



A touchscreen-based, multiple-choice approach to cognitive enrichment for captive rhesus macaques

Calapai A., Cassidy L., **Saxena, P.**, Pfefferle D., Nazari A., Yurt P., Brockhausen R., Treue S.

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A touchscreen-based, multiple-choice approach to cognitive enrichment for captive rhesus macaques

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Psychological well-being of **captive animals** is enhanced by complex and rich environments. Interaction with various enrichments (especially when spontaneous and self-regulated) improves the animal's sense of agency and competence. This is related to the perceived **sense of control** that the animal feels when engaging with an activity that stimulates and exercises the animal's cognition. In humans and captive monkeys the sense of control increases when **choice** is available.

We propose a highly customisable approach to provide choices to animals in captivity, via a **multiple-choice interface (MCI)** for computerised, stand-alone, cage-based, enrichment and assessment systems.

The MCI offers **three activities** from which the animal can choose on a trial-by-trial basis. Two activities delivered fluid reward when selected and correctly completed, while one only displayed pictures of conspecifics and naturalistic scenes.

Experimental questions to evaluate the feasibility of the MCI approach with captive rhesus macaques

- Do animals operate the device? (Figure 2 - General Engagement across: animals, sessions, time of day)
- How do animals interact with the various tasks, randomly or purposefully? (Figure 3 - Task preference across animals and Bayesian statistical evaluation)
- Does the animal engagement with the various tasks change across time (Sessions / Time of day)? (Figure 4)
- Do animals learn anything? can MCI be used to train animals (Figure 5 - Evidence of animals becoming proficient)

methodological description:

- Figure 1: device, interface, and tasks (*consider adding video of 1 animal selecting few trials - video might not be available*)
- 16 animals across 7 social groups (6 groups of 2 individuals and 1 group of 4)
- 6 consecutive Saturdays, from 9:00 to 17:00; seamless integration into husbandry routine
- no fluid / food restrictions (water available during session; feeding as normal)
- no social separation (animal identified from pictures in post processing)

Figure 1 – Methods: device, interface, tasks

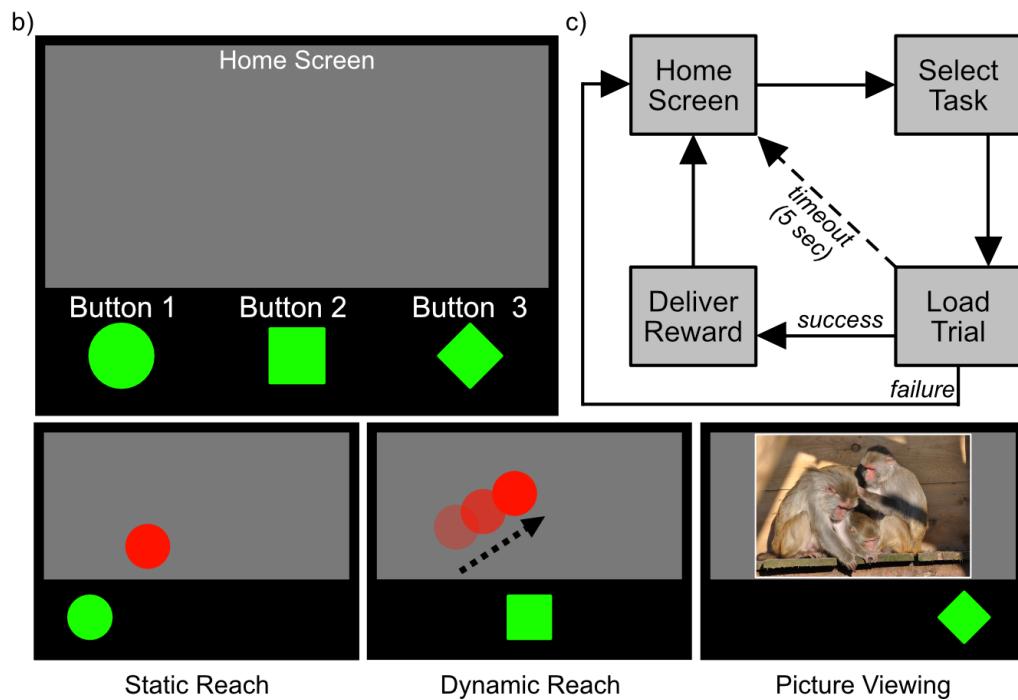
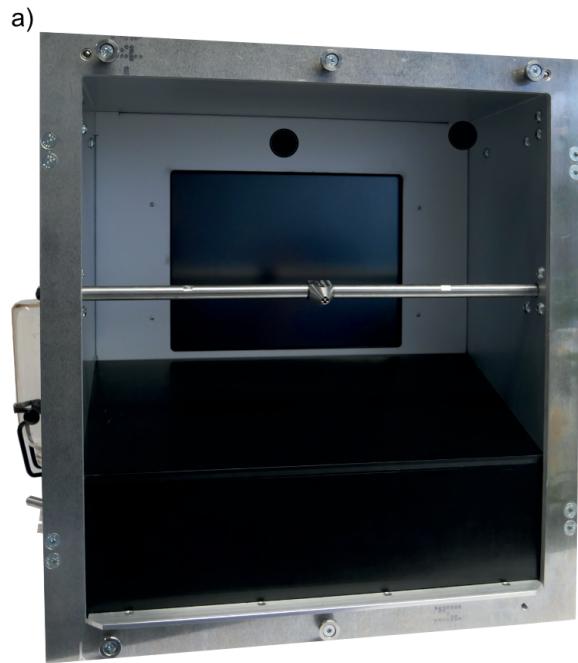


