

# A Test of Object Permanence in Cotton Top Tamarins (*Saguinus oedipus*)

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## ABSTRACT

Cotton top tamarins were tested on visible and invisible displacement tasks in a manner like de Blois, Novak and Bond (1998). All participants performed at levels significantly above chance on visible (n=8) and invisible (n=7) displacements, wherein the tasks included tests of the preservation error, memory limits in double and triple displacements, and tests of the strategy of selecting the last cup touched. Subjects failed to perform above chance levels on catch trials within invisible displacement testing, but the strategy of selecting the last cup touched did not account for a preponderance of the errors. Visible displacements were easier than invisible displacements, and performance was not accounted for by a practice effect. When participants committed errors, which was fairly infrequent, the errors were to locations adjacent to the correct hiding location, or to a particular favored location. Results suggest that tamarins possess Stage 6 object permanence capabilities, and that their errors seem consistent with the types of errors committed by great apes, including orangutans, chimpanzees, and human children (Call, 2001).

## INTRODUCTION

It is commonly accepted that tests of object permanence are an ecologically valid means to test the representational capacities of different species of animals. All animals (including humans) live in a world in which objects appear, move in space, disappear, and reappear. The capacities to recognize an object as the same through repeated appearances over time, and to search for and find a desirable object once it has disappeared, are clearly both of great adaptive value. Still, the cognitions that support such adaptations are intriguing to track because when species fail at different stages of object permanence, potential differences in the characteristics of object representation across species are revealed. Successful retrieval in object permanence tasks in individuals of a species can mean that members of that species can represent objects when they are not directly perceived, that they represent objects as distinct entities in space separate from themselves, and that they grasp that objects can move on their own.

Past studies have demonstrated successful search with visible displacements captured by Stage and of Piagetian development in:

- birds (Etienne, Dumas & Wikke; Pepperberg, Wilmer & Gravitz);
- cats (Dore, Dumas & Dore; Coulet, Dore & Rousseau);
- dogs (Gagnon & Dore; Triana & Panak);
- new world monkeys (Vaughner, Smotherman & Ord; de Blois, Novak & Bond; Dumas & Brunet; Natale & Antinucci; Schino, Spinazzi & Berlinguer; Mathieu et al.);
- old world monkeys (Natale & Antinucci; Natale & Antinucci; de Blois & Novak; Natale, Antinucci, Spinazzi, B. Pot);
- and in great apes (Natale, Antinucci, Spinazzi & Pot; Rebbah, Spinazzi & Natale; de Blois, Novak & Bond; Wood, Moriarty, Gardner & Gardner; Mathieu, Bouchard, Ganger & Herscovitch; Mathieu & Bergeron).

The tracking of an object moved visibly to a hiding location seems to be a capacity shared by most vertebrates tested, including avians, nonprimate mammals, and primates.

More advanced object permanence abilities involving invisible displacements have been reported in a small group of birds (in parrots, primarily Pepperberg et al.) in one member of one species of new world monkey (capuchin, Mathieu et al.) in dogs (Gagnon and Dore) and in the great apes (including chimpanzees and orangutans, for example Call; and gorilla, for example Natale et al.). It is possible that only great apes and a few other species who evolved specialized skills for searching (such as psittacine birds and dogs) have the ability to represent the invisible movements of a hidden object. The alternative is that primates generally carry this ability, supported from rather sparse reports of successes across individuals of a variety of old and new world monkeys and inferred by their generally good spatial memories and tool using skills (for a review, see Tomasello & Call).

