

Existence of different modules on effects of congruity and compatibility in two-digit number comparison

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Background

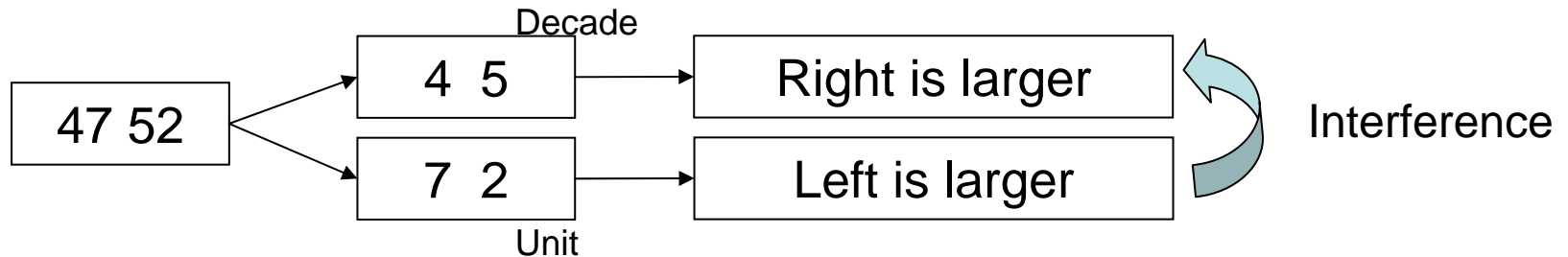
Unit-decade compatibility effect

In two-digit number comparison,
Reaction time is affected by compatibility between units and decades
(Dehaene et al., 1990; Nuerk et al., 2001).

Example: “42 57” is judged faster than “47 52”.

An account of compatibility effect

Because of **interference of unit compatibility** (Nuerk, et al., 2001)



Semantic congruity effect

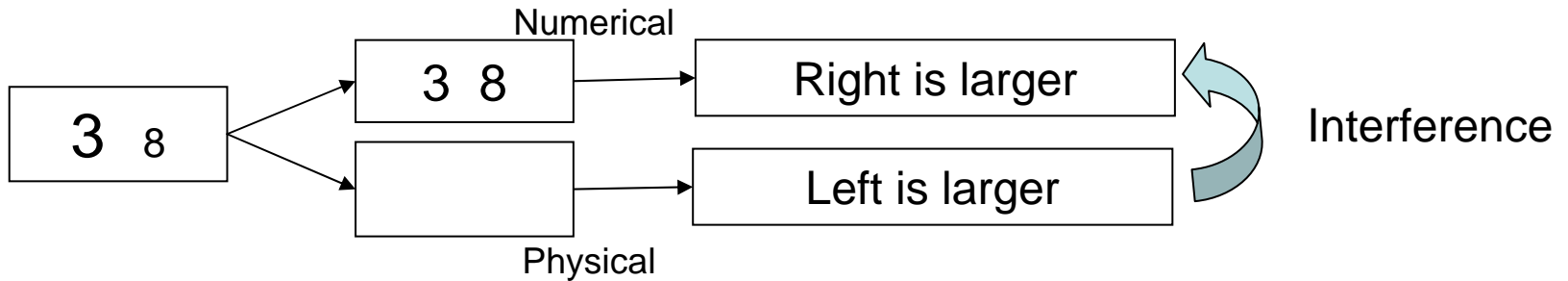
In one-digit number comparison,
Reaction time is affected by congruity between the numerical size and
physical size (Henik & Tzelgov, 1982; Ito & Hatta, 2003).

Example: “3 8” is judged faster than “3 8”.

(Note that the participants were required to judge based on the **numerical size**.)

