familiarization sessions were comprised of 36 trials.

The basic level test included the familiarization set and three category tests, each of 4 trials, for a total of 30 critical trials. One test of **Mammal** consisted of pairing a picture of a novel species of mammal (either a dog or a squirrel) with a novel picture of a monkey species from the familiarized set. The novel mammal types were selected based on a high degree of feature similarity with the monkey pictures used, as determined by subjective rating by two researchers. Similar features across the two sets included the presence of trees, the position of the animal on four limbs, the presence of a tail, and a similar body size. Another test of **Ape** consisted of pairing a picture of a novel ape species (either chimpanzee or human) with a novel picture of a species from the familiarized monkey set. In the case of the apes, examples were selected which were highly dissimilar from the monkey set, with discriminable differences including animals standing on 2 limbs, absence of tail, and a larger body size. A final critical test was the **Monkey (2)** test, and it consisted of presenting a picture of a novel species of monkey with a novel picture of a monkey

[1] There were a few trials presented in each test to examine novel processing effects, and these pitted a novel picture from the category being tested against a familiarized picture from the training set. In all cases, there was longer looking at the novel picture when paired with a

species from the familiarized set. A total of 60 critical trials were shown per session, with the 30 trials presented twice, once with locations reversed.

Superordinate Level. The familiarization set was a mammal set, and included 18 pictures of primates and 18 pictures of nonprimate mammals, including the new species lions, bears, goats, rabbits, and tigers. All pictures were presented in pairs and were intermixed across species such that the pairs represented mammals as a large class. The pairs were presented twice each, once with locations reversed, to counterbalance for location of each picture, for a total of 36 trials per session.

The first superordinate test included the category test, **Reptile**, which consisted of pairing pictures of reptiles with novel examples of the familiarized mammals. Another category test was **Mammal**, which paired novel species of mammals types (in this case, of cow, elephant, gorilla, or pig) with novel examples of the familiarized mammals. A total of 26 unique trials were shown twice, to counterbalance location, for 52 trials per session.

Two other separate familiarization phases occurred following the first superordinate test. First, the subjects viewed 17 trials of pairs of reptile pictures, presented twice each session, for 6 sessions. Habituation to these pairs were recorded. Next, 17 trials of pairs of novel pictures of dinosaurs were presented twice each session, with location of each picture counterbalanced across the two exposures, for 6 sessions to note habituation to the broad grouping. The selection of dinosaurs for this set was made to induce high perceptual variability, with changes in body size, changes in number of limbs in position (4 vs. 2), changes in coloring and skin texture (fur, scales, leather), and the presence of wings or not.

The second superordinate test was constructed of 18 trials of the prior pairs of dinosaurs, and 2 tests, presented 4 times each session. One test, **Dinosaur**, paired a novel picture of a dinosaur with a novel species of mammal (deer, horse, hippopotamus, kangaroo). The other test was a **Mammal** test which paired pictures of novel species of

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familiarized one and these data were not included in the analysis. They served to check that animals were paying attention, and noting novel presentations.

mammal (leopord, moose, ox, llama) with novel examples of mammal species already familiarized. Trials were presented twice each to counterbalance location, for a total of 52 trials per session.

Behavior Coded

Two undergraduate researchers coded look rates, and were positioned behind the television monitor to code the look direction and look duration of individual animals in each trial. A piece of corrugated cardboard equal to the size of the television screen was attached to the rear of the television facing the researcher. A vertical line bisected the cardboard and two boxes were drawn on it, corresponding to the size and the position of the pictures displayed on the television screen. This measurement device allowed the researcher to note the angle of looking by the participants. The researcher could not see the pictures being displayed to the participants from his or her position.

