Decision Making in Discrete Number and Continuous Amount Judgments

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Introduction:

Research on human infants has shown that their responses in habituation studies are sometimes based upon discrete number and sometimes based upon continuous amount [1]. One explanation suggests that automatically extracted representations of number and amount interfere with one another; evidence for this idea comes from adults' performance on number and amount judgment tasks [2]. These data are also consistent with a different interpretation: the apparent automatic extraction of amount and interference may be illusory. Instead, participants may recruit alternative unconscious strategies to perform the task [3]. In these experiments, we identify unconscious strategies used by individual participants in number and amount judgment tasks (in adults) or patterns of performance in group data from parallel tasks (in children). We predict that we will find no evidence of automatic extraction of continuous amount and no interference between amount and number representations.

Aims of Current Research:

•To expand on past research of subject response models by predicting specific strategies using larger object sets in the stimuli and fewer trials.

• Examine whether children also rely on a range of strategies when judging amount while remaining consistent in making number judgments.

Methods:

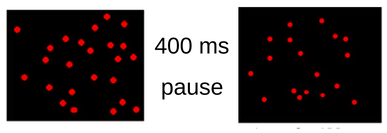
Basic Design:

•Number trials: Judge greater total number (either dots or spheres).
•Amount trials: Judge greater total amount (either pixels or clay).
•Experiments divided into blocks of amount and number judgments.
•Congruent trials: Array with larger number has greater total amount.
•Incongruent trials: Array with larger number has smaller total amount.

Experiment 1:

• Subjects were 28 students in an introductory psychology course.
• Stimuli were arrays of dots presented on a computer (Stimuli replicated from [4]).
• First dot array flashed for 400 ms, pause for 400 ms, second array flashed for 400 ms.
• Completed 192 trials; 96 judging number and 96 judging amount.

Example Set in Experiments 1 and 2



400 ms pause

Experiment 2:

• Subjects were 31 students in an introductory psychology course.
• Sets contained larger numerosities of dots than Experiment 1.
• Completed 384 trials; 192 judging number, 192 judging amount.

Experiment 3:

• Subjects were 39 child volunteers ages 4-6 years.
• Judged boxes of clay spheres.
• Completed 48 trials; 24 judging number and 24 judging amount.

Example Set in Experiment 3
Boxes are presented simultaneously.

Experiments 1 and 2 Results:

• These charts show the likelihood that a subject was using a specific model. These are the charts for subjects in Experiment 1.

• Columns represent the different possible models a subject could be using.

•In number trials data, the subjects seemed to use discrete number to make their decision.

• In the amount trials data, there is large variation in the types of strategies employed.

• This shows that adults are generally using the same strategy in judging number, and vastly different strategies in amount.

Number Trials

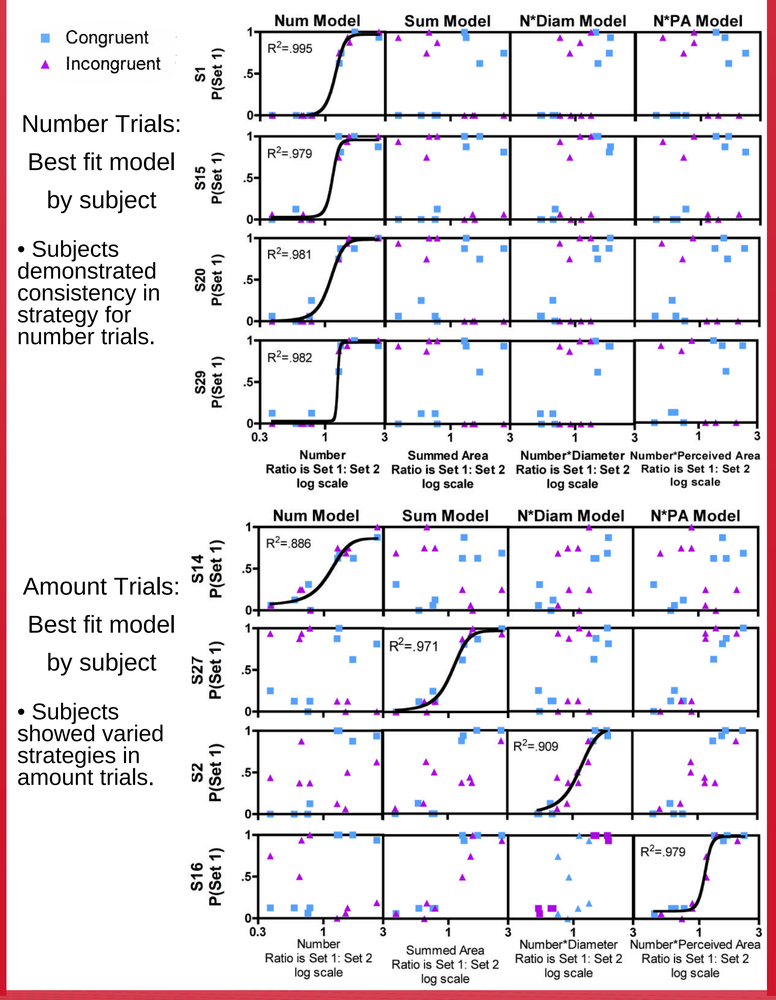
S	Num	Sum	N*Diam	N*PA	Other
1	****				
2				*	
3	****				
4	****				
5	****				
6	****				
7	****				
8	****				
9	****				
10	*				
11	****				
12	***				
13	****				
14	****				
15	****				
16	****				
18	****				
19	***				
20	**				
21	****				
22	****				
23	****				
24	****				
25	****				
26	****				
27	****				
28	*				
29	****				

