

Simple Addition and Subtraction While Reading a Narrative

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ABSTRACT

The present study examined the extent to which readers make addition and subtraction calculations while reading a narrative under normal reading instructions and conditions. Participants read short stories that presented two separate quantities (i.e., a starting amount and either an addition or a loss). Arithmetic calculation was examined by comparing reading times for inconsistent versus consistent statements regarding the sum or difference value.

INTRODUCTION

Situation Models (Johnson-Laird, 1983; van Dijk & Kintsch, 1983)

People monitor aspects of situations as they read narratives, such as information related to characters as well as the properties of entities that characters interact with. To do this, readers construct mental representations about the current state-of-affairs as they are described in a narrative and update these situation models as changes occur in the text.

In the current study, we were interested in whether people track a specific property – namely, changes in quantities. That is, as the number of people or items either increases or decreases, do people update their situation models to accurately reflect this change? Research with word/story problems has shown that when people are asked to track quantities and perform simple calculations, they are able to do this (e.g., Kintch, 1986; Thevenot et al., 2007). So, the point of this study is not whether people can track changes in quantity, but rather, do people track these changes under normal reading conditions?

In this study we asked people to read short stories for comprehension. In each story, an initial quantity of items, people, or activities were presented. Following that, the total either increased (i.e., add) or decreased (i.e., subtract) by a small amount. People were not asked about, nor were they instructed to track the quantities described in the stories.

CONCERNS AND POSSIBLE OUTCOMES:

- (1) Research with narratives has shown that readers typically do not track certain numbers, such as dates (e.g., Radvansky et al., 2001). Thus, readers may not track the numerical information at all.
- (2) If people do monitor numerical values, they may not retain them across many sentences in a text. However, people will integrate reasoning premises as long as they are only separated by 1 or 2 sentences (Lea et al., 2005); this distance was used here.
- (3) Addition tends to be easier, so people may track changes for addition but not subtraction. To keep difficulty level close and to avoid an influence of problem size (e.g., Ashcraft & Battaglia, 1978; Seyler et al., 2003), all numbers in the current study were single digits.
- (4) Readers may be more sensitive to losses rather than gains (e.g., Kahneman & Tversky, 1984). Thus, people may more accurately monitor subtractions that occur in a narrative than additions.

EXPERIMENT 1

Participants

73 undergraduates from the University of Nevada Las Vegas

Materials & Procedure:

People were presented with 8 Addition, 8 Subtraction, and 14 filler stories (10 sentences long – presented 1 sentence at a time)

- Sentence 4 – An initial quantity was introduced
- Sentence 7 – Addition or subtraction occurred
- Sentence 10 – Referred to either a Consistent (correct total) or Inconsistent (total +/- 1) value

Participants were instructed to read for comprehension (each story was followed by a Yes/No question unrelated to the quantities)

Addition

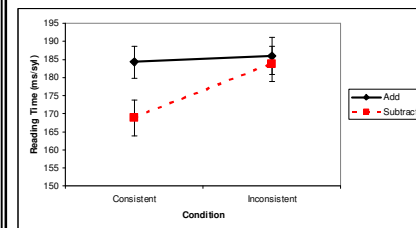
Emanuel was a manager at a bookstore. The store was closed over the weekend for renovations. They were installing more bookshelves and display cases in the store. **Emanuel had four employees scheduled to work that day.** There was a lot of work to do; more people would have to come in or else they would never finish. Emanuel phoned some additional employees to see if they could come in. **After a few calls, Emanuel had talked two more into coming in.** He was glad – he wanted to make sure the work was done this weekend. He was very grateful that he had such a dedicated group of employees. **He thought that maybe he would give all six/five of them a bonus.**

