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A low-coercion, open-loop design provides preliminary evidence of visually guided discrimination and individual differences in two Neotropical otters (*Lontra longicaudis*)

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Abstract

A low-coercion, open-loop design can extend discrimination testing to captive animals that resist standard methods, such as the Neotropical otter (*Lontra longicaudis*), for which no data exist. We tested visually guided instrumental behaviour in two individuals using a two-choice task in which an incorrect first choice cost only a delay. One otter reached above-chance accuracy with full correction; the other did not exceed chance but reduced an initial side preference and corrected more often, differing in latency and item handling. The results give preliminary evidence of this capacity and a design suited to other hard-to-test species.

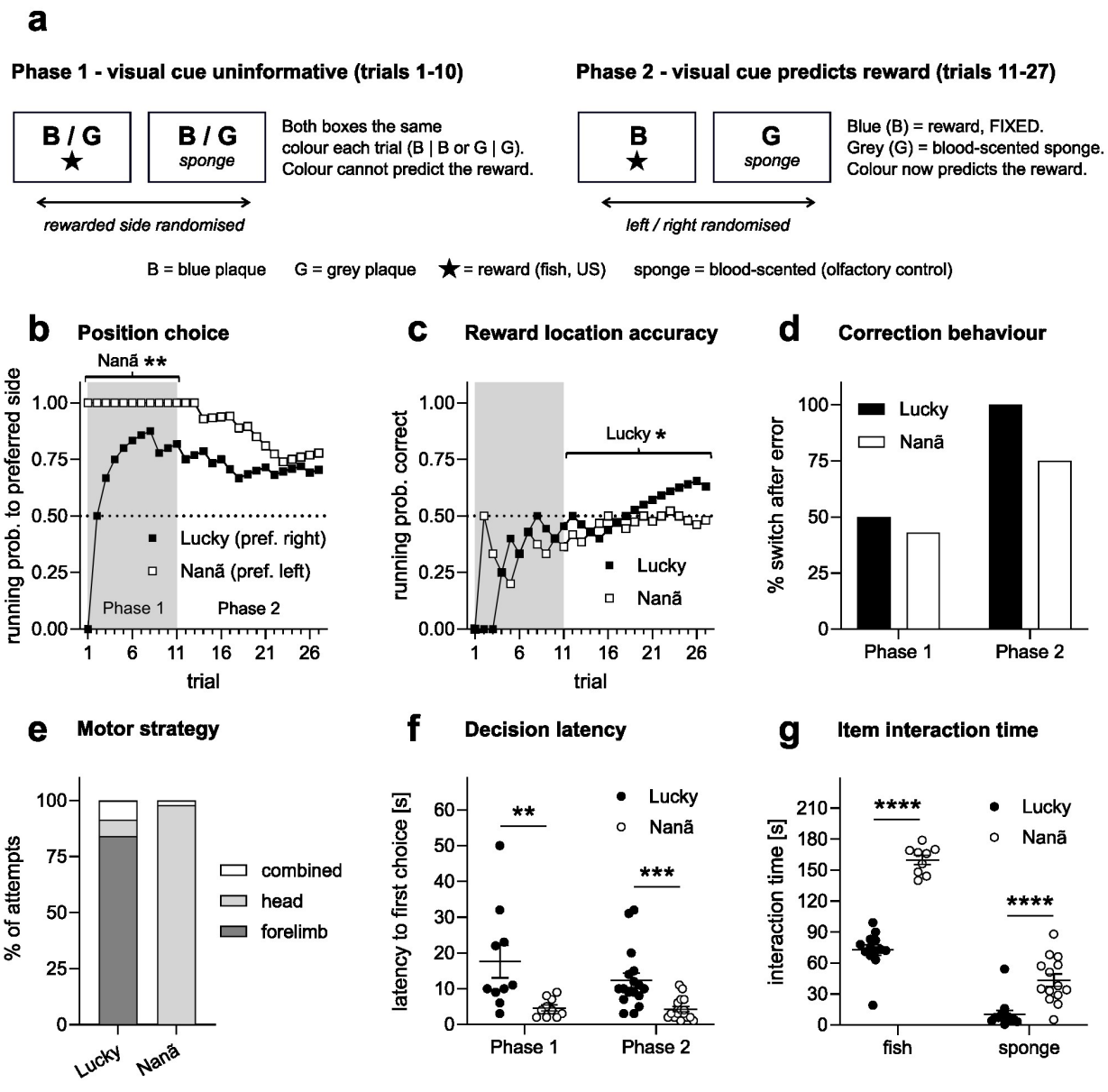


Figure 1. Visually guided discrimination in two Neotropical otters (*Lontra longicaudis*):