In this study, a species of new world monkey is exposed to a method previously used on apes and squirrel monkeys. By using a tested method, direct comparisons between an ape and two different new world monkey species can be made. The cotton top tamarin is an excellent candidate for testing because the species has demonstrated abilities that suggest both success and failure in object permanence. Their ability to use tools (Hauser, Williams, Kralik & Maskovitz) to show self-directed behaviors to mirrors (Hauser, Kralik, Botto, Garrett & Osser); Hauser; Neiworth, Anders & Parson in press) to look with surprise at violations of the "Sally Ann" story (Hauser & Santos) and to hold feeding sites in spatial memory (Milton) suggest a higher level of object representation and inference. Cotton top tamarins' inability to extrapolate the final location of an object moved in an opaque tube (Hauser, Williams, Kralik & Maskovitz) and their reported problems in inhibiting a more readily available response (Hauser, Kralik & Botto, Mahan) suggest limits on extracting invisible movements of absent objects and a limit on their ability to act on cognitive representations rather than making ready responses.

## METHODS

### Participants

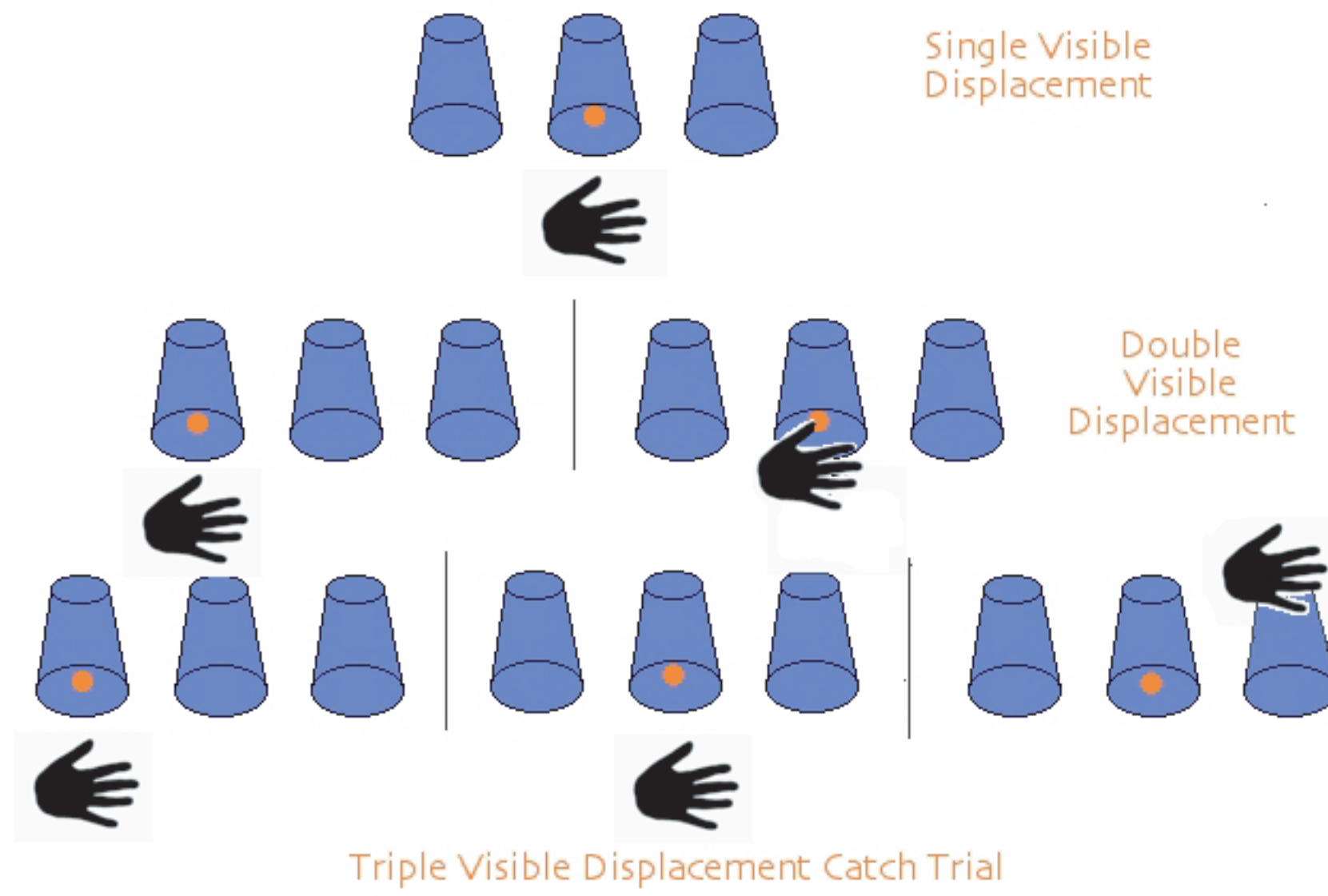
A total of cotton top tamarins (*Saguinus oedipus*) participated. All subjects completed the visible displacement tasks (Tasks - ) but one subject, Oprah, became ill and did not participate in the invisible displacement tasks. The remaining invisible displacement tasks - were successfully completed by subjects.

