

# *Can you be tempted?*

## *A description of errors among 7-17 year-old children verifying correct and incorrect arithmetic equations*

Technical Report (CDRG5), Royal Holloway University of London. 1998.

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### 1. Acknowledgement

The report is based on research funded by the Economic and Social Research Council, grant number R000236113. The present report provides subsidiary analyses of an experiment on children's memory performance. Further details are described elsewhere (Towse, Hitch, & Hutton, in prep.). We are grateful to the staff and pupils at St. Anne's Heath and St. Paul's, for their co-operation in this study.

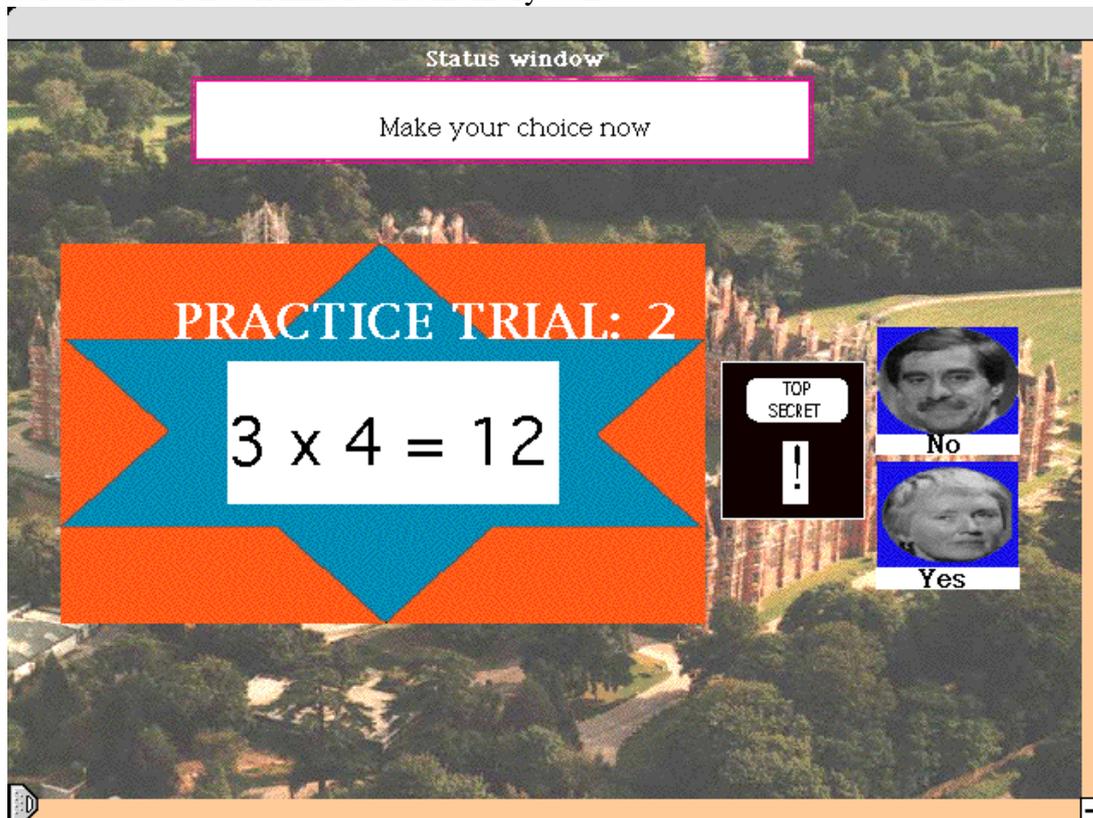
### 2. Overview

As part of an experiment on working memory performance (Towse, Hitch, & Hutton, in preparation), addition and multiplication problems were presented for verification (this formed an interpolated activity interleaved with a memory task). Children were tested individually in a quiet area of their school, and the experimenter introduced the computer program, running on a Macintosh Powerbook 5300c computer. The task was framed in terms of a game involving secret agents. Children took the role of secret agent commander, with responsibility for controlling and sending on signals to two agents under their control. In a centrally placed window of the screen (called and labelled the 'home base') appeared arithmetic problems along with answers (see accompanying screenshot). When the answer to the problem was correct, children sent a signal to one secret agent by pointing with the mouse at their photograph and clicking on their image. When the answer to the arithmetic problem was incorrect, children were to send a signal to the other secret agent by pointing and clicking on their photograph instead. The pictures of these agents also had a "Yes" and "No" label to assist children in making their response as to the correctness of the arithmetic equation. When the child's signal was the right one, a green tick symbol appeared over the agent's picture, and if the signal was wrong, a red cross was displayed. This feedback remained visible until a subsequent response was made.

