Understanding the 1-to-1 Correspondence Principle without Counting

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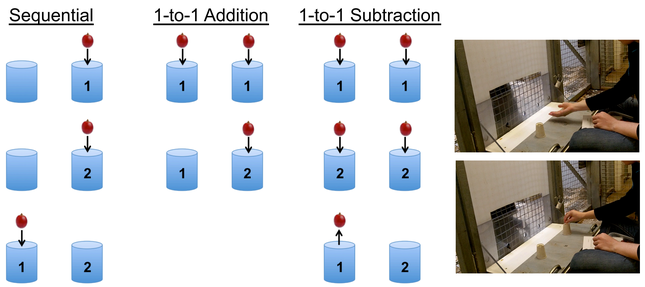
Introduction

A critical component of counting is the principle of exact numerical equality, or 1-to-1 correspondence. This is the understanding that two sets are equal if each element in one set corresponds to exactly one element in the second set. Whether children understand this property before learning numerical symbols is still debated, although some research suggests that children may have an incomplete understanding of 1-to-1 correspondence before they understand exact numbers (Izard et al., 2014). We explored this question from a comparative perspective by investigating whether non-human primates, which have no symbolic numerical system, understand the 1-to-1 correspondence principle. Specifically, we examined whether olive baboons (*Papio anubis*) could use 1-to-1 correspondence to make more precise numerical discriminations than can be made using their approximate number system.

Methods

Quantity Discrimination Task
Two opaque cups were baited with different quantities of food pieces; baboons received the contents of the cup they chose



Subjects: 3 Olive Baboons (*Papio anubis*)

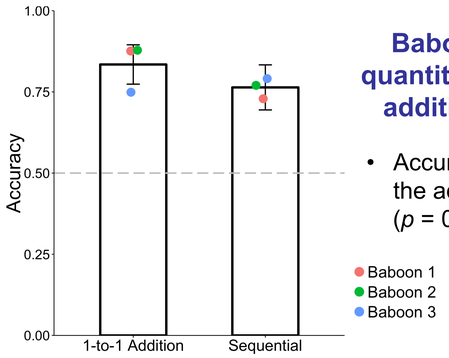
Training
Criterion: Accuracy > 70% for 2 sessions
Conditions: Sequential and 1-to-1 Addition
Quantity Pair: 1 vs 2

Test 1
Conditions: Sequential and 1-to-1 Addition
Quantity Pairs: 3 vs 4, 4 vs 5, 5 vs 6

Test 2
Conditions: 1-to-1 Subtraction and 1-to-1 Addition
Quantity Pairs: 2 vs 4, 3 vs 4, 3 vs 5, 4 vs 5, 4 vs 6, 5 vs 6

Analyses
Binomial tests were used to determine whether baboons performed better than chance
Mixed effects logistic regressions with random subject intercepts were used to compare accuracy between conditions while controlling for subject differences

Training



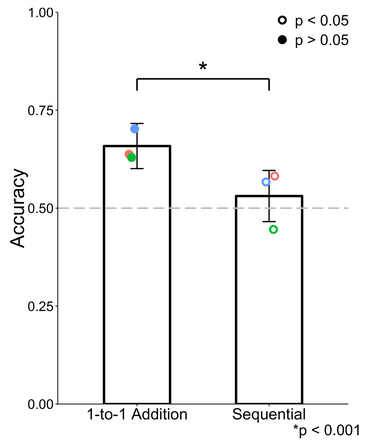
Baboons successfully make easy quantity discriminations in both 1-to-1 addition and sequential conditions

- Accuracy was not significantly different in the addition and sequential conditions (p = 0.14)

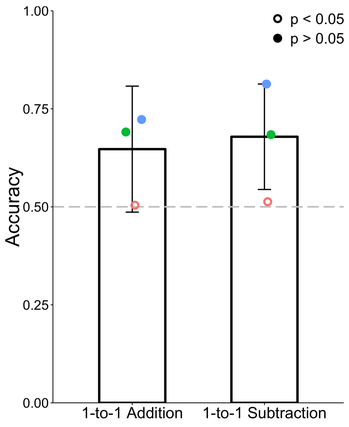
Test 1

When there is a difference of 1 item, baboons only succeed in the 1-to-1 addition condition

- Overall, baboons performed significantly above chance in the addition condition (binomial test, p < 0.01), but not the sequential condition (binomial test, p = 0.17).
- Accuracy was significantly better in the 1-to-1 addition condition than the sequential condition (p < 0.001)



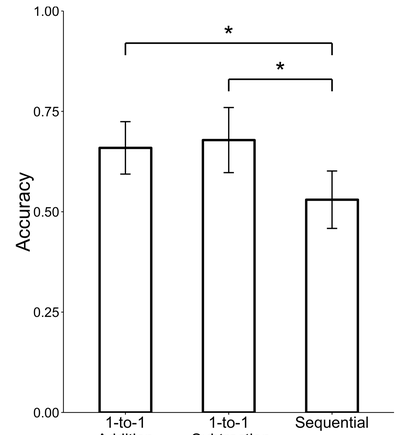
Test 2



Baboons can use the 1-to-1 Correspondence Principle over addition and subtraction

- Overall, baboons performed significantly above chance in both the addition and subtraction conditions (binomial tests, ps < 0.01)
- Accuracy was not significantly different in the addition and subtraction conditions (p = 0.19)
- There was no effect of number subtracted in the subtraction condition (p = 0.64)

Overall Analyses



Baboons had higher accuracy in the 1-to-1 baiting conditions than the sequential baiting condition

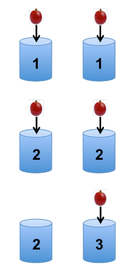
- Accuracy was significantly better in the 1-to-1 baiting conditions than in the sequential condition (ps < 0.001)
- Accuracy was not significantly different between the addition condition in Test 1 and the subtraction condition in Test 2 (p = 0.57)

Future Directions

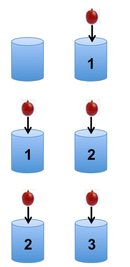
In the 1-to-1 addition baiting condition, does it matter whether the additional food piece comes first or last?

- The location of the extra piece of food must be remembered longer when the extra is added at the beginning of the trial rather than at the end
- Subjects may not use 1-to-1 correspondence when the extra is added first, since the quantities are never in exact equality

Extra added last



Extra added first



Conclusion

Baboons demonstrated understanding of the 1-to-1 Correspondence Principle over addition and subtraction, suggesting that counting experience is not necessary for understanding 1-to-1 numerical equivalence.

References & Acknowledgements

Izard, V., Streri, A., & Spelke, E. S. (2014). Toward exact number: young children use one-to-one correspondence to measure set identity but not numerical equality. *Cognitive psychology*, *72*, 27-53.

Many thanks to Kaitlin Brown, Stephen Ferrigno, and the CAOs Lab. This material is based upon work supported by the National Science Foundation Graduate Research Fellowship under Grant No. DGE-1419118, as well as grants from the James S. McDonnell and Alfred P. Sloan Foundations.

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