### Apparatus

Three opaque cups, measuring cm in height with a width of cm at the base, were used in an inverted orientation during acclimation and testing. The cups were placed on a cart ( m height, X m top) separated such that the distance center to center was cm between each pair of cups. The cups were placed cm from the front (participant side) of the cart and the outer cups were placed cm from the sides of the cart. Holes measuring cm X cm were made along the bottom rear of the base of each cup and then covered with layers of opaque cloth with vertical slits cut in them to form a curtain. Each cup was taped to the cart such that the covered openings faced the experimenter, and so that the subjects had to flip the cups back toward the experimenter to receive a food reward. Food rewards were the objects hidden, and they consisted of individual pieces of fruit, sugar cereal (Fruity Pebbles or Fruit Loops). The specific type used was varied throughout acclimation and testing depending on the participant's preferences.

### Procedure

The tamarins participated in nine different tasks involving visual displacements (Tasks - ) and invisible displacements (Tasks - ). All participants were presented the tasks in the same order, starting with Task.



**Task : Single visible displacement.** The reward was hidden under one cup location for nine completed trials. The selection of the location of the rewarded cup was randomly chosen and varied across subjects.

**Task : A not B.** The reward was hidden in a new cup location (different from that used in Task ) for nine completed trials. This task tested for the preservation error.

**Task : Random single visible displacements.** The reward was hidden times at each of the cup locations. The location of hiding for each trial was pseudorandomly determined before the task began.

**Task : Double visible displacements.** The experimenter placed the reward in one cup location through the curtained opening, removed it and showed it again to the subject, and then placed it inside a second cup at a second location, and then the search process began. The final hiding place of the reward was randomized across trials, with the reward being hidden times in each of the locations.

**Task : Triple visible displacements.** This task was comprised of trials with or of them (varied across the subjects) standard trials and the remaining or catch trials. In standard trials, the object was successively hidden, removed, shown to the subject, and hidden again across all cup locations. In the remaining "catch" trials, the reward was hidden, removed, and hidden again across cup locations, and the third cup location not involved in the successive hiding was touched by the experimenter before the search process began. Across the trials in this task, each location served as the final hiding location times. Separate percent correct scores were calculated for participants for the standard trials ( or trials total) and the catch trials ( or trials total) in Task. In de Blois, Novak, and Bond ( ), orangutans received trials of the standard type and catch trials within triple visible displacement. Squirrel monkeys were not shown any catch trials in this task in the former study, rather they were shown standard triple visible displacement trials.

**Task : Single invisible displacement.** The experimenter placed the reward in the opaque cups of the displacer and closed the displacer cups together so that the reward could not be seen. The experimenter then inserted the end of the displacer into a cup, and opened the displacer therein, leaving the cereal reward in the cup. Because the displacer was placed directly on the cart inside the cup before it was opened, no audible sound of the cereal falling out, the displacer could be heard by human experimenters, and the hiding was done invisibly to both parties. The experimenter then removed the displacer and relaxed the tongs to show that the displacer cups were now empty. The same cup location was baited for nine trials, with the terminal location varied across subjects.

