A case of ‘task switching acalculia’

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Introduction
In healthy subjects, it has been shown that performing simple calculation in blocks with repeated presentation of the same operation (‘pure blocks’) leads to faster responses and less errors than performing simple calculation in blocks with mixed presentation of different operations (‘mixed blocks’) (Miller & Parades, 1990; Rubinstein et al., 2001). There is still a controversial debate, whether this increase in RT and error rate for mixed presentation (‘task switching costs’) can be attributed to active executive functioning or to passively resolved interference (Logan, 2003). Furthermore, in mixed blocks there are significantly more cross-operation errors than in pure blocks (Miller & Parades, 1990). Moreover, after performing a block of one operation (e.g., multiplication), the rate of direct retrieval from memory may drop even in a pure block of another operation (e.g., addition) due to increased interference. Instead, an increase in the use of procedures can be observed (Campbell & Timm, 2000).

With regard to clinical implications, Roure (1993) described children with specific arithmetic disabilities due to difficulties in executive functioning. Some of them tended to apply a procedure successfully used for one operation (e.g., addition) to a newly introduced operation (e.g., subtraction). However, up to now there are only anecdotic reports about acquired ‘secondary’ acalculia specifically due to impaired task switching (Berger, 1952).

Case description FR

Biography: aged 42, mechanic & dealer for agricultural machinery
Lesion: CVA in the territory of the left mesial cerebral artery
Memory: digit span 4/5 (fw/bw), intact verbal & figural learning & memory
Attention: ➤ tonic, ➤ divided, ➤ selective attention, gets quickly tired
Executive functions: verbal fluency semantic/phono/mixed: 21/11/12 per min;
odd man out test: no error; Wisconsin CST: unimpaired;
Trail making A/B percentile 25/50;
Stroop: slow, strong decrease of performance, normal inhibition
Number processing: at ceiling (NPC, Delazer et al., 2003)
Calculation: unimpaired in error rates but slow (NPC, Delazer et al., 2003)

Method
Simple multiplication problems (n=24) were presented in pure and mixed blocks. With-in a mixed block, one to three multiplication problems appeared following a short sequence of addition or subtraction problems. Thus, different positions within the multiplication series can be distinguished: Pos 1 (following addition or subtraction) and Pos 2 (following another multiplication problem). Within the mixed block each multiplication problem was presented twice – at Pos 1 and at Pos 2. The mixed block was presented in two halves to the patient (one before and one after the pure block) and as a whole for the control patients (one before and one after the pure block). Presentation of each block took place at different days. In the pure block, there were two halves to the patient (one before and one after the pure block) and as a whole for the control patients (one before and one after the pure block). Thus, different positions within the multiplication series can be distinguished: Pos 1 (following addition or subtraction) and Pos 2 (following another multiplication problem). Within the mixed block each multiplication problem was presented twice – at Pos 1 and at Pos 2. The mixed block was presented in two halves to the patient (one before and one after the pure block) and as a whole for the control patients (one before and one after the pure block). Presentation of each block took place at different days. In the pure block, there were two halves to the patient (one before and one after the pure block) and as a whole for the control patients (one before and one after the pure block).

Discussion
Apart from a general slowing, FR showed disturbed calculation only when presented with a mixed list. This deficit may be traced back to impaired switching between arithmetic operations and/or increased sensitivity to interference from competing operations’ task sets. To our knowledge, this is the first such case reported in some detail.

Nearly all his operation errors concerned addition and multiplication, the two operations which are believed to be represented in closely interrelated networks in long term memory (Miller & Parades, 1990; Campbell & Timm, 2000). Although the addition and multiplication signs are visually similar, FR’s unimpaired performance at Pos 2 in the mixed block excludes any explanation in terms of a visual deficit or an alexia for arithmetical signs as described by Ferro & Bothello (1980). Furthermore, multiplication-related errors in addition rule out the possibility that addition was just ‘over-activated’ or multiplication ‘under-activated’. Finally, the error pattern points to the use of memory retrieval rather than to the application of calculation strategies or procedures.

With the present data it is not possible to distinguish between increased sensitivity to interference or some impaired active executive task switching device. Moreover, it is not clear, why standard tests addressing setting shifting or inhibition in general detected no comparable problems (Wisconsin CST, Trail making, OMO, verbal fluency mixed list, Stroop). Two accounts may be proposed to explain this finding: 1) these tests are simply not sensitive enough or 2) switching may be selectively impaired for the set of basic arithmetic operations.

Results
FR showed significantly increased switching costs in terms of RT (fig. 1) and accuracy (fig. 2)
• costs were highest for the position directly after the switch (Pos 1) (fig. 1 & 2)
• no significant interference was observed at the second position after the switch (Pos 2) (fig. 1 & 2)
• all wrong multiplication responses were classified as cross-operation errors (e.g., 2 x 9 = 11) or related to cross-operation errors (e.g., 5 x 7 = 13), most of them related to addition (5/6)
• addition-related multiplication errors occurred also after subtraction
• post-hoc analysis for addition accuracy revealed similar switching costs: 95%, 100%, and 72% correct for pure block, Pos 2, and Pos 1, respectively
• all error additions could be interpreted as stating the multiplication result rather about 20 min of mixed simple calculation, FR suddenly stated not to know anymore “what to do with these two numbers” and asked to break off

Conclusion
The present case illustrates that in diagnostics calculation abilities should not only be tested blocked by operation, but also in mixed presentation.

References
Rubenstein et al., 2001). There is still a controversial debate, whether this increase in RT and error rate for mixed presentation (‘task switching costs’) can be attributed to active executive functioning or to passively resolved interference (Logan, 2003). Furthermore, in mixed blocks there are significantly more cross-operation errors than in pure blocks (Miller & Parades, 1990).