An account of congruity effect

Because of **interference of physical size**

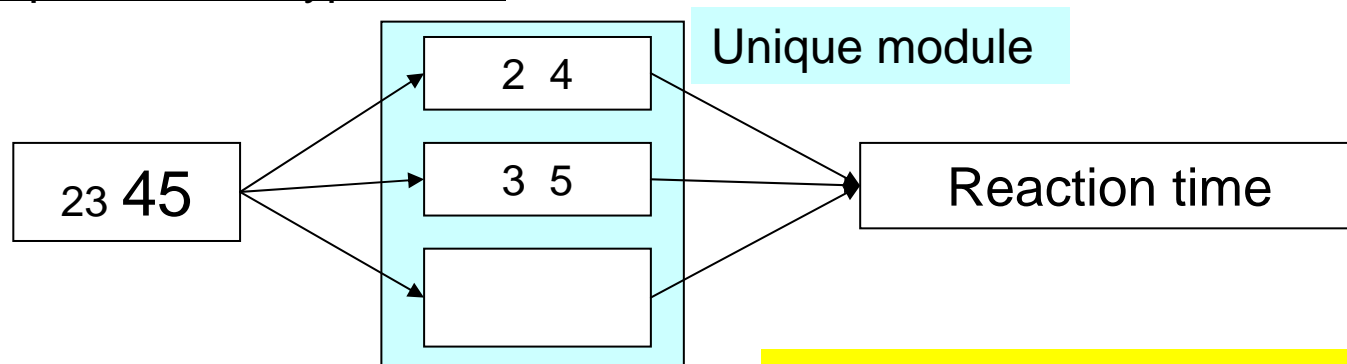


Purpose

To examine whether compatibility effect and semantic congruity effect are caused by **the unique module** or **distinguished modules**

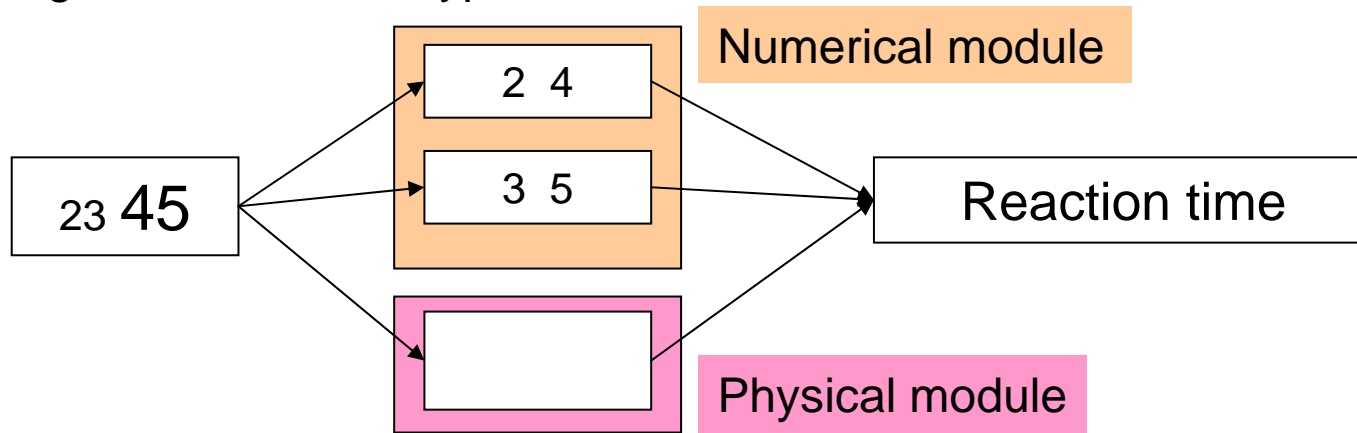
Supposed two models; Example of comparison between “23” and “45”

Unique module hypothesis



Capacity for each module is limited.

Distinguished module hypothesis



Method

Participants: Ten adults

Materials:

- Two sets of pairs of two-digit numbers were prepared.
- Unit-decade compatibility and congruity were manipulated.

Set 1: Applied to only compatibility block.

- Compatibility was manipulated.
- Physical sizes of two numbers were identical with small or large size. (i.e. Congruity was not manipulated.)

Set 2: Applied to simultaneous block.

- Both compatibility and congruity were manipulated.
- Physical sizes of two numbers were different. (i.e. Congruity was manipulated.)

Set 1	Small	Large
Compatible	42 57	42 57
Incompatible	47 52	47 52

Set 2	Congruity	Incongruity
Compatible	42 57	42 57
Incompatible	47 52	47 52

- Procedure:**
- Participants were required to **select the larger number regardless of physical size.**
 - They performed the blocks, and the order of blocks was counter-balanced.

Expectation

Capacity limitation on each module leads to the following expectations.