A further possible event was that a number on its own could appear in the central 'home base' area. Children were told that when a single digit number appeared,

these had to be placed in a 'top secret' folder, which was spatially adjacent to the secret agent photographs. It was these digit items which children subsequently attempted to recall. During presentation of the game instructions, it was emphasised to children that they should avoid sending the wrong signals to their agents, and that they should also try to work as quickly as possible. At the end of each trial, children received visual feedback about the number of agent codes despatched in the available time.

Screenshot of the arithmetic and memory task:



The present section summarises performance on these mathematical tasks. Verification problems where the answer was correct are displayed in blue. Where the answer was a close lure to a correct value, the problem is presented in red (close lure refers to the fact that the answer was correct to a closely related problem, for instance in multiplication,  $7 \times 6 = 49$ , where 49 is the correct answer to  $7 \times 7$ ). Where the answer was a distant lure of the numbers, the problem is displayed in green. Distant lures were always further away in number space from the correct answer than their close lure relatives for the same arithmetic question. These results confirm that some arithmetic equations are more tempting than others as items that can lead children astray. For the purposes of ranking error frequencies, adjustment is made for the experimental design whereby 50% of the problems presented were correct, with 25% of the problems close lures and 25% distant lures.

There were 123 children participating in this study, segregated into 6 age groups by school class; see Table 1. Except for the youngest age group, all children completed a memory study that involved concurrent addition and multiplication activities. For the youngest children, only addition problems were presented.

Table 1. Description of the age groups of children studied

Group	Number of children	Mean age	SD (months)
1	24	7;10	5
2	19	8;10	5
3	18	10;9	5
4	23	11;9	4
5	21	13;9	6
6	17	17;0	5

#### Reference

Towse, J.N., Hitch, G.J., & Hutton, U. (in preparation). The role of background activity on item retention. Manuscript in preparation.

### 3. Addition problems sorted by error frequencies (adjusted for presentation rate)

Adjusted error frequency	Problem form
0	$4 + 7 = 9$
1	$3 + 8 = 9$
2	$1 + 7 = 11$
2	$1 + 8 = 12$
3	$2 + 8 = 9$
3	$4 + 7 = 8$
3	$6 + 4 = 14$
3	$7 + 1 = 11$
3	$8 + 1 = 11$
3	$8 + 1 = 12$
3	$8 + 2 = 9$
3	$8 + 4 = 9$
4	$1 + 7 = 8$
4	$3 + 4 = 10$
4	$3 + 6 = 9$
4	$3 + 7 = 14$
4	$4 + 3 = 9$
4	$6 + 3 = 9$
4	$7 + 1 = 10$
4	$7 + 4 = 8$
4	$8 + 4 = 10$
4	$9 + 6 = 12$
4.5	$1 + 8 = 9$
4.5	$2 + 8 = 10$
4.5	$4 + 8 = 12$
4.5	$7 + 1 = 8$
4.5	$8 + 2 = 10$
5	$1 + 7 = 10$
5	$1 + 8 = 11$
5	$3 + 7 = 10$
5	$6 + 9 = 12$
5	$7 + 3 = 16$
5	$8 + 2 = 7$
5	$8 + 3 = 9$
5.5	$4 + 6 = 10$

