Units first or tens first: Does language matter when processing visually presented two-digit numbers?

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Introduction

The number word system of German inverts units and tens compared to the Arabic notation (i.e. 28 is pronounced as “eight and twenty”). This is not the case in French, which is more transparent with respect to the Arabic number code. Evidence indicates that the linguistic structure of number words can facilitate or impede numerical development. (Zuber & al., 2009).

In transcoding tasks more mistakes are made in non-transparent compared to transparent languages (Imbo, Vanden Bulcke, De Brauwer, & Fias, 2014).

Hypothesis

We tested French and German adults (monolinguals & bilinguals) and children (monolinguals) with a new paradigm in which we manipulated the order of appearance of units and tens of two-digit numbers. Our main hypotheses were:

1) The order of digit-appearance (tens vs units first) influences performance as a function of language transparency.
2) Children are highly influenced by the order of digit-appearance (i.e. German are slower than French-speaking children)
3) Bilingual adults are less influenced by the order of appearance than monolingual adults due to the influence of both bilinguals’ languages on each other

Methods

Participants:
28 Belgian French-speaking 4th grade children (Mage = 10 yo, SDage = 0.4)
19 Belgian German-speaking 4th grade children (Mage = 10.3 yo, SDage = 0.6)
24 German & French-speaking bilingual Students (12 Females)
18 French-speaking Students (13 Females)
26 German-Speaking Students (15 Females)

Experimental task: choosing the heard number among 4 alternatives

Stimuli: 42 Two-digit numbers, orally presented in 3 conditions:
1. Simultaneous appearance
2. Ten first
3. Unit first

Results

Monolinguals

Bilinguals

Monolinguals VS Bilinguals

Experimental Task

3 Conditions

1. Simultaneous
2. Ten first
3. Unit first

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3 Conditions

1. Simultaneous
2. Ten first
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Conclusion

The present data indicates that language structure qualitatively impacts on basic numerical tasks such as transcoding.

For children: Transcoding was systematically faster when the order of the stimuli stimulus appearance was congruent with their number word system (e.g. trente deux -> 3 then 2 for French-speaking , Zweiunddreißig -> 2 then 3 for German-speaking).

Overall German-speaking children were slower in transcoding. In line with previous evidence (Zuber & al., 2009) we propose that this slow-down reflects the additional difficulty imposed by the inverted number word system on children numerical learning.

Monolingual adults were faster than bilinguals (in their respective language) during the simultaneous condition. In contrast, bilinguals did not systematically differ from monolinguals during the decomposed conditions. This suggests that similar strategies (e.g. decomposition) are used by bilinguals and monolingual adults when processing sequentially presented two-digit numbers.

![Graphs showing results for monolinguals and bilinguals](image1.png)

**T-tests for adults simultaneous condition**

<table>
<thead>
<tr>
<th>Unilingual</th>
<th>Bilingual</th>
<th>T-test</th>
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<tr>
<td>French</td>
<td>German</td>
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<td>French</td>
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**Bilingual Adults:**

- Overall, German-speaking (M = 905ms; SD = 35ms) did not differ from French-speaking monolingual adults (M = 862ms; SD = 42ms).

**Bilingual VS Monolingual Adults:**

- Bilinguals are significantly slower in the simultaneous condition, but not in the 2 decomposed (i.e. tens and in the units) conditions on.