SIMPLE ARITHMETIC PROCESSING

Fact Retrieval Mechanisms and the Influence of Individual Differences, Surface form, Problem Type and Split on Processing.

by

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I declare that this thesis is my account of my research and contains as its main content work which has not previously been submitted at any tertiary education institution.
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ABSTRACT

Current theorising in the area of cognitive arithmetic suggests that simple arithmetic knowledge is stored in memory and accessed in the same way as word knowledge i.e., it is stored in a network of associations, with simple facts retrieved automatically from memory. However, to date, the main methodologies that have been employed to investigate automaticity in simple arithmetic processing (e.g., production and verification) have produced a wide variety of difficulties in interpretation. In an attempt to address this, the present series of investigations utilised a numerical variant of the well established single word semantic priming paradigm that involved the presentation of problems as primes (e.g., 2 + 3) and solutions as targets (e.g., 5), as they would occur in a natural setting. Adult university students were exposed to both addition and multiplication problems in each of three main prime target relationship conditions, including congruent (e.g., 2 + 3 and 5), incongruent (e.g., 2 + 3 and 13), and neutral conditions (X + Y and 5). When combined with a naming task and the use of short stimulus onset asynchronies (SOAs), this procedure enabled a more valid and reliable investigation into automaticity and the cognitive mechanisms underlying simple arithmetic processing.
The first investigation in the present series addressed the question of automaticity in arithmetic fact retrieval, whilst the remaining investigations examined the main factors thought to influence simple arithmetic processing i.e., skill level, surface form, problem type and split. All factors, except for problem type, were found to influence processing in the arithmetic priming paradigm. For example, the results of all five investigations were consistent in revealing significant facilitation in naming congruent targets for skilled participants, following exposure to Arabic digit primes at the short SOA. Accordingly, the facilitation was explained in terms of the operation of an automatic spreading activation mechanism. Additionally, significant inhibitory effects in incongruent target naming were identified in skilled performance in all of the studies in the present series of investigations. Throughout the course of these investigations, these effects were found to vary with operation, surface form and SOA, and in the final investigation, the level of inhibition was found to vary with the split between the correct solution and the incongruent target. Consequently, a number of explanations were put forward to account for these effects. In the first two investigations, it was suggested that the inhibitory effects resulted from the use of a response validity checking mechanism, whilst in the final investigation, the results were more consistent with the activation of magnitude representations in memory (this can be likened to Dehaene’s, 1997, ‘number sense’). In contrast, the results of the third investigation led to the proposal that for number word primes, inhibition in processing results from the activation of phonological representations in memory, via a reading based mechanism.

The present series of investigations demonstrated the utility of the numerical variant of the single word semantic priming paradigm for the investigation of simple arithmetic processing. Given its capacity to uncover the fundamental cognitive
mechanisms at work in simple arithmetic operations, this methodology has many applications in future research.
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