**Task : A not B.** A similar task was called sequential invisible displacements in de Blois, Novak, and Bond ( ). Here, the reward was invisibly hidden as described in Task, single invisible displacement, but here a new cup location was chosen and used for trials. Like the A not B test in the visible displacement tasks, this task aimed to test the preservation error.

**Task : Random single invisible displacements.** The reward was invisibly hidden using the displacer as described in Task, for trials, wherein each cup location was used times across the trials. The location of hiding for each trial was pseudorandomly determined before the task began.

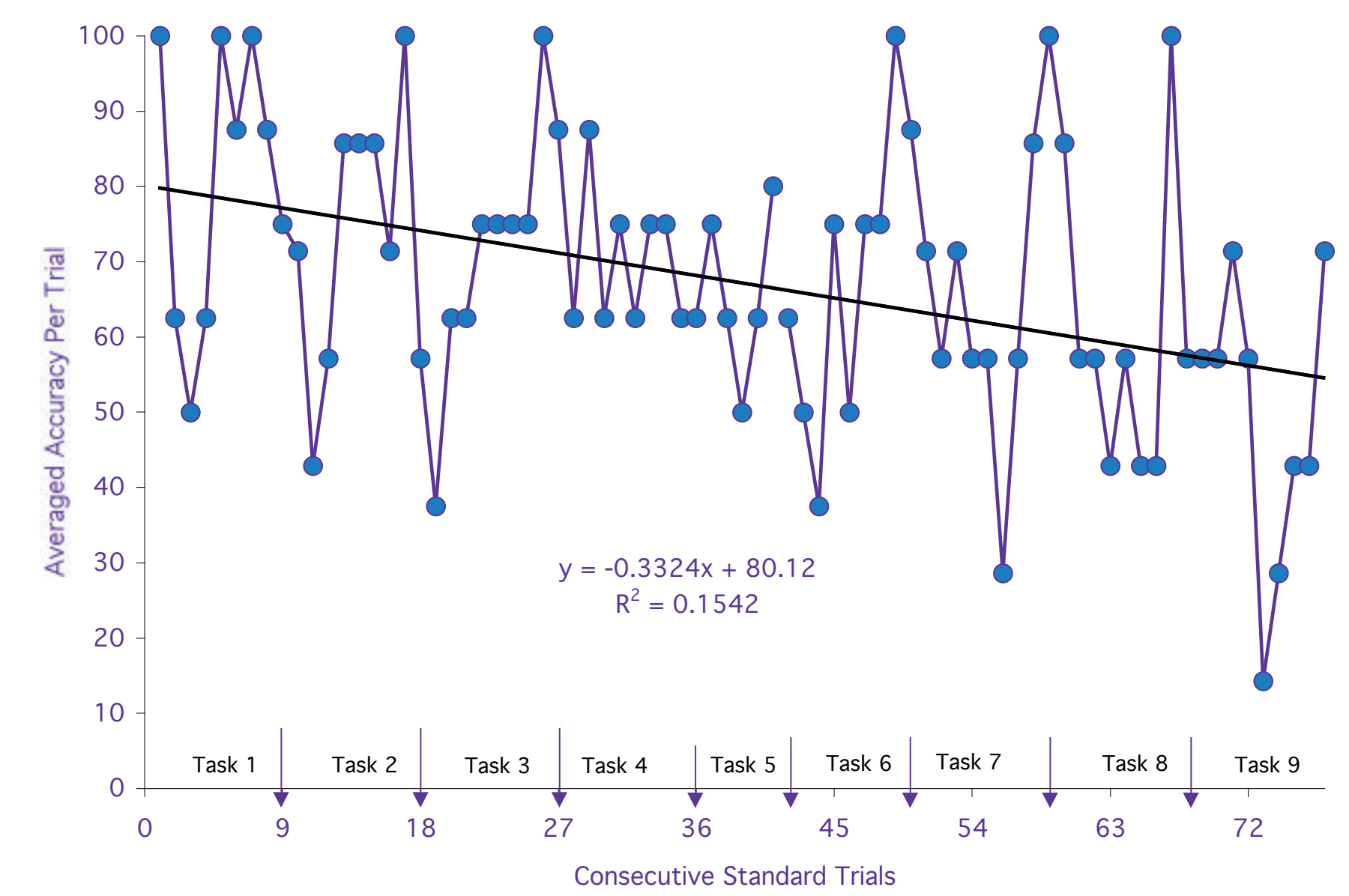
