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How task format affects cognitive performance: a memory test with two species of New World monkeys

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In cognitive tests, animals are often given a choice between two options and obtain a reward if they choose correctly. We investigated whether task format affects subjects' performance in a physical cognition test. In experiment 1, a two-choice memory test, 15 marmosets, *Callithrix jacchus*, had to remember the location of a food reward over time delays of increasing duration. We predicted that their performance would decline with increasing delay, but this was not found. One possible explanation was that the subjects were not sufficiently motivated to choose correctly when presented with only two options because in each trial they had a 50% chance of being rewarded. In experiment 2, we explored this possibility by testing eight naïve marmosets and seven squirrel monkeys, *Saimiri sciureus*, with both the traditional two-choice and a new nine-choice version of the memory test that increased the cost of a wrong choice. We found that task format affected the monkeys' performance. When choosing between nine options, both species performed better and their performance declined as delays became longer. Our results suggest that the two-choice format compromises the assessment of physical cognition, at least in memory tests with these New World monkeys, whereas providing more options, which decreases the probability of obtaining a reward when making a random guess, improves both performance and measurement validity of memory. Our findings suggest that two-choice tasks should be used with caution in comparisons within and across species because they are prone to motivational biases.

When the cognitive abilities of animals are assessed with cognitive tests, subjects are often presented with two options to choose from and rewarded with a food item if they choose the correct option. This two-choice task format has been used to test, in a range of animal species, a variety of cognitive abilities such as memory (e.g. delayed response tasks in bees, *Apis mellifera*; pigeons, *Columba livia*; several rat strains; many other species, including primates; reviewed in Lind, Enquist, & Ghirlanda, 2015), understanding intentional deception (chimpanzees, *Pan troglodytes*, Woodruff & Premack, 1979; dogs, *Canis familaris*, Petter, Musolino, Roberts, & Cole, 2009) or inferential reasoning (dogs, Erdöhegyi, Topál, Virányi & Miklósi, 2007; carrion crows, *Corvus corone corone*, Mikolasch, Kotrschal, & Schloegel, 2012; chimpanzees, bonobos, *Pan paniscus*, orang-utans, *Pongo pygmaeus*, gorillas, *Gorilla gorilla*, Call, 2006). One test that has extensively used the two-choice format in particular with a wide range of animal species is the object choice task. This task tests for sociocognitive abilities by assessing a subject's ability to use an experimenter's gestural cues (e.g. gaze, point, touch) in order to locate a reward that is hidden under one of usually two containers. The tested species include primates (all four great apes and some Old and New World monkeys), domesticated mammals (dogs; foxes, *Vulpes vulpes*; cats, *Felis catus*; horses, *Equus caballus*; goats, *Capra hircus*) and undomesticated terrestrial (wolves, *Canis lupus*; bats, *Pteropus* spp.) and marine mammals (dolphins, *Tursiops truncatus*; seals, *Halichoerus grypus* and *Arctocephalus pusillus*; sea lions, *Otaria byronia*), corvids (jackdaws, *Corvus monedula*, nutcrackers, *Nucifraga columbiana*) and parrots (African grey parrot, *Psittacus erithacus*); see Mulcahy and Hedge (2012) for a review.

Although the two-choice task format is widely used in comparative psychology, there is recent evidence that in some circumstances the task may not be a suitable method for assessing cognitive abilities. Burkart and Heschl (2006), for instance, found that common marmosets, *Callithrix jacchus*, a New World monkey species, chose at random when presented with only two containers in an object choice task, but they were able to use the

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experimenter's cues much more reliably and made more correct choices when presented with nine instead of only two containers to choose from. A likely explanation is that lowering the probability of obtaining a reward by random choice helped the marmosets to overcome an inherent social bias that makes nonhuman primates reluctant to follow communicative cues to food rewards.

In physical cognition tasks, such social biases should not influence a subject's performance, because these tasks usually do not involve any social interaction between subject and experimenter. Memory tests, such as delayed response tasks (e.g. Kendrick, Rilling, & Denny, 1986; Lind et al., 2015; Rodriguez & Paule, 2009) for instance, often require the subjects to first observe and later remember in which of two locations a reward has been hidden without obtaining any communicative cues. Consequently, if social biases alone were responsible for the effect of task format on the marmosets' performance in the object choice task, lowering the chance probability of success should not affect their performance in such nonsocial cognition tasks. Nevertheless, the subjects may prefer to choose in a random manner for other reasons, for instance to avoid the effort of memorizing. To date, it is not known whether, or to what extent, task format and chance probabilities also affect performance in physical cognition tests. But if they do so in a similar way, as demonstrated for social tests, this has far-reaching consequences for the validity of species comparisons that are often based on tasks that differ in format.