Figure 1. a) Front view of the XBI with the reward mouthpiece, the monitor and touchscreen, and the two cameras; b) the multiple-choice interface (MCI) comprising the Home Screen and the Buttons leading to the three tasks; c) flow chart of the transition between tasks and Home Screen depending on trial outcome.

Figure 2 – Sustained level of engagement between and within sessions

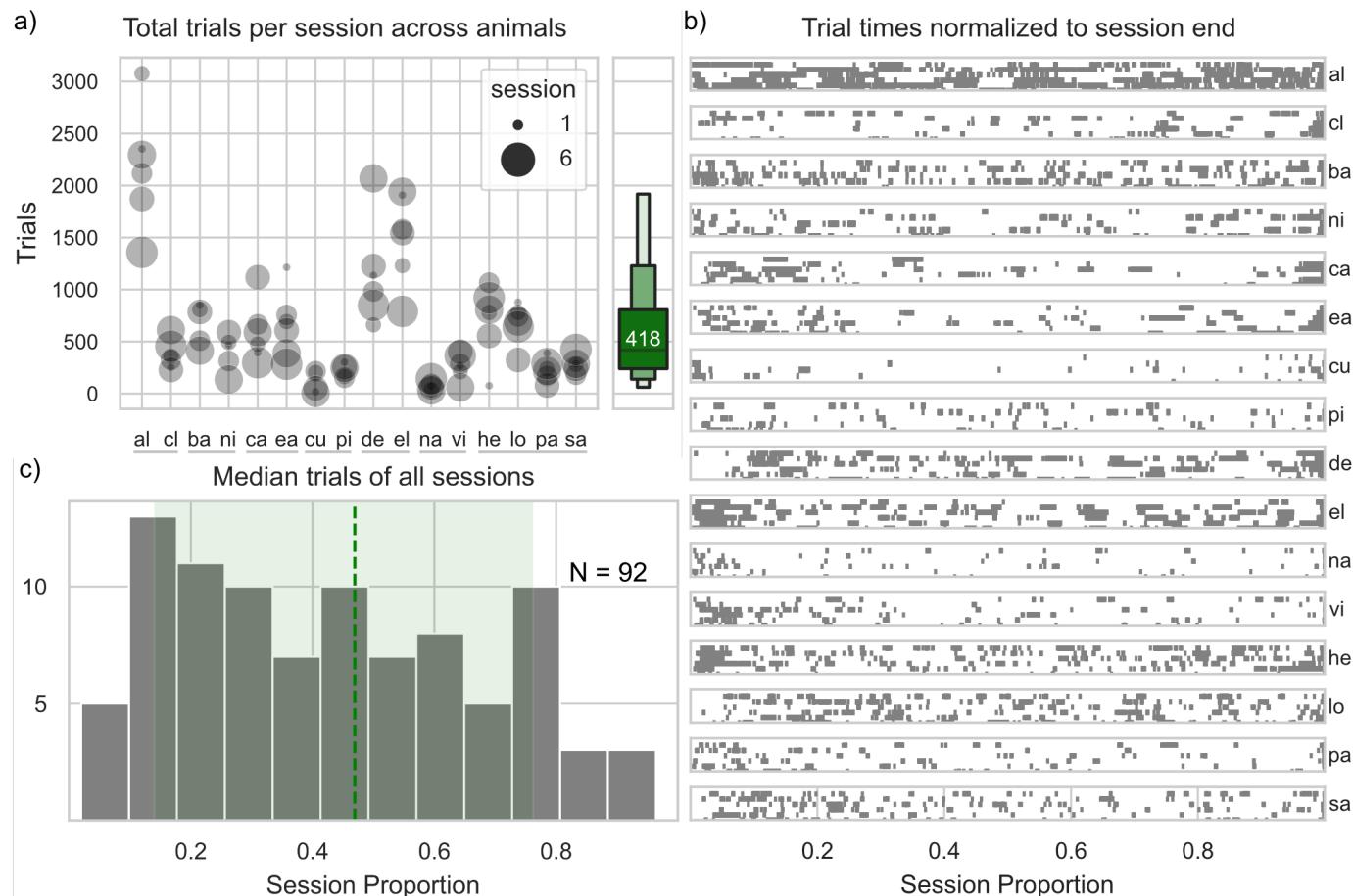


Figure 2 – Level of engagement with the MCI. **a** On the left: number of trials of each animal at each session (dot size); on the right: median trials per session across all animals (green letter-value plot). Animals on the x axis are showed next to their respective partners, indicated by the solid black line highlighting animals belonging to the same group. **b** Distribution of all trial times (normalized to the end of each session – session proportion) for each animal and each session. **c** Distribution of all median trials times across all animals and sessions. Dashed green line and greed shaded area represent the median of all median trials as well as the area between the median minimum and median maximum.