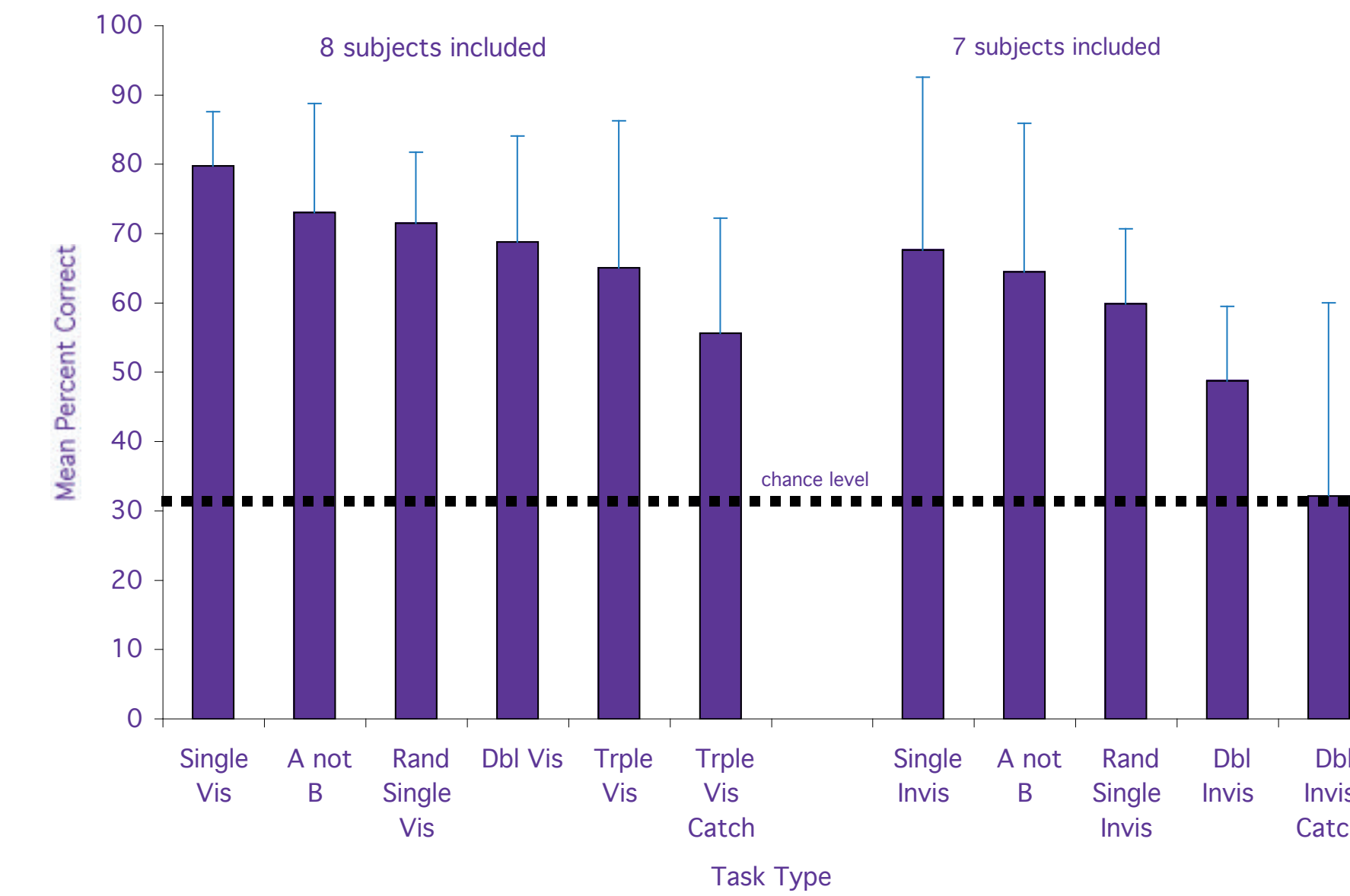
**Task : Double invisible displacements.** This task was composed of standard trials involving double displacements and "catch" trials in which a second location was touched by the experimenter at the end of the hiding process. In standard trials, the reward was placed in the displacer, and then the experimenter inserted the displacer into one cup, removed the displacer, and opened it to show the participant that the reward was still there, and then the experimenter closed the displacer again and inserted it into a second cup, where the reward was invisibly hidden. Last, the experimenter brought the displacer back out and opened it again, showing the participant that it was empty.