Direction of looking was coded as either left, right, or “general”. Looking to the left or right picture was coded if any one of the following was true: a) the animal's head and eyes were observed to be in line with the appropriate box drawn on the cardboard, b) the eyes’ angle toward a side was so extreme that the white portion of the eye on the side opposite a picture could be seen, or c) the apex of the animal's eye lens was pointed toward the appropriate box. The "general" behavior category included looks to the center of the television screen, and looks that could not be determined to fit the definition of a left- or right-oriented look.

Duration of a look began when the animal engaged the stimulus according to the criteria, and ended when the animal disengaged the stimulus either by moving its head or eye away from the stimulus. Look rates were timed to the $1/10^{th}$ s with a stopwatch.

Interjudge reliability was measured by employing another undergraduate researcher to code the same behaviors and durations during two familiarization sessions at each level (subordinate, basic, superordinate), for a total of 6 sessions of reliability assessment. A Pearson correlational analysis on look directions and durations yielded a positive correlation

of $r = +0.867$, significant at $p < 0.001$, for the two judges for number and types of looks per trial per subject. It is important to note that observers could not determine the side of the television monitor on which any type of picture was presented from their vantage point, thus there was no bias in coding direction and times.

To examine habituation rates during the familiarization phases, the total time each subject looked at the stimuli was determined per session from the coded look rates. To test for categorical differences, a preference for novelty score was calculated for each subject for each test by dividing the total duration of looks to the novel category pictures by the sum of the duration of looks to the category pictures and to their pairs.

Results

The look scores were subjected to a test of location bias, and tests of habituation during the familiarization sessions. Right-side looking ratio scores were calculated for the 5th and 6th familiarization sessions at each level (subordinate, basic, and the three superordinate familiarizations (mammals, reptiles, and dinosaurs)) for the side bias test, and were tested against a hypothetical mean of 50% in one-sample t-tests. There were no significant side preferences shown by the subjects.

The total look rates per session per subject for each familiarization phase were tested in a repeated measures ANOVA of familiarization condition (subordinate, basic, and each of three superordinate phases), and session (1 – 6). The main effect of familiarization condition was not significant, but the main effect of session ($F(5, 125) = 8.93$, $p < 0.01$) and the session X familiarization phase interaction effect ($F(20, 125) = 2.59$, $p = 0.001$) were significant. The session effect indicated that look rates decreased across sessions, and this was confirmed by linear trend analyses that showed negative slopes for all phases (for single monkey species, slope =-5.27%, $F(1,4) = 39.26$, $p < 0.01$, $r^2 = 0.91$; for 4 monkey species, slope = -6.26%, $F(1,4) = 2.84$, $p = 0.17$, $r^2 = 0.41$; for mammal, slope =-1.06%, $F(1,4) = 3.13$, $p = 0.15$, $r^2 = 0.44$; for reptile, slope =-5.09%, $F(1,4) = 3.45$, $p = 0.13$, $r^2 = 0.46$; and for dinosaur, slope = -2.27%, $F(1,4) = 2.78$, $p = 0.17$, $r^2 = 0.41$). The interaction was

accounted for by significant differences between the habituation rates to mammals as compared to reptiles (Tukey HSD = -13.51, p=0.04) and between habituation rates to the mammals as compared to the dinosaurs (Tukey HSD = -13.62, p = 0.04). For both reptiles and dinosaurs, look rates increased across the first few sessions and then decreased at a slower rate than did the look rates to the other phases, showing more initial sensitization to these two groups.

Insert Figure 2 about here

The critical test in the study was to determine whether the subjects paid more attention to the new category item introduced in each test than they did to novel pictures from the familiarized category. Preference to novelty scores were calculated for each subject for each category test. A repeated measures Friedman's ANOVA testing for category differences (subordinate test, basic level tests involving monkeys, mammals and apes, superordinate tests involving reptiles, dinosaurs, and mammals) resulted in a significant category test effect, $\chi^2(6)$ n=6: 13.14, p = 0.04.