5.5	$7 + 4 = 11$
5.5	$8 + 1 = 9$
6	$2 + 8 = 7$
6	$3 + 7 = 16$
6	$3 + 8 = 10$
6	$4 + 6 = 14$
6	$4 + 8 = 10$
6	$6 + 3 = 7$
6	$7 + 4 = 9$
6.5	$7 + 3 = 10$
7	$3 + 4 = 7$
7	$3 + 8 = 11$
7	$4 + 8 = 9$
7	$6 + 4 = 10$
7	$8 + 3 = 10$
7	$8 + 4 = 12$
8	$3 + 6 = 7$
8	$4 + 3 = 7$
8	$4 + 3 = 10$
9	$6 + 9 = 15$
9	$7 + 3 = 14$
9	$8 + 3 = 11$
9	$9 + 5 = 14$
9	$9 + 6 = 13$
10	$3 + 4 = 9$
10	$3 + 6 = 8$
10	$5 + 9 = 17$
10	$6 + 4 = 12$
10	$9 + 5 = 17$
10.5	$4 + 7 = 11$
10.5	$5 + 9 = 14$
11	$6 + 8 = 17$
11	$7 + 6 = 13$
11	$8 + 6 = 14$
11.5	$6 + 7 = 13$
11.5	$9 + 6 = 15$
12	$4 + 6 = 12$
12	$6 + 3 = 8$
12	$6 + 7 = 16$
12	$6 + 7 = 18$

13

14

14

14

14.5

15

16

16

20

$$7 + 6 = 16$$

$$6 + 9 = 13$$

$$8 + 6 = 15$$

$$9 + 5 = 16$$

$$6 + 8 = 14$$

$$7 + 6 = 18$$

$$5 + 9 = 16$$

$$8 + 6 = 17$$

$$6 + 8 = 15$$

#### 4. Multiplication problems sorted by error frequencies (adjusted for presentation rate)

3	$4 \times 3 = 20$
3	$6 \times 4 = 35$
4	$6 \times 4 = 24$
4.5	$7 \times 3 = 21$
5	$2 \times 8 = 16$
5	$4 \times 3 = 12$
5	$7 \times 5 = 35$
6	$2 \times 8 = 12$
6	$3 \times 4 = 15$
6	$3 \times 7 = 21$
6	$4 \times 3 = 15$
6	$5 \times 7 = 35$
6	$5 \times 7 = 40$
6	$5 \times 7 = 60$
6	$5 \times 9 = 56$
6	$8 \times 2 = 12$
6	$8 \times 2 = 16$
6	$8 \times 6 = 30$
6.5	$5 \times 9 = 45$
6.5	$7 \times 4 = 28$
8	$3 \times 6 = 15$
8	$4 \times 6 = 24$
8	$5 \times 9 = 36$
8	$7 \times 5 = 60$
8	$9 \times 5 = 36$
8	$9 \times 5 = 56$
9	$3 \times 6 = 16$
9	$3 \times 6 = 18$
9	$7 \times 8 = 45$
9	$8 \times 3 = 16$
9.5	$3 \times 4 = 12$
9.5	$6 \times 7 = 42$
9.5	$8 \times 3 = 24$
10	$4 \times 8 = 32$
10	$8 \times 4 = 21$
10	$8 \times 4 = 32$
10	$9 \times 5 = 45$

10.5	$7 \times 6 = 42$
11	$3 \times 7 = 32$
11	$4 \times 6 = 35$
11	$6 \times 3 = 16$
11	$6 \times 3 = 18$
11	$6 \times 4 = 28$
11	$6 \times 8 = 48$
11	$7 \times 3 = 32$
11	$7 \times 8 = 48$
11	$8 \times 2 = 14$
12	$2 \times 8 = 14$
12	$3 \times 8 = 24$
12	$4 \times 7 = 36$
12	$4 \times 8 = 21$
12	$7 \times 4 = 36$
12	$8 \times 6 = 42$
13	$3 \times 4 = 20$
13	$3 \times 8 = 16$
13	$4 \times 7 = 32$
13	$6 \times 8 = 30$
13	$7 \times 8 = 56$
13.5	$8 \times 6 = 48$
14	$7 \times 3 = 24$
14	$7 \times 5 = 40$
14	$8 \times 7 = 45$
14	$9 \times 6 = 81$
15	$3 \times 8 = 21$
15	$8 \times 7 = 48$
15	$8 \times 7 = 56$
15	$9 \times 6 = 63$
15.5	$6 \times 9 = 54$
15.5	$9 \times 6 = 54$
16	$4 \times 6 = 28$
16	$6 \times 7 = 54$
16.5	$4 \times 7 = 28$
17	$6 \times 3 = 15$
17	$6 \times 7 = 49$
17	$6 \times 9 = 81$
17	$7 \times 6 = 54$
17	$8 \times 3 = 21$