Intermixed with the standard trials were catch trials in which the progression of events occurred as described, but the food reward was actually deposited in the first cup location visited. The displacer was then shown to be empty, but was then placed in a second cup and removed again, and shown to remain empty. By this method, there was final manipulation of a nd cup not involved in the actual invisible hiding. Locations of final hiding were counterbalanced to occur times at each location across the standard trials, and at least time at each location in the catch trials, with one location acting as the final hiding location twice. De Blois, Novak, and Bond ( ) showed orangutans trials of the standard trials described here, and trials of the catch trials, and calculated accuracy across the trials. They did not present this task to squirrel monkeys, chiefly because they failed Tasks, and

## RESULTS

THE FIGURE TO THE LEFT depicts the mean percent correct score for all subjects (n for visible displacement tasks, n for invisible displacement tasks) for each task and the standard deviation for each. Illustrates the range of scores the subjects emitted. A determination of accurate performance for each task was made by pitting the percent correct scores for all subjects against a hypothetical mean of chance level, responding or correct (based on selection from cups). By nonparametric testing using a Wilcoxon One-Sample test, subjects were found to perform at levels significantly higher than chance in:

single visible displacement (Z, p);  
A not B visible displacement (Z, p);  
random single visible displacement (Z, p);  
double visible displacement (Z, p);  
triple visible displacement (Z, p);  
the catch trials in triple displacement (Z, p);  
single invisible displacement (Z, p);  
A not B invisible displacement (Z, p);  
random invisible displacement (Z, p);  
and in double invisible displacement (Z, p). Performance was not different from chance level responding in the catch trials in double invisible displacement. The same significant results were found when the data were subjected to parametric one sample t tests (single visible t( ) p; A not B visible t( ) p; random single visible t( ) p; double visible t( ) p; triple visible t( ) p; catch trials for triple visible t( ) p; single invisible t( ) p; A not B invisible t( ) p; random single invisible t( ) p; and double invisible t( ) p). Performance was not different from chance by the t test for catch trials in double invisible displacement either. On the whole, these results indicate that performance was significantly more accurate than chance through all standard visible and invisible displacement tasks, and these results remained significant even when the variability across subjects' scores was taken into consideration in the t test analyses. Performance dropped to chance levels for catch trials in double invisible displacement when a nd irrelevant cup was manipulated by the experimenter before subjects were allowed to make a choice. However, performance did not drop to chance levels in a similarly tricky task in triple visible displacement, in trials in which the experimenter hid the visibly displaced item in the nd container of visited, and then touched a nd container. There was significantly more accurate performance for visible displacement tasks (mean ) than for invisible displacement tasks (mean ; t( ) p). A linear trend analysis was performed on averaged accuracy per trial across all subjects starting on trial of Task, single visible displacement, and for each of consecutive trials for each of the tasks. The resulting averaged accuracies SHOWN ON THE FIGURE TO THE RIGHT, are constructed of a total of trials with consecutive trials from Tasks - consecutive standard trials across subjects for Task (i.e. without the catch trials included) and consecutive trials from Tasks -. The correlation between trial order and accuracy revealed a correlation of - with R, which was significant (F( ) p). The best fitting line across all tasks HAS a negative slope, with an intercept of. Accuracy generally started quite high in Task, showed a wide range across tasks, and generally decreased across tasks.