Figure 3 depicts the mean preference scores to the 7 novel category tests examined. Testing of each category against a hypothetical mean of 50% in one-sample t-tests was conducted to determine which categories generated increased attention. After habituating to pictures of a single monkey species, the subjects showed a signficant preference to look at the novel species pygmy marmosets (mean = 67.98%, t(5) = 4.02, p=0.01). Conversely, after habituating to 4 species of monkeys as a basic level category, the tamarins did not show a preference to look at apes (mean = 56.05%, t(5)=0.59, p=0.58) nor at novel species of monkeys (mean =41.16%, t(5)=-.66, p=0.54). In contrast, subjects exhibited a significant preference to look at novel species of nonprimate mammals (mean = 70.90, t(5)=4.09, p=0.01) over novel species of monkeys.

After habituating to mammals at the **superordinate** level, subjects showed a preference to look less often at reptiles (mean = 35.95) than at mammals by a trend ($t(5)=-2.23$, $p=0.07$). This could be explained by an avoidance to look at reptiles, or a preference to continue to look at novel examples of mammals, a finding demonstrated when mammals were first introduced.

Insert Figure 3 about Here

After being familiarized to reptiles and to dinosaurs in the other **superordinate** level phases, the tamarin subjects showed a significant preference to look at novel pictures of dinosaurs (mean = 56.21) over novel pictures of mammals ($t(5)=6.49$, $p<0.01$).

DISCUSSION

The results indicate that adult tamarins can differentiate examples of animals at the subordinate or "species" level, basic or "local" level, and superordinate or "global" level, and that shifts in attention toward novelty are directly related to the variability in the familiarized set that preceded the test. In general terms, this seems to be the catalyst behind young infants' attention toward natural kinds categories, although they are usually tested with only basic level and global level sets. Infants have also shown particular peculiarities in that they have acquired a global level before a local or basic-level representation in some studies (i.e., Quinn and Johnson, 1997; Younger and Fearing, 2000), and they have mistakenly included examples (cats) at the basic-level when the initial basic category contained high perceptual variability (e.g., dogs, Quinn, Eimas and Rosenkranz, 1993). Human infants at younger ages seem hypersensitive to within-category variability, and this supersenstivity leads them to generate global more inclusive categories preferentially. Is this the process found in adult nonhuman primates?

When first familiarized with a single species of NW monkey with fairly low variability across examples, cotton top tamarins noted as different another species of NW monkey. In other words, tamarins naturally represented species-specific groupings and naturally noted other species of monkeys as "different", a finding previously established in the animal cognition literature. It is not clear in the published literature whether human infants would preferentially represent animals at the species-specific level if initially familiarized with a species category with low variability. At this level, elemental feature change and nonanalytic processing are probably the bases of categorical representation.

When next familiarized with 4 different species of monkeys, the tamarins did not react to the novelty of pictures of other species of monkeys, and interestingly, not to pictures of apes either. One cannot conclude that the tamarins' processing of monkeys prevents them from seeing other monkeys as different since the initial preference at the subordinate phase was to reject novel species of monkeys. Habituation to multiple species of monkeys seems to have established a "primate" representation in the tamarins, which is a more global categorical representation than we expected. Note also that the novel pictures that drew their attention significantly at this level were nonprimate mammals which had been selected to be perceptually similar to the monkey pictures. Instead of forming a "monkey" representation that should have discluded apes due to feature differences and should have included nonprimate mammals due to feature similarities, the tamarins formed a more global representation of "primates" which included the more perceptually dissimilar apes and rejected the more perceptually similar nonprimate mammals. We cannot make a direct comparison of this result to human infants since monkeys, apes, and nonprimate mammals as classes have not been tested in an experiment. Still, we can say from this study and the published infant work that tamarins and human infants seem inclined to generate more global categories of animals when the familiarized set is more variable, and then to utilize a defining feature to separate global categories, for example, in this case, a

frontally positioned face with eyes, which is different from the laterally positioned eyes on nonprimate mammals.

