

Detecting math ability with brain potentials

It is known that the various individuals differ in their ability to perform arithmetic calculations. Some people can find mathematics an extremely easy exercise while for others it can become an insurmountable problem. For example, a significant number of consumers have difficulties making everyday calculations during shopping, and understanding key information about prices and discounts applied to the merchandise.

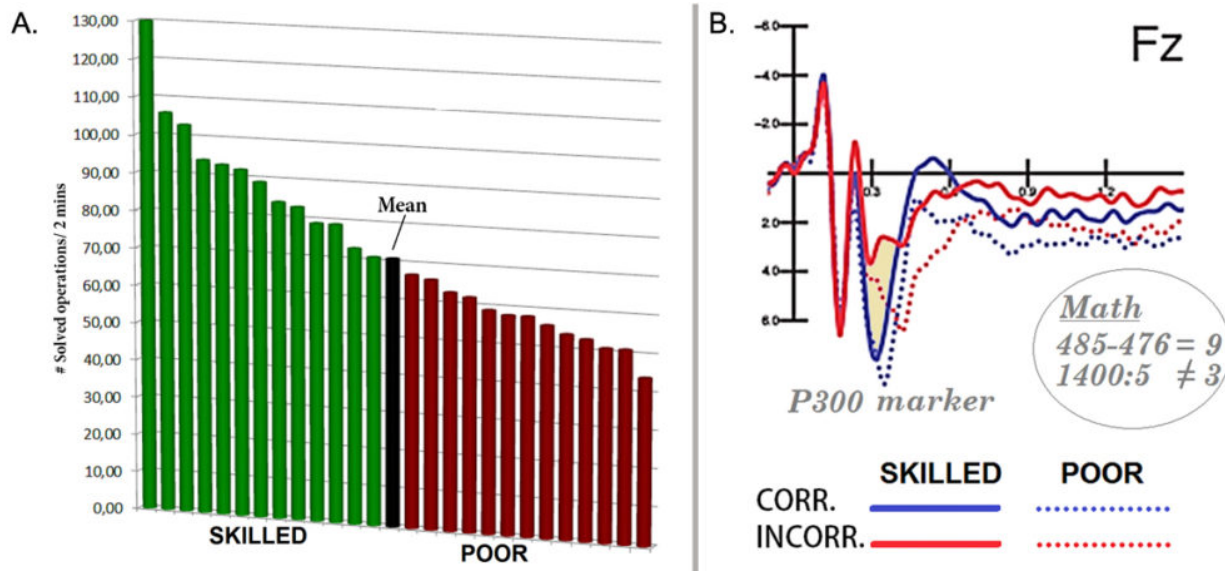


Fig. 1 A. Average number of solved operations within 2 minutes by each individual subject. A shortened version of N section of Kit of Factor-Referenced Cognitive Tests was administered in paper & pencil format. The median value was used to subdivide the population and consider the most skilled and the less skilled individuals.

B. Grand-average Event related Potentials (ERPs) recorded from a frontal site in skilled and poor calculators during solving of math operations. P300 component revealed to be a reliable marker of individual math abilities.

Signs of dyscalculia in the healthy population include: difficulty in remembering numbers (including passwords, cell phone numbers, important dates, multiplication tables), easily losing track when counting, difficulty in solving complex math calculations (divisions, multiplications arithmetic, algebra); struggling with visualizing, time, directions, sequences, scheduling, procedures, and logistics. It is thought that most of these functions might involve the left angular gyrus of the brain (located in the parietal cortex). However, neuroscientific markers of superior/poor arithmetic ability in the healthy population are still poorly understood.

Here we correlated electric potentials with math performance in 13 high-skilled and 13 low-skilled

individuals selected among a wider sample of 41 graduate students on the basis of their poor or superior arithmetical ability assessed through a time-based test (Fig. 1A). The brain electrical activity (EEG) was recorded from 128 sensors while participants solved 352 arithmetical operations (additions, subtractions, multiplications, divisions) and decided if the provided result was correct or incorrect. Overall skilled individuals correctly solved a higher number of operations than poor calculators and responded with faster response times. Consistently, the latency of frontal P300 component of event-related potentials (ERPs) peaked earlier in the skilled than poor group. The P300 was larger in amplitude to correct than incorrect math results, but only in the skilled group, with just a tendency found in poor calculators (Fig. 1B). Spearman's Rho correlation coefficient analyses showed that the larger P300 response to correct arithmetical solutions, the better was the performance; conversely, the larger the P300 amplitude to incorrect solutions the worse was the performance. The results suggest that poor calculators had a less clearer representation of arithmetic results, and difficulty in quickly accessing it. This study provides a standard method for directly investigating arithmetic ability throughout non-invasive electrical recordings that can be useful for assessing acalculia/dyscalculia in the clinical and in the healthy population (including children, elderly, brain-damaged patients).

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