## DISCUSSION

This study utilized separate tasks to examine object representation by tamarins within visible and invisible displacement tasks. The results were that all participants chose the correct cup at rates significantly higher than chance in both visible and invisible displacement tasks. A strategy of selecting the last cup touched by the experimenter could not explain the data, as the tasks which provided catch trials that should have lured subjects to incorrect cups because experimenters touched them last failed to lure them away from the correct hiding location (Task ) or failed to lure them systematically to the cup last touched (Task ). Moreover, the accurate performance could not be explained by a practice effect, for over all tasks, performance actually decreased slightly, and in only tasks of did performance increase within the trials of testing. Unlike the squirrel monkeys tested by de Blois, Novak, and Bond, the tamarins in this study could successfully choose the correct hiding locations through tests of invisible displacement, and it does not appear that they did so as a result of practice with prior tasks or as a result of a simpler strategy like choosing the last cup touched by the experimenter.

A direct indication that the tamarins were doing the same kind of cognitive work as other primates tested in this way were the tendencies in accuracies and in errors found here and found elsewhere in other primates, including orangutans, chimpanzees, and human children (Call). Tamarins selected accurately at significantly higher levels when items were visibly displaced than when they were invisibly displaced, a tendency found in prior studies with primates (de Blois, Novak & Bond; Call). Second, tamarins did not show a preservation error, in that they did not persistently emit a previously reinforced response when the hidden object was suddenly placed in a new hiding location (the A not B error tests). In the prior study, de Blois, Novak and Bond ( ) found that squirrel monkeys and orangutans did not commit preservation errors with visibly displaced items and orangutans did not commit them with invisibly displaced items. A common error problem discovered in orangutans, chimpanzees, and children by Call ( ) was also revealed in tamarins in several analyses of errors. First, it became clear that tamarins showed a tendency to make errors toward adjacent cups, a finding that led to more accurate performances with adjacent hidings in orangutans, chimpanzees, and human children (Call). Second, tamarins tended to select favored locations when they made errors, although this finding is confounded by the adjacency issue since most of the biased participants favored the middle cup, which was also adjacent to either of the "correct" hiding locations when it was selected in error. Call also found location biases in the chimpanzees.

The successful performance of tamarins in this study stands in conflict with recent prior tests of another type of new world monkey. It is possible that the results mean that cotton top tamarins have particular cognitive capacities demonstrated in studies of problem solving, tool use, and spatial memory that allow them specialized abilities in object representation. Alternatively, it is possible that the methodology allowed for their capabilities to be revealed, and that other new world monkeys might show similar results given this design and the subsequent analyses of their responses. In this case, cotton top tamarins show many of the same tendencies for object search as do chimpanzees, orangutans, and children after months of age, including a greater facility with visible displacements, accurate performance with invisible displacements, a lack of preservation of a previously reinforced response, cognitive limits within invisible displacement tasks, and a tendency to favor locations, and especially adjacent search spots when the correct location eludes them. By their accurate performance, and by many aspects of their performance tendencies, tamarins demonstrate an ability to represent absent objects and to extrapolate their locations when they are visibly or invisibly moved, as do all tested great apes.