In human infants, a class like mammals is often pitted against furniture or vehicles, and the diversity within the two categories being compared visually is very high. In that case, infants tended to look longer at the novel category (i.e., furniture and vehicles) as opposed to the familiarized category. In tamarins, attention continued to be drawn to the mammals when paired with reptiles, but the reptile group had narrower variability within it. A final test pitted dinosaurs, an unrealistic but highly diverse set of animals, against mammals, a similarly broad and diverse set. Tamarins showed preferential looking toward novel dinosaurs over novel species of mammals, an attentional effect that verifies that mammals are not naturally always the class of animals that draws more attention. It has been suggested in the infant research that global categorical differentiation is made on the basis of a few defining features (i.e., wheels or leg length or body size). This strategy for noting differences in groups may be used in the present study in tamarins; while dinosaur pictures were selected with a number of overlapping features with mammals, at least some of them had certain colorations of skin (blue/purple/green) that separated them from mammals.

In sum, individuals of a NW monkey species with no prior training in categories, concepts or language attended to novel categories at all levels of abstraction. The level that was acted upon by the tamarins was a direct result of the variability of the familiarized set. The most interesting result was that NW monkeys operate like young infants in their preferential tendency to attend to a global category once variability is higher, and in this experiment, the global category “primate” was preferred to a more basic level discrimination that was intended, that of “monkey”. Perhaps infants without conceptual understanding and language use perceptual-based attention to group animals together in the same ways that adult tamarins, and presumably other adult primates can do. The cognitive change that

differentiates humans from primates in categorical processing occurs when infants develop to 9 – 10 months of age and start to show conceptual differentiation preferentially.

