

An examination of dual mental number line model by using single- and double-digit number comparison task

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Purpose of this study

- The purpose of this study is to examine the process of single- and double-digit number comparison.
- For example, “Which is larger, 7 and 52?”

Models

In this study, the process of single- and double-digits number comparison like 7 and 52 is examined.

Following three hypotheses are examined.

- Identical mental number line model
- Place interference model
- Dual mental number line model

Identical mental number line model

- Presented two numbers are mapped onto identical mental number line.
- RT is a function of the distance between the numbers mapped on the line.
- For example, 7 and 52 are mapped onto the identical mental number line.

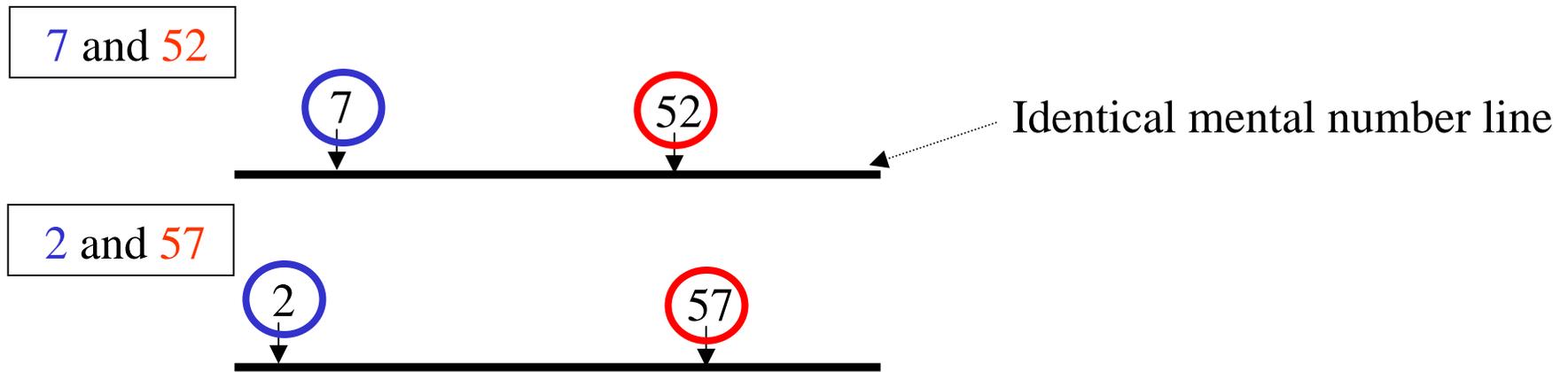


Figure 1: Identical mental number line model.

Place interference model

- Units and decades are distinguished, and the units and the decades are mapped onto discrete mental number lines, respectively.
- For example, when 7 and 52 are presented, 52 is divided between decade(5) and unit(2), and 7 is also divided between decade(0) and unit(7)
- The decades (0 and 5) are mapped onto the decade line, and the units (7 and 2) are mapped onto the unit line, respectively.
- RT is decreased as a function of the distance between the decades mapped on the decade line.
- The distance and the direction between the units mapped on the unit line interfere with judgment based on the decade line.

7 and 52

Decade number line

0

5

Unit number line

2

7

Interference

2 and 57

Decade number line

0

5

Unit number line

2

7

Interference

Figure 2: Place interference model.

Dual mental number line model

- There are two mental number lines.
- Most important information on judgment are mapped onto first mental number line, on which it is permitted that number lengths (e.g. 7 is one, 52 is two) are mapped.

- Second important information are mapped onto second mental number line.
- RT is decreased as a function of the distance between the number lengths mapped on the first line.
- The distance and the direction between the numbers mapped on the second line interfere with judgment based on the decade line.

