Celeration charts as an assessment tool of learning and executive performance in psychiatric patients

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The term executive functions (EF) has been used to refer to many dimensions of complex human behaviour. It encompasses a broad set of cognitive skills that are responsible for the planning, initiation, sequencing and monitoring of complex *goal-directed* behaviour [1]. For behaviour to be classified as EF, it may not be smooth or automatic but must evoke thinking, problem-solving, and decision making in reaction to *new* or *unusual* situations that conflict systematically with well-established sources of behaviour regulation. Efficient executive performance is thus characterized by the flexibility of an individual to follow, apply, derive or generate rules or strategies in novel situations or, in short, the ability of an individual to *learn* in new or conflict situations.

Learning is a continuous process of acquiring knowledge; in order to form new and more effective rules or strategies, people extract knowledge about problem structures from previous solution attempts they made, but different subjects may learn different rules or strategies [2]. Our aim is to systematically explore (and influence) these individual behavioural differences to offer a broader window on the performance and trainability of executive functioning in clinical and non-clinical groups which, in time, could lead to a better understanding and treatment of executive dysfunctioning.

The Tower of Hanoi (TOH) puzzle has proved to be a suitable task environment in which to study a variety of executive processes [2]. Welsh and Huizinga [3] suggested that the constraints of the TOH are conducive to the spontaneous generation of several problem solving strategies that vary in effectiveness and may explain normal individual differences in performance. Using the TOH as an procedural learning task (administering a single TOH problem repeatedly) will provide information on the issue of *learning*: does repetition lead to substantial improvement of accuracy and speed in performances? How do individuals differ in their ability to learn?

The use of strategy and strategy change was measured by analyzing the acquired verbal reports. This method has considerable utility in the study of complex human behaviour and allows for detailed analysis of human language and cognition from a behavioural perspective [4]. However, competent and adaptive executive performance is not only characterized by the use of efficient strategies, but is also dependent on the fluid combination of accuracy *and* speed of performing. When learners achieve certain frequencies of accurate performance they seem to retain and maintain what they have learned, remain on task or endure for sufficient periods of time to meet real-world acquirements (even in the face of distraction), and apply, adapt or combine what they learned in new situations [5].

To monitor and analyze the growth of learning across time (i.e. the *celeration*), correct and incorrect responses are plotted in a Standard Celeration Chart. This chart is a standard display of frequency as count per time interval (e.g. minute, week, year) and can be used to display change in any human behaviour [6]. Frequency is performance: it tells what happened during one time period, but by itself it tells little about learning. To see whether performance accelerates or decelerates we need to measure it across time [7]. By representing both frequency and celeration in standard graphic and quantitative units, the standard chart clearly differentiates between changes in performance level (frequencies) and changes in learning rates (celerations); higher frequencies of accurate executive performance on a problem solving task predict individual learning ability [5].

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