18

$$3 \times 7 = 24$$

18

$$4 \times 8 = 24$$

18

$$8 \times 4 = 24$$

20

$$6 \times 9 = 63$$

20

$$7 \times 4 = 32$$

22

$$6 \times 8 = 42$$

29

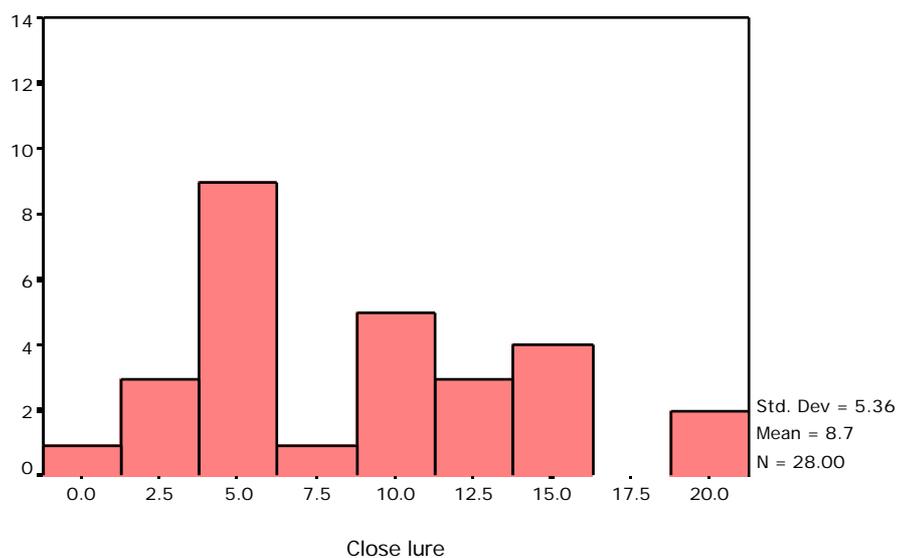
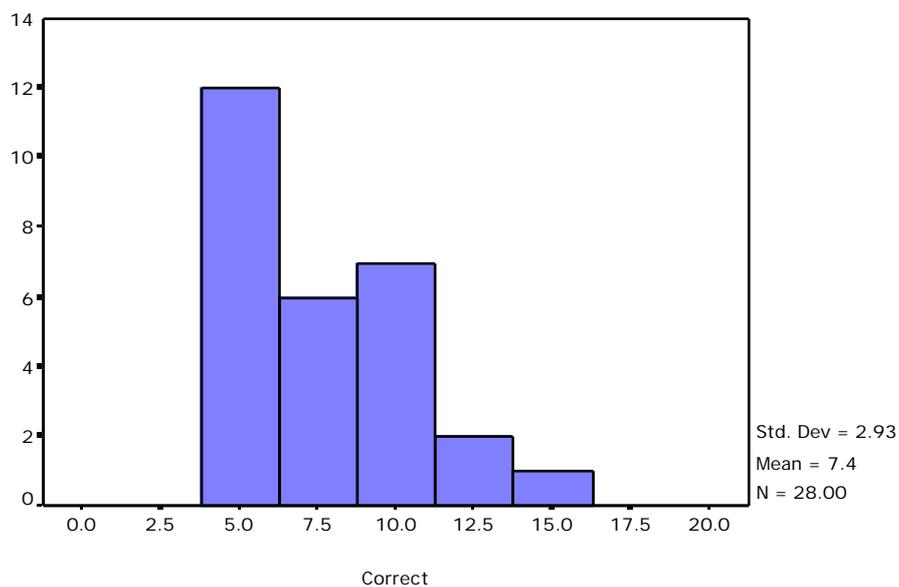
$$7 \times 6 = 49$$