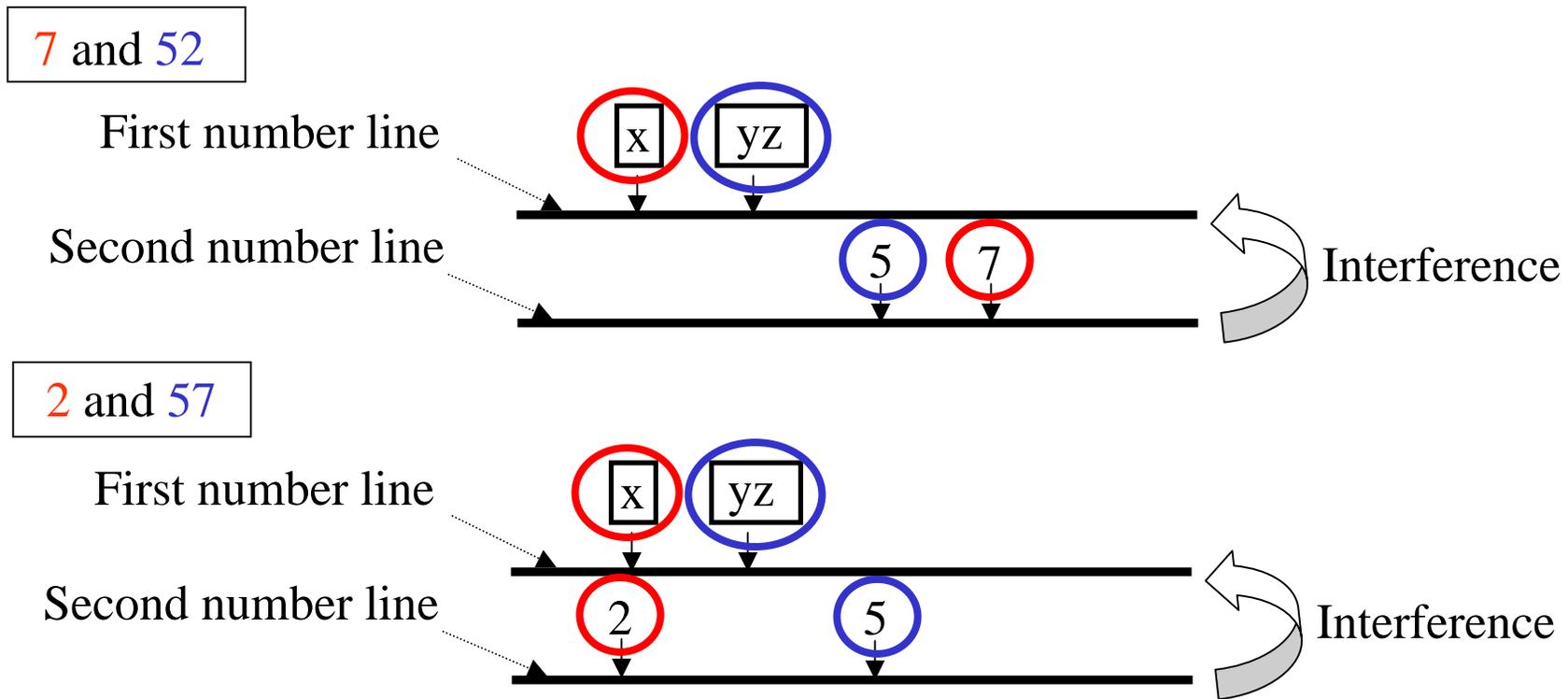


Figure 3: Dual mental number line model.

Method

Participants: 15 adults participated in this experiment.

Materials: (i) 50 pairs of numbers which were consisted of a single- and a double-digit numbers. (e.g. 7 and 52)
(ii) 40 pairs of numbers which were consisted of two single-digit numbers or two double-digit numbers. (e.g. 32 and 56)
These pairs were dummy trials, and excluded from analysis.

Procedure: Following figure (Figure 4).

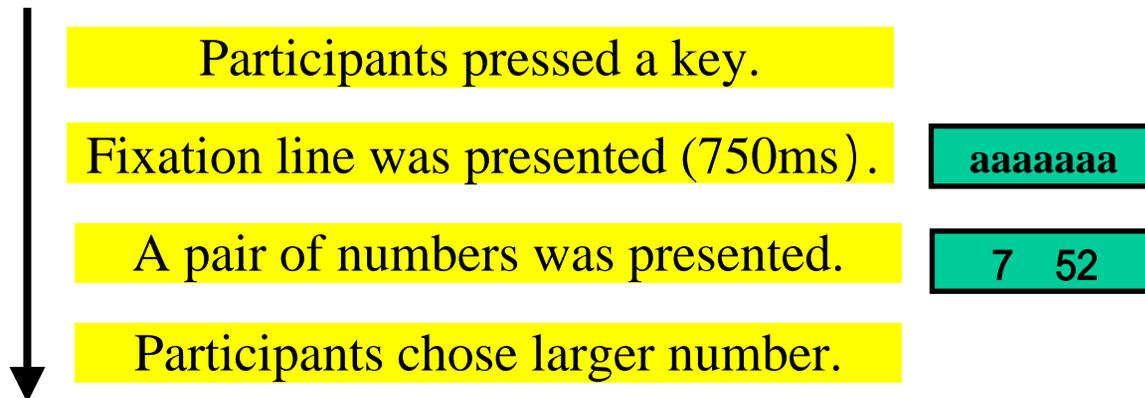


Figure 4: Procedure of a trial.