Lucky (male, filled symbols/bars) and Nanã (female, open symbols/bars) were tested over 27 trials each (Phase 1, trials 1–10; Phase 2, trials 11–27; grey shading in **b**, **c** marks Phase 1). **a** Task design. Each trial offered two boxes bearing a coloured plaque (B, blue; G, grey), one holding the reward fish (★, unconditioned stimulus) and the other a leaf-wrapped, blood-scented sponge (the alternative item) that equated odour across boxes and held no food. In Phase 1 both boxes carried the same colour per trial and the rewarded side was randomised, so colour could not predict reward; in Phase 2 the reward was always in the blue box and the sponge in the grey box, with left–right position randomised. **b** Running proportion of choices to each subject's preferred side (Lucky, right; Nanã, left). **c** Running proportion of correct first choices. Dotted lines in **b**, **c** mark chance (0.5); asterisks denote two-tailed binomial tests of the full-phase proportion against chance. **d** Percentage of error trials followed by a switch to the alternative box, by phase. **e** Percentage of door-opening attempts made with forelimbs, head, or both. **f** Latency to first choice (s; individual trials with mean ± SEM, two-tailed Mann–Whitney U between subjects within phase). **g** Time spent with the reward fish and the sponge (s; individual interactions with mean ± SEM, two-tailed unpaired t test between subjects within item; fish n = 13 Lucky, 9 Nanã; sponge n = 14 each). Asterisks in **f**, **g** denote between-individual comparisons. * p < .05, ** p < .01, *** p < .001, **** p < .0001.

Description

Otters are behaviourally flexible carnivores with demanding foraging niches, and they are also difficult subjects for standard discrimination testing. They are fast-moving and voracious, and they are not easily deprived or coerced. Their learning has, in consequence, been studied in only a handful of species, and rarely in any depth. Sea otters use tools (Hall and Schaller, 1964), North American river otters discriminate stimuli varying in shape and colour and generalise to novel stimuli (DeLong et al., 2018; Wegman et al., 2025), and Asian small-clawed otters show discrimination learning, spatial memory, and long-term retention, with marked variation between individuals (Perdue et al., 2013; Svoke et al., 2014; Saliveros et al., 2020). Neotropical otters (*Lontra longicaudis*) are semi-aquatic carnivores of conservation interest (de Almeida Rodrigues et al., 2013), and no learning or discrimination data exist for the species. The gap also matters in captivity, where effective enrichment depends on how animals read and respond to cues (Wegman and DeLong, 2023). Whether otters rely on colour is not fully resolved, since anatomical evidence points to reduced colour vision in several marine carnivores (Peichl et al., 2001; Levenson et al., 2006), while an Asian small-clawed otter can discriminate colour stimuli (Svoke et al., 2014), making colour a plausible cue.

Discrimination learning is most often studied using forced-choice procedures, which gate the reward behind a correct first choice under strong motivational control. Implementing such procedures is not straightforward in otters, whose speed, appetite, and occasional aggression make many captive testing protocols risky or impractical, and harder still for naïve subjects tested over a realistically short window, where there is little time for conventional shaping. At one or two trials per day over a few weeks, forced-choice testing yields little information about what a subject can do, and its demands travel poorly to settings where deprivation and coercion are undesirable. Neither discrimination nor learning is fully captured by whether a trial ends correctly; both are also visible in how an animal moves through the trial, in its approach, corrections, and handling of the alternatives. We therefore asked whether visually guided instrumental behaviour could be established in *L. longicaudis* with a procedure that asks less of the animal and records the whole sequence of actions in a trial, so that differences between subjects, including in what appears to motivate them, are described rather than averaged away as noise. The design carries a cost. Leaving both options open within a trial weakens the selective pressure on first-choice accuracy and lowers the discriminative role of the reward, so the procedure tests for discrimination and learning under conditions that work against their expression.