Author Notes

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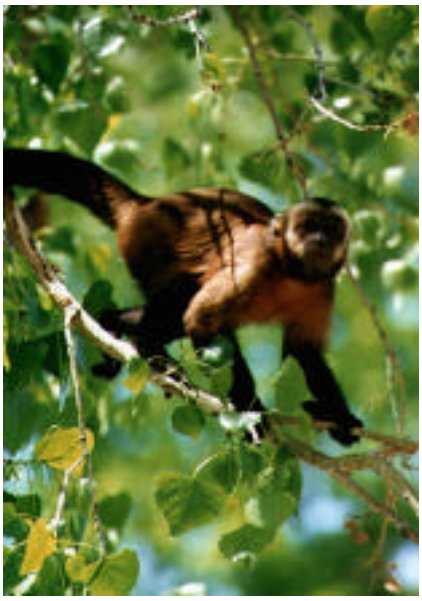
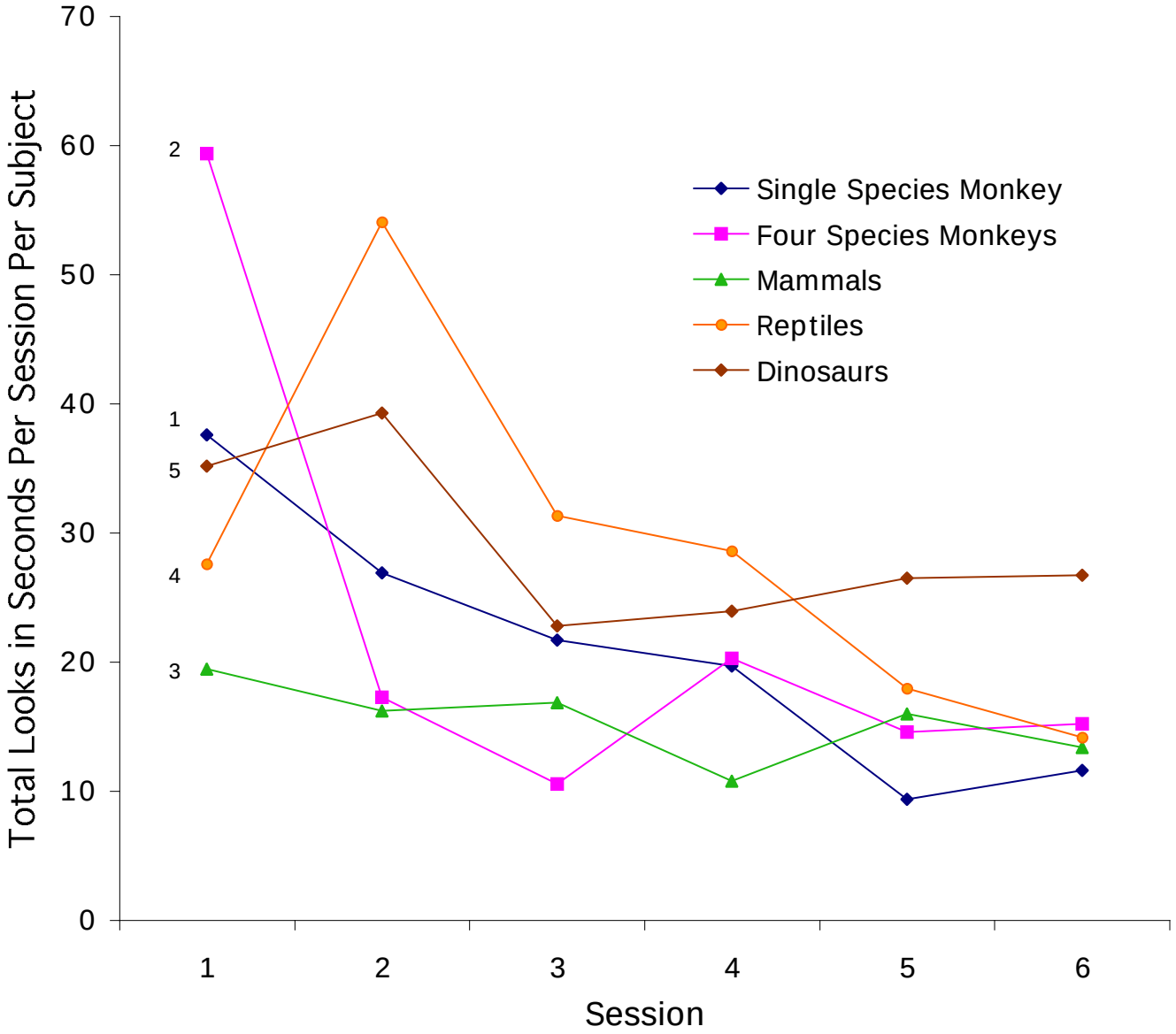
Figure Captions

