

## Three (Minus One) Cup Task w/ Absence - Preregistration (#208499)

### Author(s)

This pre-registration is currently anonymous to enable blind peer-review.  
 It has 4 authors.

Pre-registered on: 01/19/2025 08:23 AM (PT)

### 1) Have any data been collected for this study already?

No, no data have been collected for this study yet.

### 2) What's the main question being asked or hypothesis being tested in this study?

Previous work shows that a basic logical operation-the disjunctive inference (e.g., the hidden object is an apple or a stone; its is not a stone; therefore, it must be an apple)- is deployed by infants to infer the identities of objects (Cesana-Arlotti et al., 2018, 2020, 2022). Additionally, recent work has shown evidence that adults deploy spontaneous and irresistible disjunctive inferences in an object recognition task (Braswell, Firestone, and Cesana-Arlotti, in prep.). Taken together, these data point toward prelinguistic, developmentally primitive, and procedurally automatic logical operations in human cognition.

But if preverbal infants have basic logical capacities, then these cognitive resources might be language independent and possibly in place in nonhuman animals. Previous research has attempted this question in nonhuman primates (Call, 2004, 2006; Ferrigno, Huang, & Cantlon, 2021) with inconclusive results (Mody & Carey, 2016), Leahy and Carey, 2020; Engelmann et al., 2023). However, in a previous study, we found that subjects (free-ranging rhesus macaques, *Macaca mulatta*, living at the Cayo Santiago Biological Field Station) who saw our novel variation of the three-cup task (Mody & Carey, 2023) preferred the certain reward over the uncertain outcome at levels of unprecedented success (~80%). Building on this success, the current study aims to resolve the discrepancy between our positive findings and others' failures.

In this study, the same population of subjects will be shown a different variation of the three-cup task (Mody & Carey, 2023) wherein two rewards (small apples) will be hidden each in one of three cups. One apple will be hidden in a standalone cup (i.e., the single-cup side), and the other apple will be ambiguously hidden in one of the remaining two cups (i.e., the paired-cup side), such that the subject is unaware which cup in the pair contains the reward. Upon removing one of the cups from the pair, the experimenter will walk away and allow the subject to approach the apparatus. If rhesus macaques can still distinguish between the certainty of the reward on the single-cup side from the uncertainty of the reward on the paired-cup side, they should approach the single-cup side first at rates above 50% of the time (chance-level). Alternatively, if the involvement of an empty cup is a barrier to reasoning about the possible location of the reward on the paired-cup side, they should approach the single-cup side at or less than 50% of the time.

### 3) Describe the key dependent variable(s) specifying how they will be measured.

Choice when approaching: Which of the two sides of the apparatus the subject approaches first. When the macaque gets within reach of one of either the single-cup side or the paired-cup side, the trial will conclude and the choice will be recorded.

### 4) How many and which conditions will participants be assigned to?

There will be four between-subjects conditions. Evidence from previous studies has suggested that the cup taken from a pair did not affect the ultimate choice of the subject. Therefore, for half of the subjects, the paired-cup side will appear on the monkey's left and the single-cup pair will appear on the monkey's right; for the other half, the order will be reversed. For half of the subjects, the apple will be placed on the paired-cup side first, and the apple will be subsequently placed on the single-cup side. For the other half, this order will be reversed. All conditions are counterbalanced between subjects and collapsed for the purpose of our analysis. Monkeys will be randomly assigned to one of the four conditions by a random condition generator.

### 5) Specify exactly which analyses you will conduct to examine the main question/hypothesis.

See #7.

### 6) Describe exactly how outliers will be defined and handled, and your precise rule(s) for excluding observations.

If the trial is interrupted (due to interference by another monkey, the subject walking away, or experimenter error) before the experimenter can finish the demonstration, then the trial will be considered incomplete and not assigned a trial number. Upon completion of the demonstration, the subject will have one minute to approach the apparatus and make a choice. If another monkey approaches the subject or the apparatus within this time, the trial will be excluded for interference. If the subject walks out of sight of the apparatus within this time, the trial will be recorded as a walkaway. Finally, if the subject does not approach the apparatus within arm's length during the minute long observation period, the trial will be recorded as no approach. Trials in which the subject approaches but does not come close enough to reach inside one of the cups will be recorded as no approach.

### 7) How many observations will be collected or what will determine sample size? No need to justify decision, but be precise about exactly how the number will be determined.

We plan to apply a Sequential Bayes Factor analysis using the `BayesFactor` and `BFpack` package in R (Mulder et al., 2018; Mani et al., 2021). We will test an initial sample of 20 subjects and calculate the Bayes Factor (BF) on our hypothesis (H1: Subjects choose the single-cup side on more than 50% of trials)

over the null hypothesis ( $H_0$ : Subjects do not choose the single-cup side on more than 50% of trials). We will continue data collection until we either reach a  $BF > 3$  (interpreted as moderate evidence in favor of  $H_1$ ), a  $BF < 1/3$  (moderate evidence in favor of  $H_0$ ), until our data collection time is exhausted, or until we collect a maximum of 40 participants. However, a minimum sample of 20 participants will be required for this analysis.

**8) Anything else you would like to pre-register? (e.g., secondary analyses, variables collected for exploratory purposes, unusual analyses planned?)**

We also will conduct a Bayes Factor analysis comparing these data to the results of our novel 3-cup task. We will calculate the BF on our hypothesis ( $H_1$ : Subjects choose the single-cup side significantly less than they did on the previous study) over the null hypothesis ( $H_0$ : Subjects choose the single-cup side at equivalent levels relative to the previous study).