Two adult otters, Lucky (male) and Nanã (female), were tested at Projeto Lontra, a conservation facility in Florianópolis, Brazil. Each otter chose between two boxes bearing a visual cue (a blue or grey plaque), one holding a reward fish and the other a leaf-wrapped, blood-scented sponge that equated odour across boxes. The sponge held no food, and we refer to it as the alternative item. Both boxes remained accessible within a trial, so an incorrect first choice cost only a delay, not the reward, and no food deprivation was imposed. In Phase 1 (trials 1 to 10), both boxes carried identical plaques and the rewarded side was randomised, so the visual cue could not predict reward. In Phase 2 (trials 11 to 27), the blue plaque always marked the reward (Fig. 1a).

Both otters showed spontaneous spatial preferences in Phase 1 (Nanã, left side, 10/10 trials, two-tailed binomial test, first significant at trial 6, p = 0.031, overall p = 0.002; Lucky, right side, 8/10 trials, overall p = 0.11), and neither located the reward above chance (4/10 correct each, p = 0.75), confirming that odour alone did not guide choice. In Phase 2, side preference no longer reached significance in either otter (Lucky, right side, 11/17, 65%, p = 0.33; Nanã, left side, 11/17, 65%, p = 0.33). Lucky's accuracy rose above chance, first significant on the 15th Phase 2 trial (trial 25; 12/15, p = 0.035) and maintained overall (13/17, 76.5%, p = 0.049), while Nanã's did not (9/17, 53%, p = 1.0). Correction after an incorrect first choice was roughly equal to persistence in Phase 1 (Lucky 50%, Nanã 43%) and increased in Phase 2 for both otters (Lucky 100%, Nanã 75%), a descriptive measure not tested inferentially, as each derives from a single subject (Fig. 1b-d).

The two otters also used different motor strategies throughout: of 96 attempts, Nanã used her head alone on 94 and a head-and-forelimb combination on 2 (Extended Data Video 1); of 82 attempts, Lucky used a forelimb push on 69, his head alone on 6, and a combination on 7 (Extended Data Video 2). They differed consistently in decision latency, with Lucky slower than Nanã in both phases (Phase 1: 17.6 ± 4.6 s versus 4.6 ± 0.8 s, Mann-Whitney $U = 10$, $p = 0.003$; Phase 2: 12.3 ± 2.0 s versus 4.2 ± 0.7 s, $U = 38$, $p < 0.001$), and in time spent with the reward fish and the alternative item, with Nanã longer than Lucky with both (fish: 159.9 ± 4.5 s versus 72.6 ± 5.2 s, $t(20) = 11.95$, $p < 0.0001$; sponge: 43.4 ± 5.9 s versus 10.2 ± 3.5 s, $t(26) = 4.80$, $p < 0.0001$) (Fig. 1e-g; pseudo-replicated; see Methods). Both otters handled the alternative item, which was therefore not motivationally neutral.

When the visual cue carried no information in Phase 1, both otters moved quickly and consistently to whichever box was less visible from their point of entry, and their opposite side preferences matched their different points of entry relative to the two boxes. We did not vary entry geometry and cannot exclude simpler accounts, but the pattern was orderly, and position defaults of this kind have been noted before in otter discrimination testing (Slack, 1966). Our observation adds a candidate form for the default, a tendency to explore first what cannot be seen from the point of entry.

Visually guided discrimination is therefore achievable in *L. longicaudis*, the first such evidence for the species. With two individuals, these findings are a proof of principle and do not support population-level inference. Lucky and Nanã differed consistently across several measures beyond first-choice accuracy.