Figure 3 – Clear task preference with high variability across animals

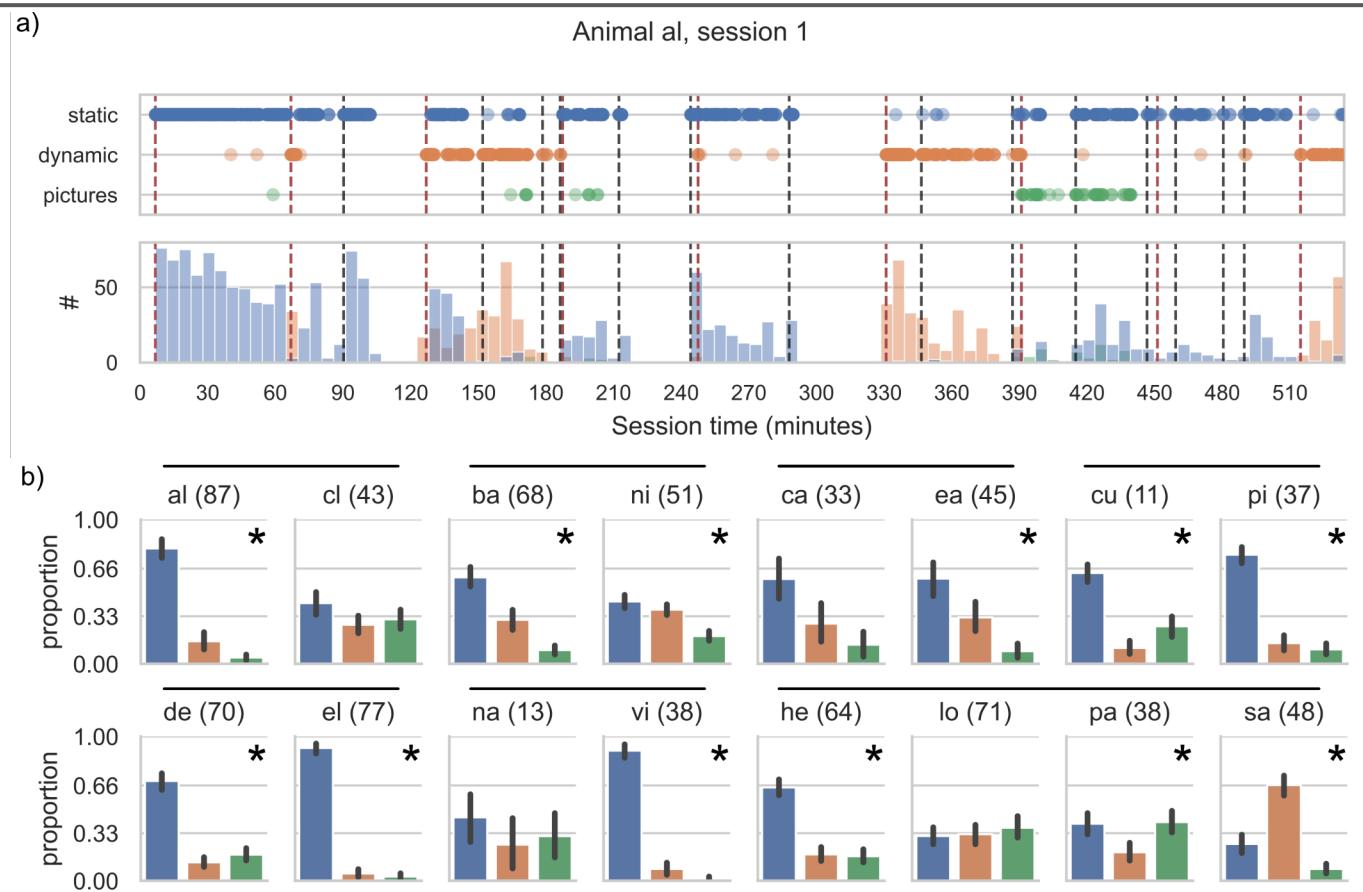
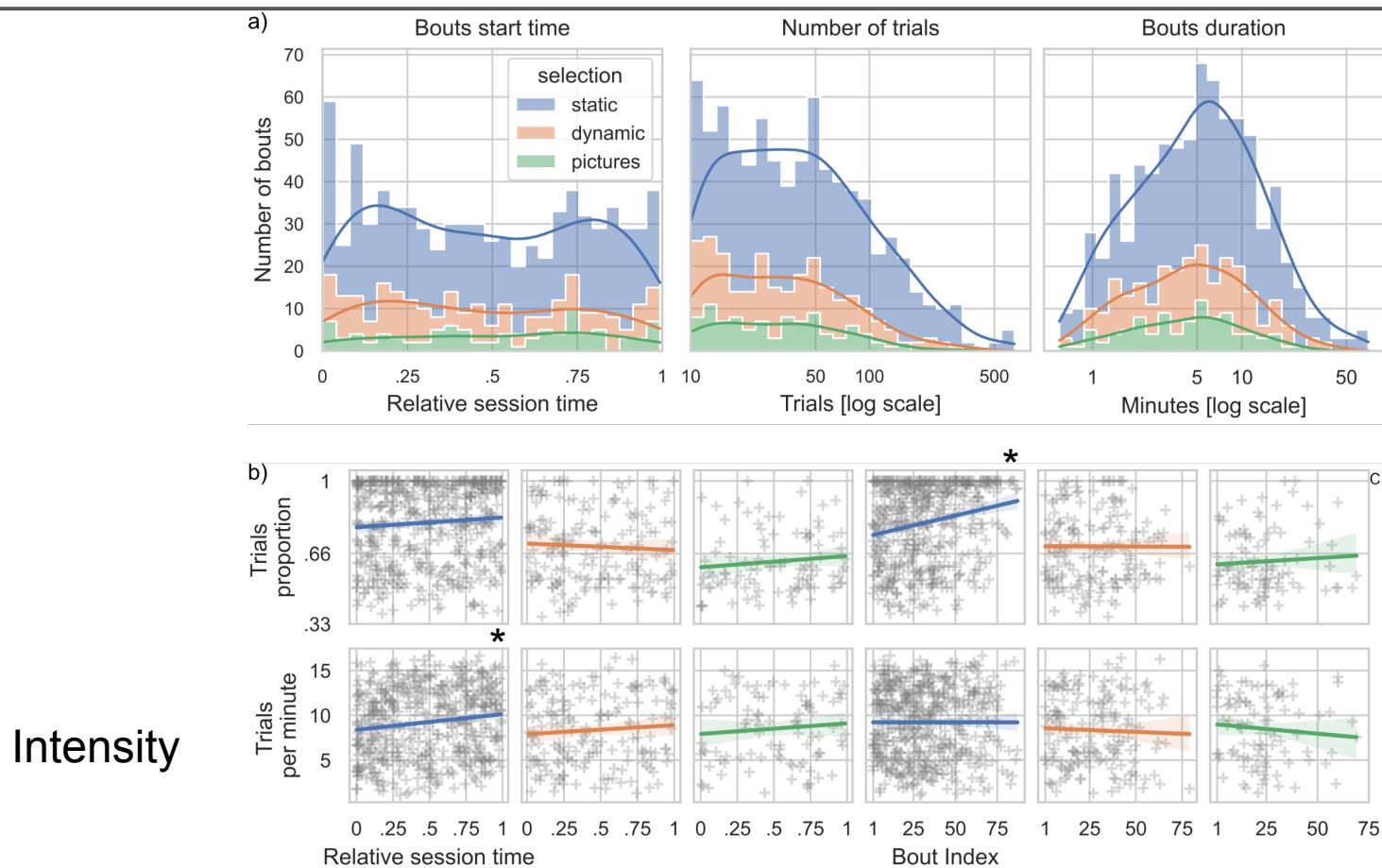