Unique module hypothesis

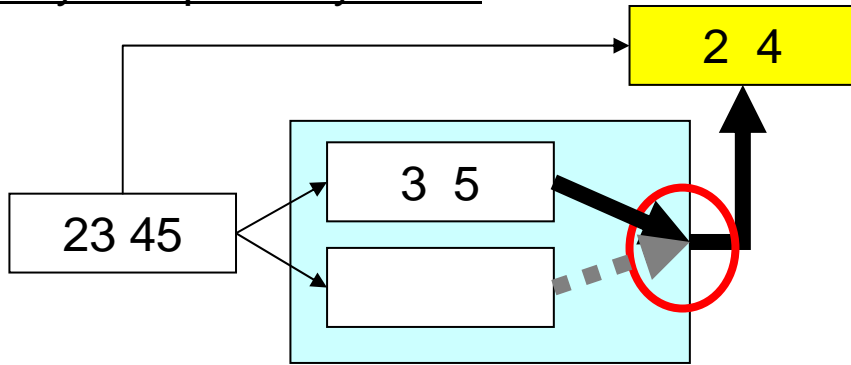
- Compatibility effect should observe in the only compatibility block should be weaker than in simultaneous one, **or**
- Congruity effect in the simultaneous block should disappear because of competition with compatibility.

Distinguished module hypothesis

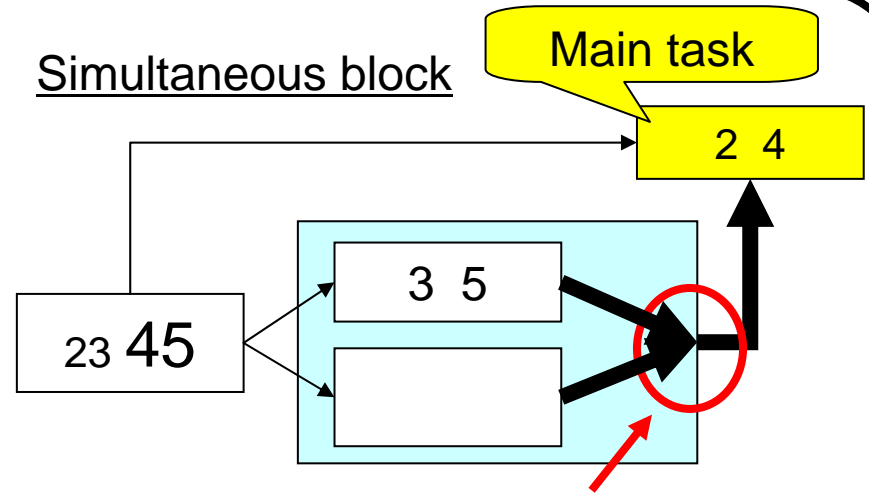
- Equivalent effects of compatibility should be observed in both blocks, **and**
- Congruity effect should be found.

