Are Two-Digit Numerals Decomposed or Holistically Represented? Evidence from Number Comparison

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How are multi-digit numbers mentally represented? We all agree that the meaning of numerals like 2653 are computated on the basis of both single digits and syntactic values associated to them. However, how are two-digit numbers like 63 represented? Is their representation holistic or decomposed? In a number comparison task, Dehaene, Dupoux and Mehler (1990) observed that when participants have to decide whether a target number is larger or not than a standard (i.e. 65), responses are as faster and more accurate as the difference between the target and the standard increases. This distance effect does not show any discontinuity with decade crossing (i.e. 59-65). According to Dehaene and colleagues, two-digit numbers, like single-digit numbers, correspond to points along a logarithmic compressed mental number line and they would be processed and represented as a whole. On the contrary, some authors maintain that two-digit numbers are syntactically decomposed or represented both in decomposed and holistic way (Nuerk, Weger & Willmes, 2001). Nuerk et al. have found that in number comparison responses are slower and less accurate when the comparison on the units is not in the same direction as comparison on the decades (incompatibility effect, i.e.: 47-62). Moreover, in a recent naming study exploiting the priming paradigm (Ratinckx, Brysbaert & Fias, in press), it has been found facilitation when a two-digit number is preceded by a number sharing one digit on a corresponding position (i.e. 13-18 and 28-18) and inhibition when a two-digit number is preceded by a number sharing one or two digits on different positions (83-18 and 81-18). However, the authors ascribe these effects to the level of the verbal production of the Arabic numerals. If we want to compare the decomposed representation hypothesis with the holistic hypothesis on the basis of such syntactic effects, then we will need to use a task that does not directly request a verbal processing for the response. The number comparison task is a good candidate. Moreover, it is usually assumed that number comparisons only require comparisons between quantities. We also hypothesize effects due to the Arabic form processing.

In our study we have employed the number comparison task in order to investigate the syntactic inhibition effect and the role of Arabic code between two-digit numerals. In Experiment 1, we have found that responses with pairs containing one repeated digit in a different syntactic position (i.e. 26-32) are significantly slower and less accurate than the other incompatible pairs. This effect is significant both with internal and external repetition (26-32 and 43-37). We have also found a compatibility effect and its interaction with the distance. A symbolic distance effect has been found just with pairs sharing the same decade (compatible pairs). No distance effect is found with the incompatible pairs. The results were also confirmed by the study of the function better fitting the data (Fechner-Weber's function: reaction time = a + b*log (larger/larger-smaller)) and by the multiple regression analysis. Results prove a syntactic inhibition effect on two-digit numbers and confirm the incompatibility effect.

However, a possible objection against Experiment 1 might be that the interference between repeated-digit pairs is not due to the syntactic information activation, but it is a perceptive interference arising during simultaneous processing of the two numbers. In order to discard this hypothesis, in Experiment 2 we have increased the stimulus onset asynchrony (SOA) from 0 ms to 550 ms. This SOA guarantees us that the first number processing is finished when the second number appears. Moreover, the first number disappeared just before the second number's appearance. Results by Experiment 2 confirm those from Experiment 1.

Experiments 1 and 2 demonstrate that a syntactic interference effect occurs also in a number comparison task. This effect is not likely to be a semantic one, but it is probably due to the syntactic processing of the Arabic form. Our results are compatible with a syntactic-computational model of the two-digit numbers' representation.

References

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