Figure 3 – Subdivision of sessions in bouts of engagement. a: timeline of task selection (top), and respective count histogram (bottom) for the first session of one example animal (animal al). Each dot represents a trial performed on the corresponding task (y axis) as function of session time (in minutes). Black dashed lines represent the start of each bout (definintertrial interval)). b top: percentage of bouts for each category across all animals (error bar represents 95% confidence interval); bottom: distributions of valid bouts duration across sessions (Pearson correlation -0.07; p-value 0.5; CI -0.3/0.15). c Average of task selection, in valid bouts only, across all animals (error bars represent 95% confidence interval). Animals are showed next to their respective partners, indicated by the solid black line. Stars indicate reached significance at a Friedman chi-square test for different than chance choice distribution.

Figure 4 – Similar engagement between bouts of different tasks, with few changes across times

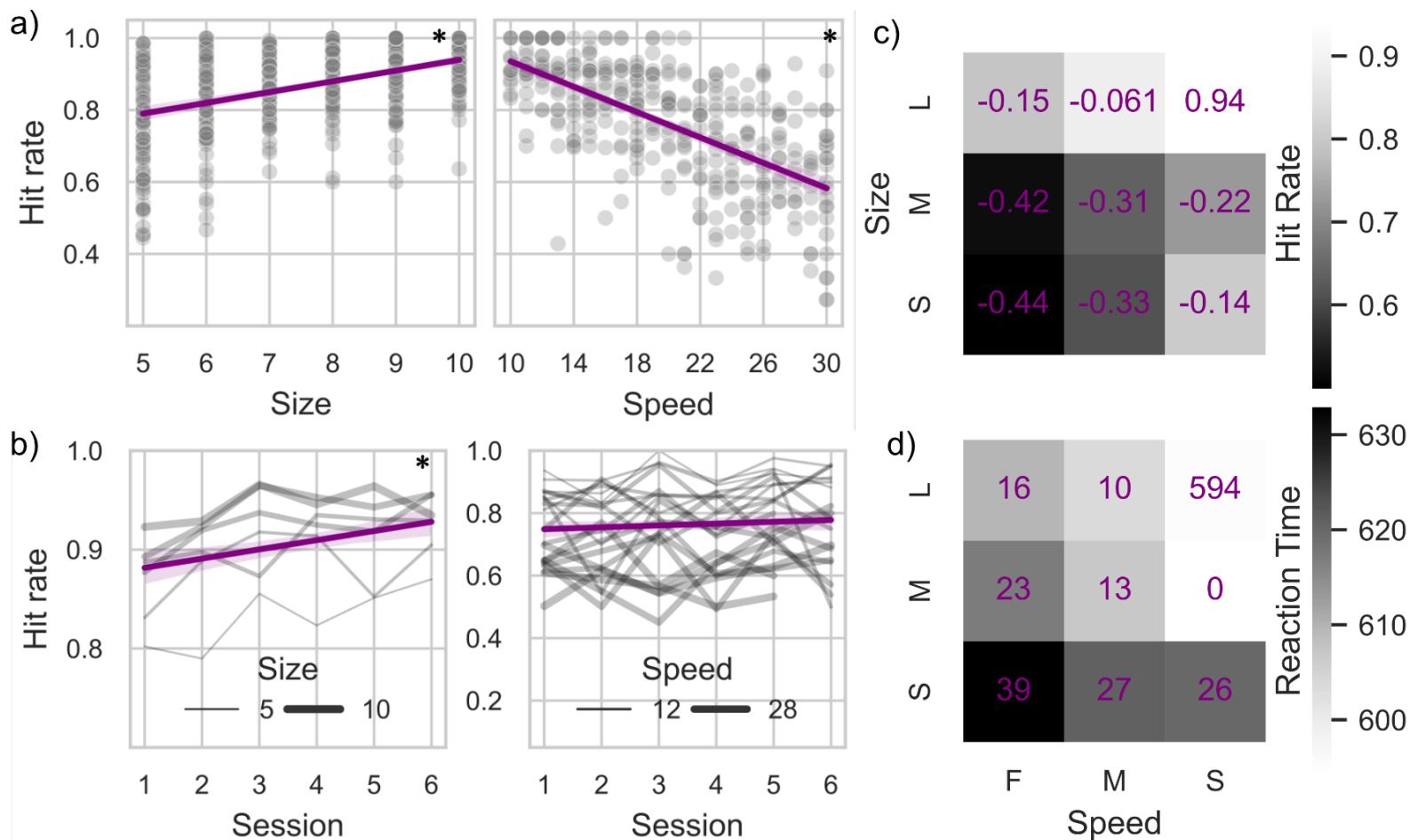


Intensity

Focus

Figure 4 – Descriptive statistics of all valid bouts for included animals only. **a)** Left: distributions of the time each bout's start normalised to the each session time; Middle: distribution of the number of trials across bouts [x axes in logarithmic scale]; Right: distribution of bouts duration [x axes in logarithmic scale]. **b)** Top row: proportion of static, dynamic, and picture trials comprised in their respective bouts, against the relative session time (first three plots) and the bouts index (plots four to six). Bottom row: number of static, dynamic, and picture trials per minute comprised in their respective bouts, against the relative session time (first three plots) and the bouts index (plots four to six).

Figure 5 – Performance on static and dynamic tasks



Conclusions

- General engagement across time:
 - Animals consistently use / understand the MCI (no habituation detected)
 - Engagement is purposeful for most animals;
- Clear task preference for n out of N animals, mostly low effort, rewarded task;
- Within sessions, the intensity of engagement with the low effort, rewarded task increases (*static task*);
- Between sessions the engagement with the low effort, rewarded task becomes more focused (*static task*);
- Performance at the fluid rewarded tasks improves across sessions and is modulated by task parameters, suggesting that MCI can be used to train and assess animals on cognitive and motor tasks.

FINE