Temperament offers one reading of these stable differences. Nanã was fast and stereotyped in her decisions and engaged both items at length, fitting a proactive, routine-forming style weakly guided by a changing cue (Koolhaas et al., 1999). Lucky was slower and more variable, handled the alternative item only briefly, and reached above-chance accuracy, consistent with a reactive, cue-sensitive style (Réale et al., 2007). This reading of Lucky rests on his accuracy, complete correction, and differentiated handling of the two items together, not on accuracy alone. This is not the only reading available. Nanã's long engagement with both items need not mean inattention to the visual cue. The alternative item was not neutral for her, and she often carried it away to work at it at length (Extended Data Video 3). A subject who invests little in first-choice accuracy may be responding sensibly to conditions where both boxes hold something worth her time, in which case her record reflects efficient use of the contingency rather than weak discrimination. Two animals cannot decide between these accounts.

Several limitations bound these claims. The sample precludes population-level inference and leaves sex and individual identity confounded with any temperament reading, echoing Slack (1966), whose one male and one female showed the same sex-outcome pairing. Blue was rewarded for both otters and was never set against grey before Phase 2, so above-chance choice of blue cannot be separated from an unlearned preference for blue, arising from brightness, contrast or another property of the plaques. Lucky chose blue on 2 of the first 5 Phase 2 trials and on 11 of the remaining 12 (Extended Data Table 1), consistent with acquisition but not excluding a preference masked early on by his side bias. The cue dimensions that supported discrimination, hue and brightness, were not separated. The features that limit this study also set its sequel. A matched, motivationally neutral alternative item would separate discrimination from engagement with that item. A measure of effort to secure reward would separate discrimination from efficient use of an open contingency. An apparatus that varies entry geometry would test the spatial default we observed but did not manipulate. Counterbalancing the rewarded colour, or testing blue against grey before either is rewarded, would separate learning from colour preference, and achromatic controls would isolate hue from brightness. The outcome is therefore twofold. The study gives preliminary evidence of visually guided discrimination in *L. longicaudis*, and an open-loop design that, asking little coercion and no deprivation, could extend to further otters and to other species difficult to test with conventional forced-choice methods, letting a behaviourally flexible carnivore do more in the apparatus than any single accuracy score can hold.

Methods

Subjects and housing

Two adult Neotropical otters were tested at Projeto Lontra, a conservation facility in southern Florianópolis, Santa Catarina, Brazil, adjacent to natural otter habitat. Lucky was a male aged five years at the time of the study; Nanã was a female aged seven years (Extended Data Fig. 1). Both were rescued as orphaned cubs and remained in institutional care thereafter. Throughout the study, Lucky and Nanã were housed in separate enclosures, each with a holding area (Extended Data Fig. 2). Each otter was tested only in its own enclosure. Ethical approval covered four resident otters. Two were tested, as local circumstances during the study period reduced the number available. Their routine included two daily feeding sessions, with environmental enrichment on a daily or alternate-day schedule. Fish, varying in species according to local availability, constituted the main dietary component and served as the unconditioned stimulus (US). No food deprivation was imposed beyond the interval between a trial and the subsequent routine feeding session. All procedures were non-invasive and were approved through Liverpool John Moores University's ethical review process for non-regulated animal research, with institutional authorisation from Instituto Ekko Brasil.

Apparatus

The apparatus consisted of two identical modified animal-transport boxes (114 × 50 × 51 cm), each fitted with removable coloured plaques (blue or grey) affixed to the sliding door and to one external side panel (Extended Data Fig. 3). Colour was used as the discriminative dimension rather than shape or pattern, following behavioural evidence of colour-stimulus discrimination in otters (Svoke et al., 2014). Hue and brightness were not separated. The plaque on the side panel was intended to reduce the chance that a fast-moving otter would open a door from the side without having faced the front plaque, and so register a choice not based on visual comparison. Its separate contribution was not quantified, because fast side approaches were not reliably visible to the front-facing camera and observer. Sliding doors were set to leave a gap of approximately 6 cm, allowing the otter to push the door open and enter. Four PVC tubes arranged in front of each box channelled the otter's approach towards the door, extending exposure to the coloured stimulus before each choice. A pulley-and-rope mechanism held the heavy door as the otter entered, preventing it from dropping shut under its own weight and injuring the animal. Once the otter was inside, the door closed fully, and the otter had to push it open again to exit. The mechanism provided no assistance with opening and served solely as a safety measure during entry.