Subtraction

Sherry loved cats. She particularly loved the Calicos and Tabbies. Her favorite cat was Buttons, a young Tabby. **Right now Sherry had five cats living in her apartment.** Unfortunately, the cats were beginning to get too expensive for her. Sherry decided to find friends and family members to adopt some of the cats. **After a short while, Sherry had given away three of them.** She was sad to see them go, but she was glad they were going to good homes. She knew that everyone would take proper care of the cats. **She went to the kitchen to feed the two/three cats that she had kept.**

Results

Reading Times (ms/syl)



Consistency Main Effect: $F(1, 72) = 7.33$, $MSE = 691$, $p < .01$

Math Main Effect: $F(1, 72) = 8.91$, $MSE = 635$, $p < .01$

Interaction: $F(1, 72) = 5.17$, $MSE = 626$, $p < .05$

Addition Effect: $F < 1$

Subtraction Effect: $F(1, 72) = 11.93$, $MSE = 688$, $p < .01$

EXPERIMENT 2

Participants

92 undergraduates from the University of Nevada Las Vegas

Materials & Procedure:

Similar to Experiment 1, except stories were re-written so that each could have an Addition and a Subtraction version (4 versions of each, within-subjects design). For both the Addition and Subtraction versions, the initial quantity was kept constant.

Example Story (Addition: $4 + 1$ / Subtraction: $4 - 1$)

Manny was a manager at a bookstore. The store was closed over the weekend for renovations. They were putting more bookshelves in the store. Manny had four employees scheduled to work that day.

(ADD) There was a lot of work to do; more people would have to come in or else they would never finish. After a few calls, Manny had talked one more into coming in.

(SUBTRACT) Because of the renovations he didn't need as many employees at work. After a few calls, Manny had talked one into not coming in.

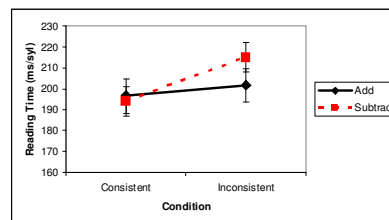
He was glad that his employees were so accommodating.

(ADD) Manny sat down to plan what the five/six employees would work on.

(SUBTRACT) Manny sat down to plan what the three/two employees would work on.

Results

Reading Times (ms/syl)



Consistency Main Effect: $F(1, 91) = 14.23$, $MSE = 1093$, $p < .001$

Math Main Effect: $F(1, 91) = 1.04$, $MSE = 2647$, $p = .31$

Interaction: $F(1, 91) = 4.40$, $MSE = 1335$, $p < .05$

Addition Effect: $F < 1$

Subtraction Effect: $F(1, 91) = 21.62$, $MSE = 937$, $p < .001$

EXPERIMENT 3

Participants

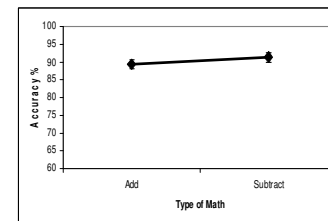
70 undergraduates from the University of Nevada Las Vegas

Materials & Procedure:

Same stories as in Experiment 2, except people were instructed to track quantities and to report the final total at the end of each story.

Results

Accuracy (% correct)



Add vs. Subtract: $F(1, 69) = 1.56$, $MSE = .008$, $p = .22$

DISCUSSION

- In both Experiments 1 and 2, under normal reading instructions people were more likely to do subtraction rather than addition, based on reading times for inconsistent sentences.
- As expected, Experiment 3 showed that people were equally accurate for the addition and subtraction calculations when specifically asked to attend to that information.
- Thus, the results do not seem to be due to the addition calculations being more difficult. Also, memory for the initial values did not affect performance (both addition & subtraction stories started with the same initial value), nor did the context of the story (the same stories were used for both addition and subtraction).
- Two possible explanations remain. First, people may be more sensitive to losses than gains. For example, psychologically, a loss of 2 items may be considered a greater change than the gain of 2 items. Second, while the addition and subtraction stories started with the same initial values, the addition problems ended with higher total amounts (although these were always less than 10). It is possible that people are less likely to track quantities once the total becomes too high.

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