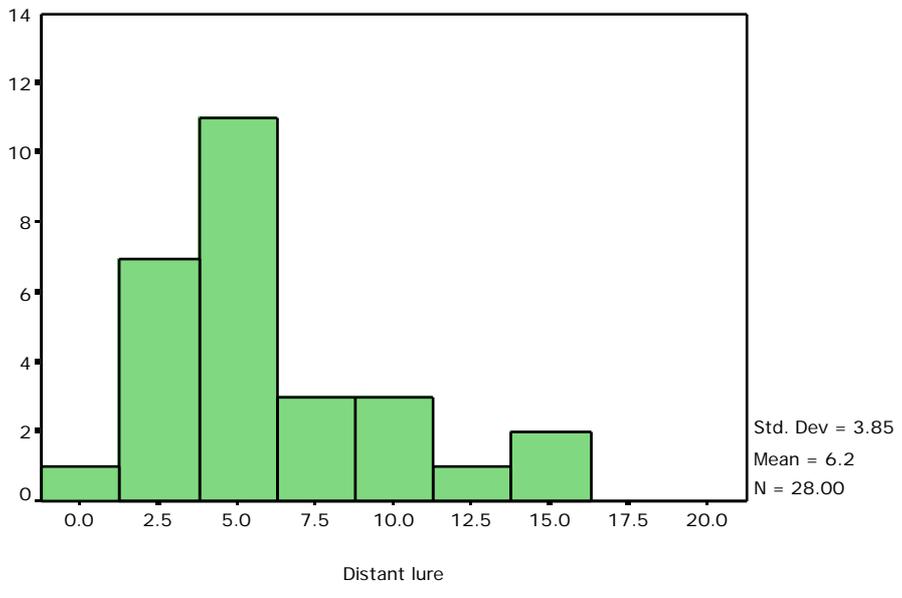
## 5. Response performance as a function of accuracy and lure type

To explore these errors further, histograms were produced to indicate the frequency of errors when the answers were correct, when the answers were incorrect but related (close lures), and when the answers were incorrect and less related (distant lures).

## Addition

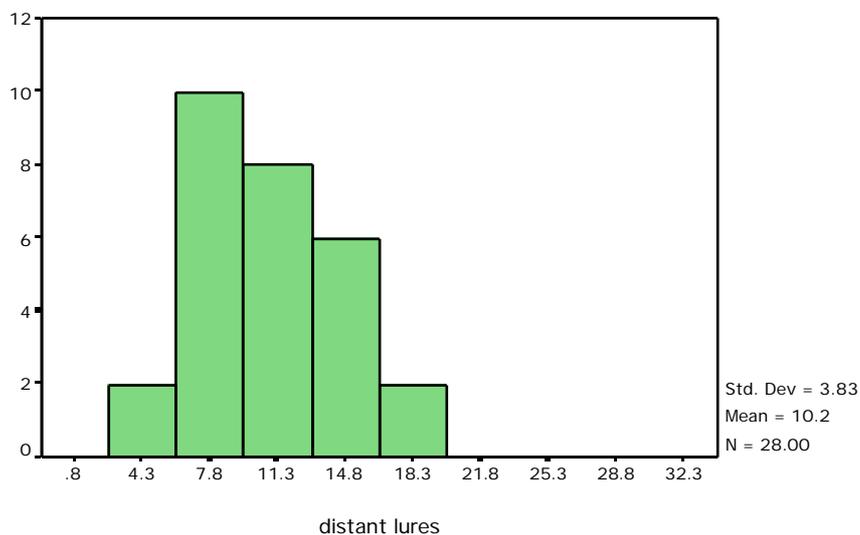
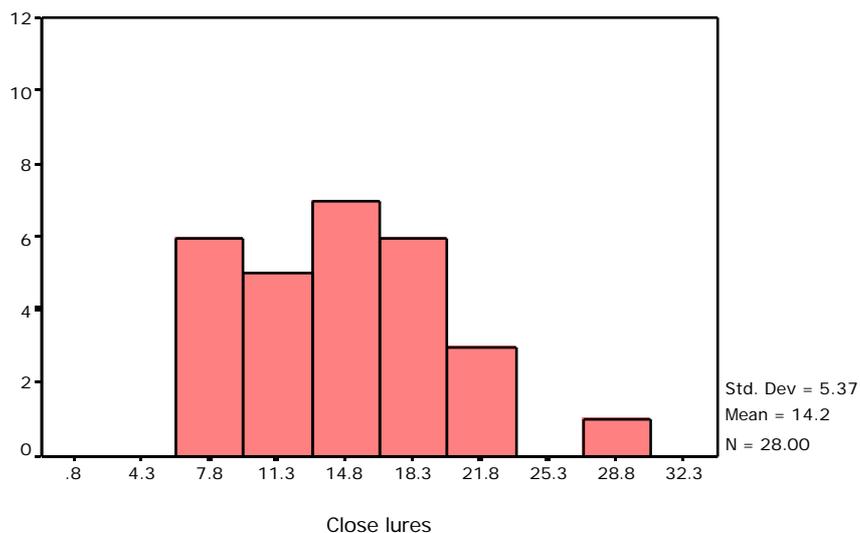
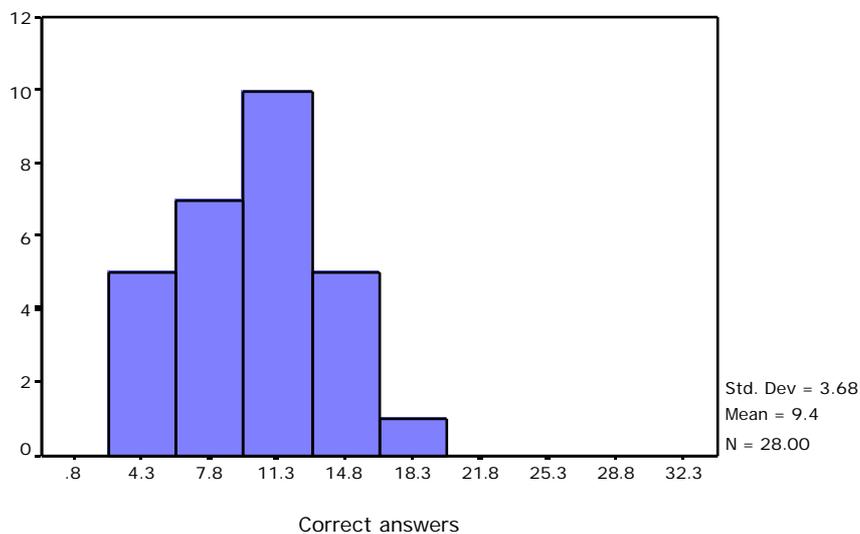
The distribution for addition is shown below. Paired t-tests showed that incorrect answers forming close lures produced more errors than incorrect answers to the same question with distant lures,  $t(27) = 3.67, p < .01$ .