Experimental design

The study ran over 14 days with two trials per day, except on the final day when one trial was conducted, yielding 27 trials per individual. All trials were run immediately before routine feeding sessions. The experiment comprised two sequential phases. In Phase 1 (trials 1–10), both boxes were assigned identical colours (blue or grey, randomised across trials) and the US was randomised across boxes, in order to reveal spontaneous spatial preferences and to verify that olfactory cues did not guide choice. In Phase 2 (trials 11–27), boxes were assigned distinct, fixed colours: the US was always placed in the blue box and the olfactory masking stimulus in the grey box. The left–right position of the colour plaques was randomised across all trials. Each box contained either the reward fish (~60 g) or a loofah sponge soaked in fish blood, both wrapped in a large leaf following a standardised protocol (Extended Data Fig. 4); the sponge was prepared as shown in Extended Data Fig. 5. Boxes were washed with unscented soap between trials.

Trial procedure and data collection

At the start of each trial, the otter was secured in the holding area of its own enclosure, without visual access to the testing area, while the apparatus was positioned. A trial began when the otter was released and ended either after 10 minutes or once the subject had accessed both boxes and ceased interacting with the apparatus. The first door-opening attempt constituted the first choice for that trial. All trials were video-recorded, and an observer recorded choice outcomes in real time.

Statistical analysis

Choice accuracy and side bias were assessed using cumulative binomial tests applied trial by trial within each phase, identifying the trial within the phase at which accumulated choices first deviated from chance ($p < 0.05$); the proportion across the full phase was also tested. All binomial tests were two-tailed. Correction behaviour and reward-location memory were characterised as descriptive indices for each individual; no inferential tests were applied to these measures, as each derives from a single subject. Individual differences in latency to first choice and in item interaction time were compared between subjects using two-tailed Mann–Whitney U tests (latency) and two-tailed unpaired t tests (interaction time). We emphasise that these between-subject comparisons are pseudo-replicated: they characterise two specific individuals and do not license population-level inference. Descriptive statistics are reported as mean ± standard error of the mean (SEM). Data were organised in MS Excel (Microsoft Corp, Redmond, WA, USA). Statistical analyses were performed in Python with SciPy (Virtanen et al., 2020) and Prism 10.2.0 (GraphPad Software Inc, San Diego, CA, USA).

Data availability

The underlying data necessary to reproduce the figures and analyses have been deposited in a Zenodo repository (DOI: **10.5281/zenodo.23601897**). Extended Data (Figures 1–5 and Videos 1–3) have been submitted directly to microPublication Biology and are also archived in the same Zenodo repository.

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Extended Data

Description: Extended Data Video 1. Nanã's door-opening technique. Nanã opening the choice box by pushing the door with her head. Resource Type: Audiovisual. File: Extended Data Video 1 Nanadoorsshort.mp4. DOI: 10.22002/xthjg-yr689

Description: Extended Data Video 2. Lucky's door-opening technique. Lucky opening the choice box by pushing the door with his forelimbs. Resource Type: Audiovisual. File: Extended Data Video 2 Luckydoorsshort.mp4. DOI: 10.22002/jqjkm-zw766

Description: Extended Data Video 3. Nanã's handling of the non-reward item. Nanã carrying the sponge to the pond and chewing it. Resource Type: Audiovisual. File: Extended Data Video 3_NanaSponge.mp4. DOI: 10.22002/jkw0d-ne658

Description: Extended Data Figures 1-5. (Fig 1) Subjects. Photographs of Nanã (female) and Lucky (male), the two Neotropical otters tested in this study. (Fig 2) Housing and testing layout. Photographs of the two enclosures housing Lucky and Nanã during testing. (Fig 3) Choice box. Photographs of the modified animal-transport box used as a choice apparatus, fitted with the blue and grey discriminative plaques. (Fig 4) Wrapping of stimuli in leaves. Photographs documenting the standardized leaf-wrapping protocol applied to the reward fish and the non-reward sponge. (Fig 5) Preparation of the scented sponge. Photographs documenting preparation of the blood-scented sponge used for olfactory control. Resource Type: Image. File: Chiarella and De Marco 2026 Extended Data.pdf. DOI: 10.22002/jb4bz-hh791

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