In the present study, we tested New World monkeys with a physical cognition test that assesses their memory ability and investigated whether an alternative task format with nine choices would also be more suitable than the traditional two-choice task format. In experiment 1, we tested common marmosets with a traditional two-choice memory test, i.e. the memory subtest (hidden reward retrieval) of a cognitive test battery designed to assess general intelligence in nonhuman primates (Banerjee et al., 2009). In this traditional delayed response memory test, the subjects had to remember the location of a food reward over various time delays. After watching how a food reward was hidden in one of two locations, the subject could no longer see the reward and had to wait until the delay interval had expired before it could choose one of the two locations. New World monkeys, particularly smaller species such as marmosets (Miles, 1957a; Miles & Meyer, 1956) and squirrel monkeys, *Saimiri sciureus* (French, 1959; Miles, 1957b), have been shown to perform worse on such delayed response tasks than Old World monkeys (mainly rhesus macaques, *Macaca mulatta*) and apes (e.g. Fischer & Kitchener, 1965; Harlow, 1932; Miles & Meyer, 1956; reviewed in: Tomasello & Call, 1997). Even though the methodological details are not always comparable, New World monkeys have also been shown to perform as well as (capuchins, *Cebus apella*) or better than (spider monkeys, *Ateles geoffroyi*) Old World monkeys (long-tailed macaques, *Macaca fascicularis*), and even as well as great apes (Amici, Aureli, & Call, 2010). Moreover, even smaller monkeys usually still perform well above chance, at least with short delays (comparison of apes and monkeys, Fischer & Kitchener, 1965). We therefore expected the marmosets to pass the traditional memory test in experiment 1. Furthermore, in humans, the ability to remember a specific memory content declines exponentially the more time has elapsed since its acquisition, a phenomenon known as the forgetting curve (Ebbinghaus, 1885, 1913; hereafter Ebbinghaus effect). In experiment 1, we therefore expected that the marmosets' performance would similarly decline with increasing duration of the time delay if this test accurately measured memory performance. Since the marmosets performed relatively poorly in experiment 1 and did not show an Ebbinghaus effect, we conducted experiment 2, which was designed to assess the effect of reducing the chance of obtaining a reward when choosing at random. We tested a new sample of marmosets and squirrel monkeys and compared their performance in a traditional two-choice versus our newly developed nine-choice version of the memory test.

EXPERIMENT 1: TRADITIONAL TWO-CHOICE MEMORY TEST

Methods

Subjects

Fifteen common marmosets, eight males and seven females, participated in this study. All subjects were housed in social groups consisting of two to six individuals at the Primate Station of the Department of Anthropology of the University of Zurich, Switzerland. Their indoor enclosures had both daylight and artificial light and were composed of one to three components (depending on group size) measuring 1 × 2 m and 2 m high, each of which was equipped with several climbing structures such as natural branches, a sleeping box, an infrared lamp and a mulch floor. Whenever the weather conditions allowed it, each group had free access to an outdoor enclosure. The marmosets were fed a vitamin and calcium-enriched porridge in the morning, fresh fruit and vegetables at lunchtime, and gum and mealworms in the late afternoon. In addition, they received a daily protein snack in the afternoon such as pieces of cooked egg. Water was available ad libitum from water dispensers. All subjects were tested between their regular feedings and never food deprived during the study. They could enter and leave the test enclosure through semi-transparent plastic tubes that were connected to their home enclosures and were not handled at any time.

Materials and set-up

Each subject was tested individually in the same compartment (41 × 53 cm and 33 cm high) of a larger test enclosure, with its group members present in an adjacent enclosure (100 × 122 cm and 78 cm high) so that the subject could hear and smell but not see them during testing. The test compartment had a transparent Plexiglas window front containing two rectangular openings (4 × 2.5 cm). The test apparatus consisted of two white opaque cylinder-shaped plastic containers (3.0 cm in height and 5.3 cm in diameter) that were attached to a wooden board (33 × 33 cm) placed 2 cm from its front, and was placed on the wooden test table (40 × 40 cm) that was level with the test compartment's floor. The test apparatus could be slid in and out of the subject's reach. The two containers were filled with dark-brown bark mulch that corresponded to the flooring substrate in the marmosets' home enclosures. A small piece of a yellow locust, *Schistocerca gregaria*, served as a reward in each trial. At the beginning of each trial, the test apparatus was placed just out of the subject's reach and the two containers were each covered with a rectangular piece of mulch approximately the same size as the container.

Procedure

The experimenter stood behind the test apparatus, called the subject's name, said 'look' while showing it the reward and started a trial as soon as the subject was attentive. She removed the cover of one of the two containers, placed the food reward in the container and again covered it with the piece of mulch so that the reward was no longer visible and both containers, the baited and the empty one, remained covered. After the delay interval had expired, she slid the board with the containers towards the test compartment's window. The subject could then make a choice by reaching through one of the two rectangular openings in the window and removing the cover with its hand(s). There were six conditions with increasing time delays of 5, 10, 15, 20, 25 and 30 s. Each test session consisted of 10 trials of one delay condition, if