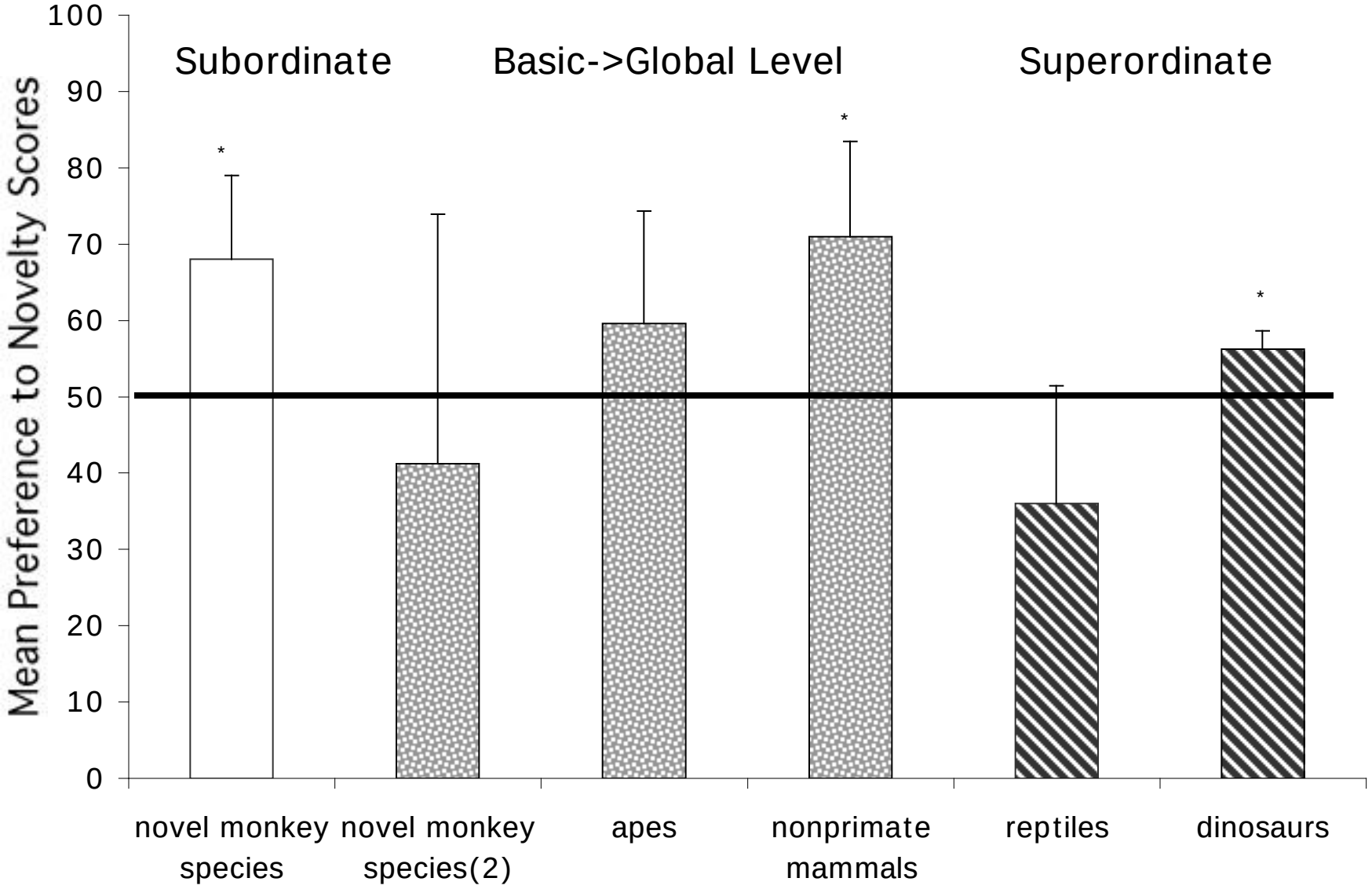
Figure 1. Examples of test pairs for each level of the experiment. Top pair are golden lion tamarin (left), a familiarized species, and pygmy marmoset (right), a novel species, tested at the subordinate level. The middle pair are a capuchin monkey (left), an example from basic level familiarization, and a priarie dog (right), a novel mammal species. The bottom pair are an allosaurus (left) and elephants (right), a test of dinosaurs versus novel mammals.

Figure 2. The averaged total look rates per subject per session during each of 5 familiarization phases. Numbers at the beginning of each line indicate the order of familiarization exposure.

Figure 3. Mean preference to novelty scores and standard deviations for each test. Changes in the filled-in portion of the bars indicate a change in level of testing from subordinate, to basic/global, to superordinate. Asterisks indicate signficance at the $p = .05$ level from chance level looking, 50%.




Total Looks in Seconds Per Session Per Subject
70
60
50
40
30
20
10
0
2
1
5
4
3
Single Species Monkey
Four Species Monkeys
Mammals
Reptiles
Dinosaurs
1
2
3
4
5
6
Session


Subordinate
Basic->Global Level
Superordinate
Mean Preference to Novelty Scores
100
90
80
70
60
50
40
30
20
10
0
*
*
*
novel monkey species
novel monkey species(2)
apes
nonprimate mammals
reptiles
dinosaurs