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Simple questions on simple associations: Regularity extraction in non-human primates

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- Despite the word “learning” above having some extraneous letters around it, you were probably still able to easily identify and extract it from the surrounding letters.
- But what if instead of from left to right, the elements unfolded in time, one after the other? And then if the elements were not letters, but some other environmental pattern?
- In this work, we investigate how baboons extract and learn regularities from noisy environmental input by manipulating the position of the regularity in noise, as well as the length of the sequence in which the regularity is embedded.

Research Questions

1. Does a regularity's **position in a sequence** impact learning?
2. Does the regularity appearing at **unpredictable positions** in the sequence impact learning?
3. Does the **length of the sequence** a regularity is embedded in impact learning?

Experiment 1 addresses RQ 1, while Experiment 2 addresses RQs 2 and 3.

Participants and Apparatus

Participants. 20 Guinea baboons (Papio papio) participated in each experiment.

Apparatus. The baboons had free access to Automated Learning Devices for Monkeys (ALDM, Fagot & Bonté, 2010) equipped with tactile screens and a food dispenser (**Fig. 1**).

References

Fagot, J., Bonté, E. Automated testing of cognitive performance in monkeys: Use of a battery of computerized test systems by a troop of semi-free-ranging baboons (Papio papio). Behavior Research Methods 42, 507–516 (2010).

Materials and Methods

Experiment 1

Procedure. Structure of a trial: a) press a yellow cross at the bottom of the screen; b) touch the red circle appearing at one out of 9 possible positions; c) repeat this action until the end of a sequence of 4 touches; d) receive a reward (**Fig. 2**). The RT between the appearance of the circle and the touch was recorded.

Materials. Structure of the experiment: a) 500 4-touch trials containing no regularities (*XXXX* condition); b) 500 trials each with the *AB* regularity (two positions which always appeared one after the other) appearing either at the start (*ABXX*, where *X* denotes another point not included in the regularity), in the middle (*XABX*), or at the end (*XXAB*; cf. **Table 1**). Ordering of blocks was counterbalanced across participants.

Analysis. Anomalous RTs (>800ms or >2.5 SD from mean) were excluded. For each baboon, we computed the linear regression fit to the RTs for the transition from *A* to *B* over the 500 trials for each condition as an index of learning (*ABXX*, *XABX*, *XXAB*; **Fig. 3**).

Experiment 2

Materials. Contrary to Exp. 1, the position of the *AB* regularity varied from trial to trial. Length of the sequence was also manipulated. (**Table 2**).

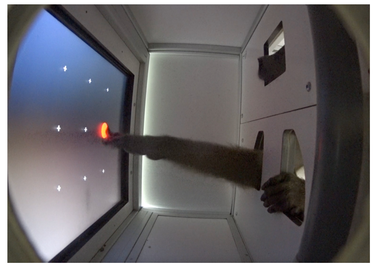

Fig. 1: A baboon completing a trial in the test box.

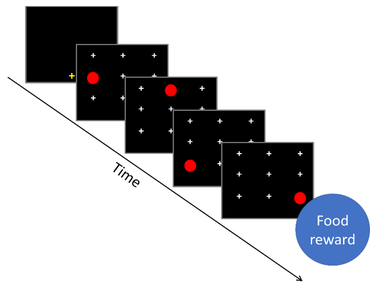

Fig. 2: Trial schematic for a 4-element trial.

Table 1: Schematic for stimuli in Exp. 1.

block 1	block 2	block 3	block 4
XXXX	ABXX	XABX	XXAB
XXXX	ABXX	XABX	XXAB
XXXX	ABXX	XABX	XXAB
XXXX	ABXX	XABX	XXAB
⋮	⋮	⋮	⋮

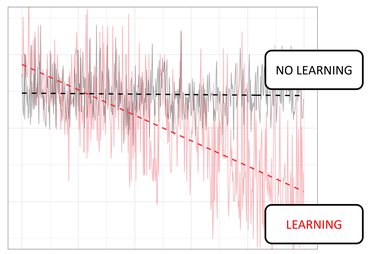

Figure 3: Fitting of regression lines to RTs.

Table 2: Schematic for stimuli in Exp. 2.

Variable-4		***Variable-5***	
block 1	block 2	block 1	block 2
XXXX	ABXX	XXXXX	XABXX
XXXX	XABX	XXXXX	XXABX
XXXX	ABXX	XXXXX	ABXXX
XXXX	XXAB	XXXXX	XXXAB
⋮	⋮	⋮	⋮

Results

Experiment 1

- Learning in all three conditions (i.e.: slope different from *XXXX/Random* baseline condition):
  - BF = 97.18 ± 0.4%
- Same learning rate in all learning conditions:
  - 1/BF = 7.24 ± 0.77%

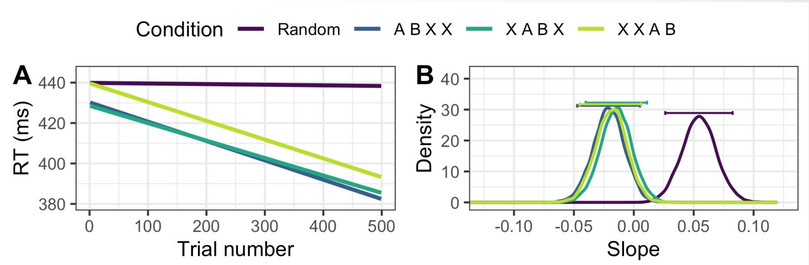

Figure 4: Results of Experiment 1. A: Regression lines for all conditions. B: Posterior distributions for slopes by condition.

Experiment 2

- Learning in all three regularity conditions:
  - BF = 733.61 ± 0.4%
- Same learning rate in all learning conditions:
  - 1/BF = 3.42 ± 0.61%

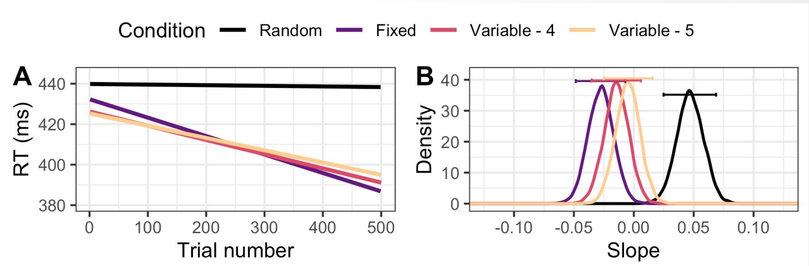

Figure 5: Results of Experiment 2.

Conclusions

- Learning in all conditions containing *AB* regularities
- Learning rate did not vary as a function of:
  - Regularity’s position in sequence
  - Stability of regularity position in sequence/ positional noise
  - Length of sequence

Acknowledgments

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