Amount Trials

S	Num	Sum	N*Diam	N*PA	Other
1					none
2	****				
3					none
4					none
5		**			
6			*		
7				**	
8			**		
9			****		
10			***		
11			***		
12		**			
13					none
14		***			
15			****		
16			**		
18		***			
19					none
20					none
21	**				
22				**	
23	*				
24			****		
25				*	
26		****			
27			***		
28		***			
29					none

Key: *=3-10 times more likely **=10-100 times more likely
=100-1000 times more likely *= ⁺1000 times more likely

• The following graphs show examples of subject data plotted depending on strategy. These are the graphs for subjects from Experiment 2.
• The best fit model for each subject includes a sigmoidal curve.
• Subjects are represented by row, and the y-axis measures the proportion of trials in which the subject chose set 1.



Number Trials: Best fit model by subject

• Subjects demonstrated consistency in strategy for number trials.

Amount Trials: Best fit model by subject

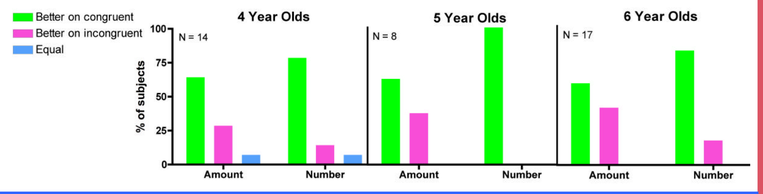
• Subjects showed varied strategies in amount trials.

Experiment 3 Results:

• Subjects' performance on congruent and incongruent trials differs depending on what they are judging.

• In amount trials, more subjects perform better on incongruent trials than congruent trials compared with their performance in number trials.

• Suggests a different (and broader) range of strategies used for amount judgments relative to number judgments.



Conclusions:

• When asked to judge discrete number , adults overwhelmingly seem to use the discrete number model.

• When asked to judge continuous amount, adults vary in their choice of decision model and are likely to respond based on a variety of possible representations, including discrete number and approximate number*diameter and number*perceived area calculations.

• These results suggest that we do not automatically extract continuous amount but we do automatically extract number.

•Taking into account different models, apparent differences between congruent and incongruent trials disappear as incongruent trials tend to have more difficult ratios to judge using the number*diameter and number*perceived area strategies.

• This provides evidence against the theory of competing representations of number and amount interfering with decision making.

• Looking at the differences in performance for the types of trials suggest that children also use different strategies when judging amount than when judging number, though there is not enough data to determine any specific strategies they may be using.

• Taken all together, the data suggests that both children and adults use different strategies for judging discrete number and continuous amount.

Further Exploration:

•Are there specific strategies that children use to judge number and amount?

• If so, how do they compare with those that adults use?

References:

1. Xu F (2003) Numerosity discrimination in infants: evidence for two systems of representations. Cognition 89: B15-B25.

2. Hurewitz F, Gelman R, Schnitzer B (2006) Sometimes area counts more than number. Proc Natl Acad Sci U S A 103:19599-19604.

3. Barth H (In review). Qualitative differences in quantitative judgments: continuous vs. discrete quantity. Cognition.

4. Barth H, Ballinger A, Carrasco A, Jacobson R, Tsai J (2007). Children's assessments of volume and number in 3D object arrays. Conference abstract, Annual Meeting of the Society for Research in Child Development (SRCD).

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