## Multiplication

The histogram distributions for the multiplication questions are shown below. Again, more errors occurred to questions with close lure answers than questions with distant lures,  $t(27) = 5.36, p < .01$ .

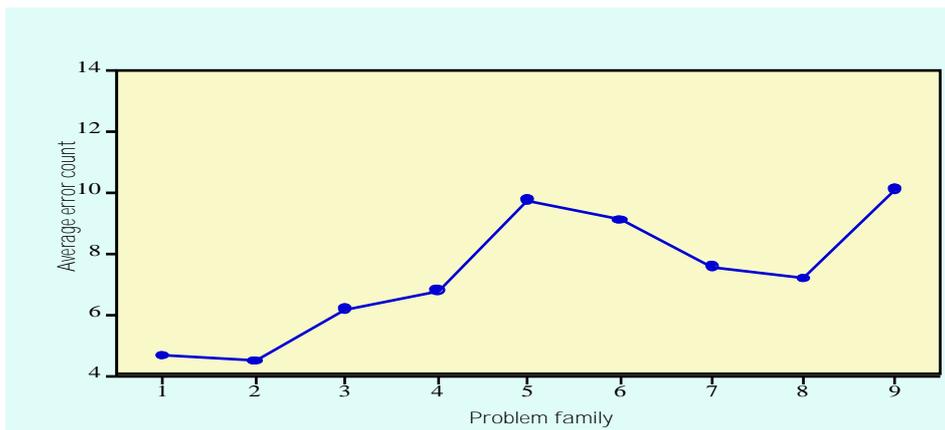


## 6. Problem size effects

The impact of problem size was also assessed, in the following way:

The number of errors for a problem size  $n$  was calculated as an average of all  $n \times a$  problems and  $a \times n$  problems for verifications that involved the correct answer. The problem size effect for addition is shown in the next figure, followed by the problem size effect for multiplication. In both cases, data show prototypical problem size effects.

Addition problems



Multiplication problems