Results

Mean reaction time for each pair of numbers was computed.

For the mean RTs, regression analysis was carried out with following three independent variables:

In case that a number pair is “ x ” and “ yz ”,

- (1) LogDistance: it was defined as $\text{Log}(10y+z-x)$.
- (2) LogUnitDistance: it was defined as $\text{Log}(x-z+1)$ if $x > z$ and 0 if $x < z$.
- (3) LogFirstDistance: it was defined as $\text{Log}(x-y+1)$ if $x > y$ and 0 if $x < y$.

Each model has critical variable, respectively.

- | | |
|--|-------------------|
| (1) Identical mental number line model | LogDistance |
| (2) Place interference model | LogUnitDistance** |
| (3) Dual mental number line model | LogFirstDistance |

●As a result of the stepwise method ($p_{\text{in}}=.05$, $p_{\text{out}}=.10$),

LogFirstDistance was entered, but

LogDistance and LogUnitDistance were removed.

● $\text{RT} = 4.7 * \text{LogFirstDistance} + 385.7$

- The coefficient of LogFirstDistance was significant ($H_0: =0, p<.05$) even when Lorch & Myers (1990) procedure for repeated measures data was applied.

** : In this model, the decade of the double-digit number for each pair also critical, so LogDoubleDigitDecade which was defined as $\text{Log}(y+1)$ was examined. But it was also excluded as a result of the stepwise method.

Discussion and Conclusion

- In multidigit number comparison between single- and double-digit numbers, dual mental number line model was acceptable.
- According to dual mental number line model, it is predicted that:
- In multidigit number comparison in which presented two numbers have different figures like 235 and 8341, the lengths of the two numbers are mapped onto the first line and the first (i.e. top) digits of the two numbers are mapped onto the second line (Figure 5).
- RT for each pair is a function of the distance between the lengths on the first line and the distance between the two first numbers on the second line.
- If participant recognizes to-be-presented numbers have same number lengths like 2359 and 8641, the first numbers are mapped onto the first line, and the second numbers are mapped onto the second line (Shimada, submitted).

- Most and second important information are mapped onto the two mental lines, but next important information is not mapped any lines because there are only two lines. Shimada (submitted) and Cowan (2001) implies this constraint.

235 and 8741

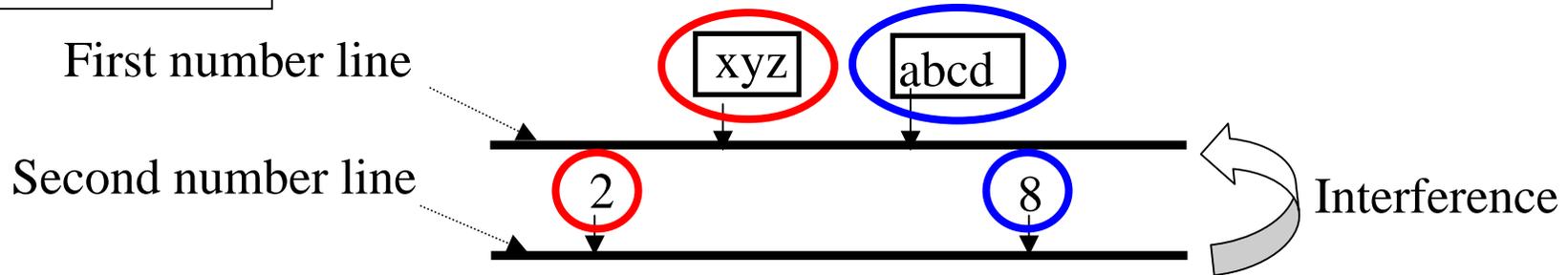


Figure 5: Processing for 235 and 8341 according to dual mental number line model.

References

- Cowan, N. (2001) The magical number 4 in short-term memory: A reconsideration of mental storage capacity. *Behavioral and Brain Sciences*, **24**, 87-185.
- Lorch, R. F., & Myers, J. L. (1990) Regression analyses of repeated measures data in cognitive research. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **16**, 149-157.
- Shimada, H. (submitted) Two-digit processing model and its evidence in multidigit number comparison.