Science Education Collection

Numerical Cognition: More or Less

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Overview

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One of the goals of the modern education system is to teach children mathematical literacy. They are taught to add, subtract, multiply, and divide, and this base knowledge is used to support learning about geometry, algebra, calculus, physics, and statistics. School-aged children usually acquire these skills in formal educational settings, but the foundation of mathematical understanding is developed much earlier in life.

As infants, humans begin to form the rough representations that allow them to make judgments about number, and perhaps the first numerical concept that humans develop is the idea of less versus more. However, probing these concepts can be challenging, because even if babies have some understanding of number, they have very few ways of showing off what they know. What they can do is crawl, eat, cry, and sleep. Thus, researchers developed a task using this limited set of responses to investigate whether babies can mentally represent number.

This experiment demonstrates how researchers can creatively use food to study concepts of numerical cognition in infants using the method by Feigenson, Carey, and Hauser.[1]

Procedure

Recruit 12-month-old infants. For the purposes of this demonstration, only one child is tested. Larger sample sizes (as in the Feigenson, Carey, and Hauser study[1]) are recommended when conducting any experiments.

1. Participants should be healthy, have no history of developmental disorders, and have normal hearing and vision.
2. Because infants of this age can be uncooperative or fussy (*e.g.*, refuse to watch a demonstration or fall asleep during testing), extra participants may need to be recruited in order to obtain sufficient data.

1. Data collection

1. Collect the necessary materials: one empty small bucket, one small bucket filled with square graham crackers, two tall opaque containers too tall for an infant to see inside, and one age-appropriate toy.
2. Warm-up
    1. Sit on the floor facing the infant, approximately 100 cm apart.
    2. While the infant is watching, place the toy into the empty bucket.
    3. Non-verbally encourage the infant to crawl to the bucket and retrieve the toy. Use verbal encouragement if the infant does not immediately crawl to the bucket.
    4. Remove the toy and bucket.
3. Test
    1. Instruct the parents to refrain from providing any feedback to the infant.
    2. Simultaneously introduce the two large containers. Show the infant that they are empty. Place the containers approximately 70 cm in front of the baby and 35 cm apart. This placement ensures that the infant cannot reach both containers at the same time.
    3. Retrieve the small bucket of graham crackers. Hold up individual crackers drawn from the bucket and say, “Look at this.” Only present the crackers and place them into the containers while the infant is watching. The number of graham crackers placed in each container varies by condition.
        1. 1 vs. 2 condition: One container contains 1 cracker and the other contains 2.
        2. 2 vs. 3 condition: One container contains 2 crackers and the other contains 3.
        3. 3 vs. 4 condition: One container contains 3 crackers and the other contains 4.
    4. Counterbalance the order of placement and which side contains which quantity of crackers across infants.
    5. After placing all crackers in the containers, look down to avoid influencing the infant’s response. If the infant does not approach within 10 s, provide verbal encouragement without looking up.
    6. Video tape the infant’s choice.

2. Analysis

1. Exclude from the analysis the infants who do not approach a container within 20 s of the experimenter looking down and infants who looked into one container before approaching the other container.
2. Code the videos of infants who approach a container and reach into it or sit in front of it for at least 8 s without reaching in.
3. Use two independent coders to score videos of infants who made a choice. The coders determine which container the infant approaches, but they do not know how many crackers are in each container.

4. Analyze the proportion of infants selecting the container containing more food to determine if more infants approached it than would be predicted by chance.

Results

In order to see significant results, researchers would have to test at least 16 infants in each condition, not including infants dropped for failing to complete the task. Infants presented with 1 vs. 2 crackers and 2 vs. 3 crackers typically selected the container containing more crackers **(Figure 1)**. However, infants typically showed no strong preference for the container holding more crackers when presented with 3 vs. 4 crackers.

Infants consistently chose the container containing the greater number of crackers when presented with comparisons of 1 vs. 2 and 2 vs. 3. However, infants failed to represent differences between larger numbers of items. Critically, this result does not rely solely on proportions, because infants also fail to discriminate between 3 vs. 6, which is the same proportion as 1 vs. 2.

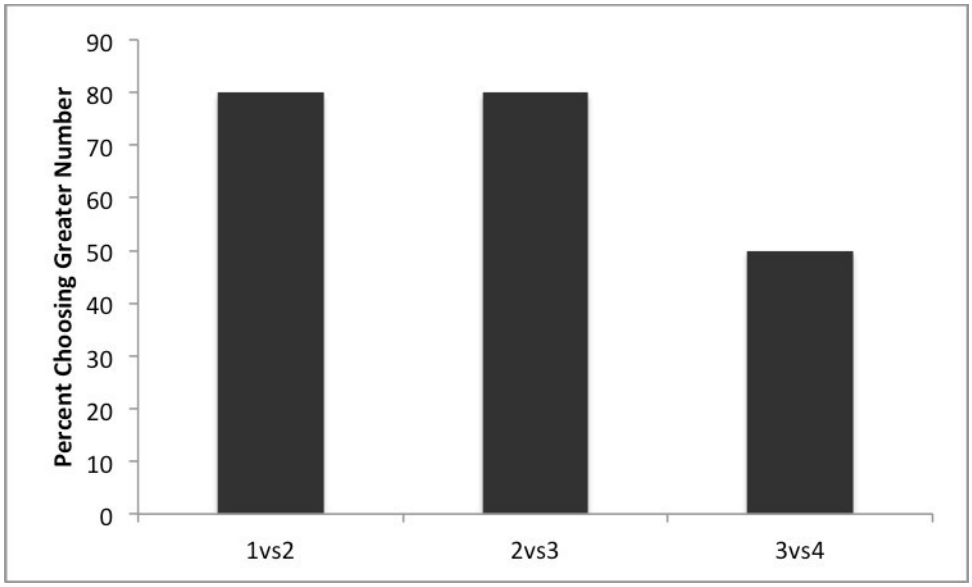

Figure 1: Proportion of infants selecting the container with the greater number of crackers.

Applications and Summary

Although infants are limited in the number of objects they can represent at any given time, the fact that they can represent 2 vs. 3, or up to five items, at one time is cited as evidence that even very young infants can represent number and make comparisons between different values. The method described here can also be applied to measuring how other species, such as dogs and chimps, reason about number.

Infants are impressively capable of representing number and making comparisons of more versus less at a very young age. The results reported here show that infants can reason about their environment in sophisticated ways, and this early skill may contribute to the emergence of numerical reasoning and mathematical ability later in development. However, there is an ongoing debate about whether these representational skills indicate true mathematical understanding, or if they are more appropriately considered in terms of visual representations.

References

1. Feigenson, L., Carey, S., & Hauser, M. The representations underlying infants' choice of more: Object files versus analog magnitudes. *Psychological Science.*, **13**, 150-156 (2002).