Unique module hypothesis

Only compatibility block



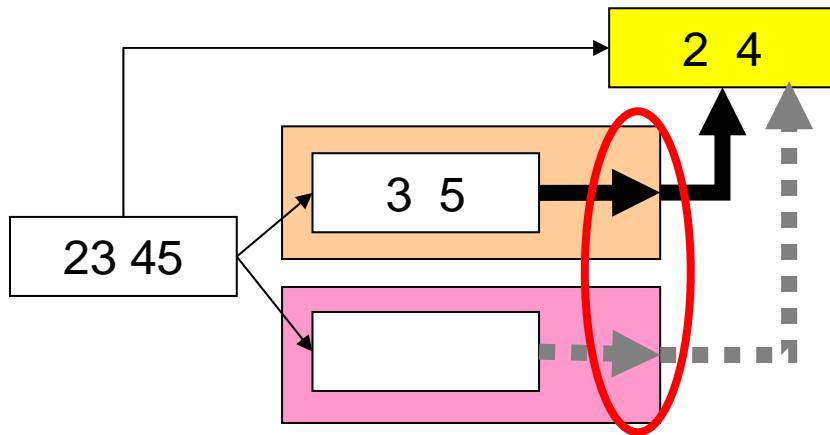
Simultaneous block



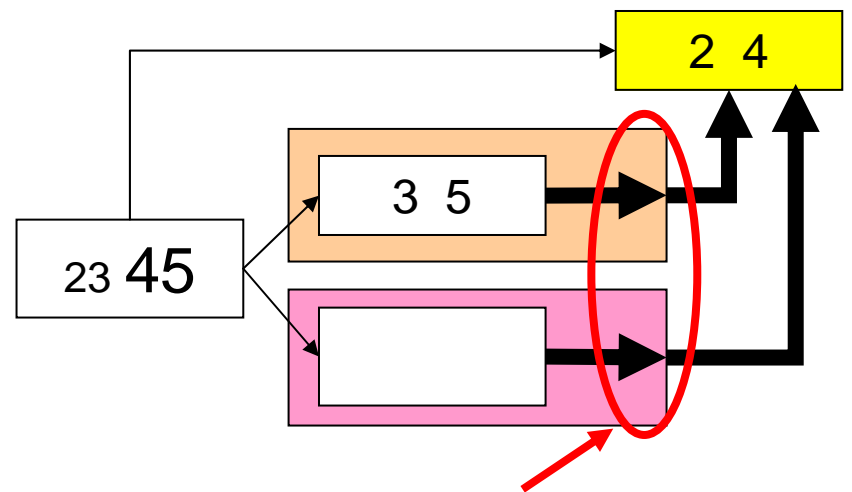
Capacity **limited** interference effect

Distinguished module hypothesis

Only compatibility block



Simultaneous block



Capacity **non-limited** interference effect

Note that the expectations are complemented by (see **Appendix**)

- Capacity limitation of multi-digit number comparison (Shimada, 2003)
- Capacity limitation of working memory (Cowan, 2001)

Results

In simultaneous block

As a result of an analysis of RT in the simultaneous block (Figure 1),

- Main effect of compatibility and congruity were found.
- No interaction was found.

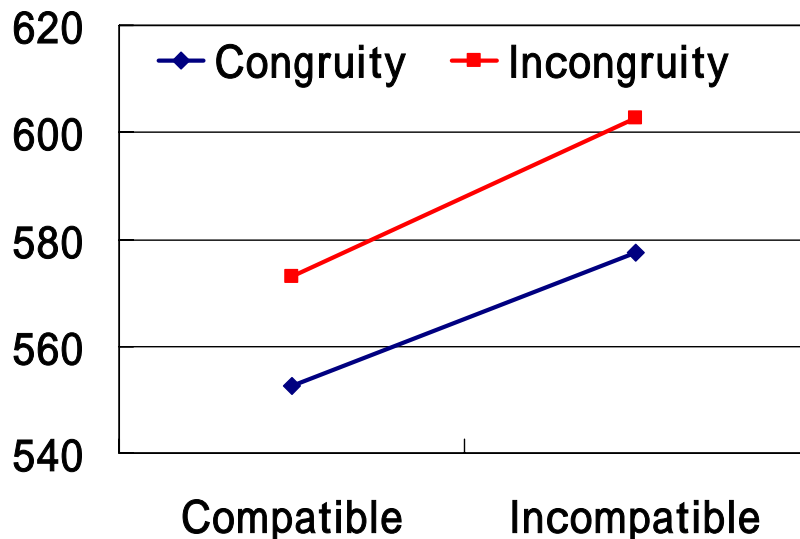


Figure 1: Mean RT in Simultaneous Block

Comparison of compatibility effects

As a result of the comparison of compatibility effect between the two blocks (Figure 2),

- No difference was found.

