Cognitive Arithmetic: Effects of numerical surface form and equation presentation format

Michael C. W. YIP

School of Arts & Social Sciences, The Open University of Hong Kong

myip@ouhk.edu.hk

Introduction

In the research of cognitive arithmetic, many previous studies suggested that people usually make use of many different strategies to solve simple arithmetic problems (Campbell, 2005; Lemaire & Fayol, 1995; LeFevre, Bisanz, Daley, Buffone, Greenham, & Sadesky, 1996; Zbrodoff & Logan, 1990). For example, to verify simple multiplication questions, 2 x 3 = 7; 4 x 6 = 25, people will retrieve the answer of the question from their memory base and compared it with the mentioned answer: memory-retrieval hypothesis *or* people will first check out if the mentioned answer of the question violated the parity rules of multiplication: parity-checking hypothesis (Lochy, Seron, Delazer, & Butterworth, 2000). Similar studies were conducted to attest these kinds of hypotheses and found out that many important factors were operated during the cognitive processes of arithmetic problem solving. For example, Campbell and Fugelsang (2001) demonstrated that numerical surface form was a central stage of cognitive arithmetic. In their experiment, participants in fact used more time to verify equations in word form than in digit form. Moreover, in Yip's (2002) study, the researcher demonstrated that presentation format of equations was important to affect the processing time of arithmetic problem solving. In his experiments, participants used lesser time to verify equations presented in normal equation format (3 + 5 = 7) than in reversed equation format (7 = 5 + 3). These studies are useful to assess the validity of those hypotheses. However, to further verify the cognitive processes of arithmetic problem solving, I extend the research scope by mixing up the two variables (equation presentation format and numerical surface form), and examine their combined effects on cognitive arithmetic in the present study.

Experiment

The basic design of the present experiment is similar to other relevant studies using true/false verification task (e.g., Campbell & Fugelsang, 2001; Yip, 2002). Two main variables in the present experiment are: (1) equation presentation format: normal (3 + 4 = 8) vs. reversed (8 = 3 + 4); (2) numerical surface form: digit (3 + 4 = 8) vs. written Chinese format (三 + 四 = 八). Altogether, there are four different experimental conditions in the experiment.

Procedure

A series of simple addition problems were randomly presented to each participant in one of the four experimental conditions (3 + 4 = 8) or (8 = 3 + 4) or (三 + 四 = 八) or (八 = 三 + 四). Participants were asked to verify whether the equation is true or false by pressing a key. Response latencies were recorded from the onset time of the equation displayed on the computer screen to the manual response.

Results and Discussion

Three main findings in the present study were concluded.

First, the variable presentation format in fact influences the equation verification time of the participants (reversed equation format takes longer time to verify than the normal equation format). This result is consistent with our previous findings (Yip, 2002).

Second, the variable of numerical surface form also influences the verification time of the participants (word form takes longer time to verify than digit form). This result is also in line with Campbell and Fugelsang's (2001) findings.

Third, the most interesting point here is that there is an interaction of the two variables. Collapsed over the levels of equation presentation format, participants really used more time to verify equations in word form than in digit form under the normal equation presentation format but this was not the case for the reversed equation presentation format. Under the reversed equation presentation format, participants used comparable time to verify equations in both word and digit form. These results suggest that the effect of equation presentation format seems to be stronger than the others factors, such as numerical surface form and difficulty level of the arithmetic problem (Yip, 2002).

References

Campbell, J. I. D. (2005). *Handbook of Mathematical Cognition*. New York: Psychology Press.

Campbell, J. I. D. & Fugelsang, J. (2001). Strategy choice for arithmetic verification: effects of numerical surface form. *Cognition, 80*, B21-30.

LeFevre, J., Bisanz, J., Daley, K. E., Buffone, L., Greenham, S. L., & Sadesky, G. S. (1996). Multiple routes to solution of single-digit multiplication problems. *Journal of Experimental Psychology: General, 125*, 284-306.

Lemaire, P. & Fayol, M. (1995). When plausibility judgments supersede fact retrieval: The example of the odd-even effect on product verification. *Memory & Cognition, 23*, 34-48.

Lochy, A., Seron, X., Delazer, M., & Butterworth, B. (2000). The odd-even effect in multiplication: Parity rule or familiarity with even numbers? *Memory & Cognition, 28,* 358-365.

Yip, M. C. W. (2002). Presentation effects on arithmetic problem solving. *Psychologia, 45*, 90-97.

Zbrodoff, N. J. & Logan, G. D. (1990). On the relation between production and verification tasks in the psychology of simple arithmetic. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 16,* 83-97.