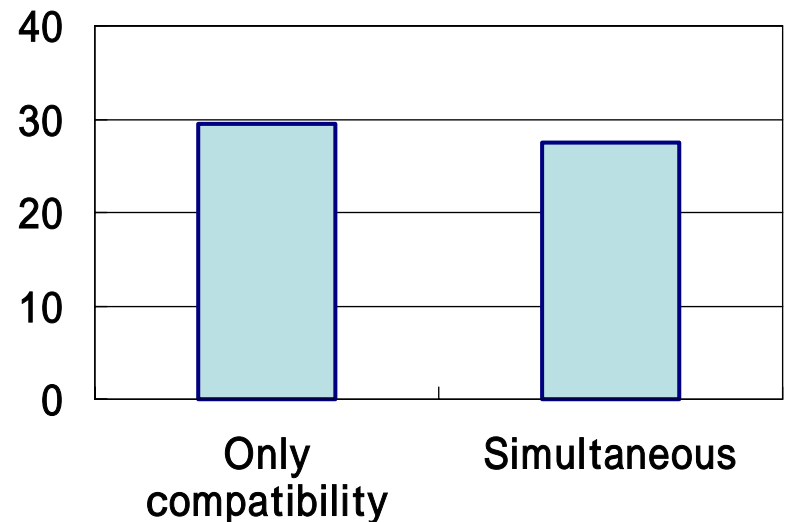


Figure 2: Mean Effects of Compatibility

Discussion & Conclusion

Discussion

It reveals that

- Equivalent effects of compatibility were observed in both blocks.
- and**
- Congruity effect was found in simultaneous block.

The results are consistent with the expectation extracted from the **distinguished module hypothesis**.

Conclusion

Compatibility effect and semantic congruity effect are caused by **the distinguished modules**.

The results suggest the discrete existence of:
the module for processing of numerical size information and
the module for processing of physical size information.

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.
- Dehaene, S., Dupoux, E., & Mehler, J. 1990 Is numerical comparison digital? Analogical and symbolic effects in two-digit number comparison. *Journal of Experimental Psychology: Human Perception and Performance*, **16**, 626-641.

Henik, A. & Tzelgov, J. 1982 Is three greater than five: the relation between physical and semantic size in comparison tasks. *Memory and Cognition*, **10**, 389-395.

Ito, Y. & Hatta, Y. 2003 semantic processing of arabic, kanji, and kana numbers: evidence from interference in physical and numerical size judgments. *Memory and Cognition*, **31**, 360-368.

Shimada, H. 2003 (under review) Two-digit processing model in multidigit number judgment.

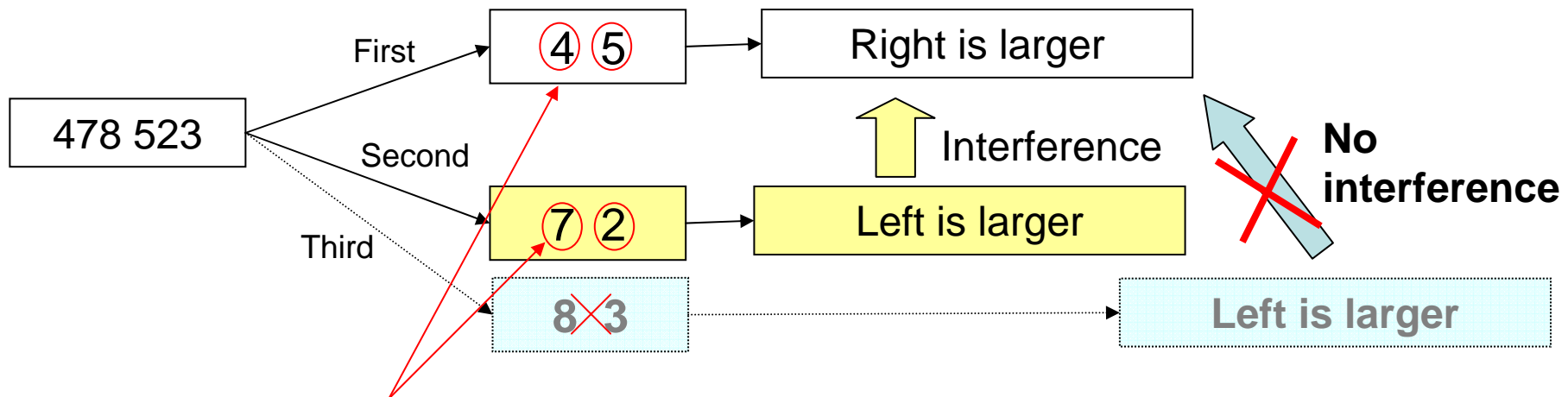
Nuerk, H., Weger, U., & Willmes, K. 2001 Decade breaks in the mental number line? Putting the tens and units back in different bins. *Cognition*, **82**, B25-B33.

Appendix

Capacity limitation in multidigit number comparison

Reaction time is **affected** by compatibility in the **second place**, but **not** affected by that in the **third or more than three places** (Shimada, 2003).

Example: In case of judgment between “478” and “523”.



Four digits can be processed simultaneously in short-term memory.
(Quoted from Cowan's "Magical Number Four" (Cowan, 2001).)