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Reaction time: An alternative method for assessing the effects of multiple sclerosis on information processing speed

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Abstract

The ability of a newly developed measure of information processing to detect deficits in cognitive functioning associated with multiple sclerosis (MS) was investigated. The Computerized Tests of Information Processing (CTIP; Tombaugh, T., & Rees, L. (1999). *Computerized Tests of Information Processing (CTIP). Unpublished test*. Ottawa, Ontario, Canada: Carleton University) was administered to 60 clinically definite MS patients and 60 healthy controls. MS patients responded significantly slower than controls on the reaction time tests composing the CTIP. Moreover, as the CTIP tests became more difficult (i.e. as processing demands increased), the difference between the performances of the two groups progressively increased. These results suggest the CTIP is sensitive to the cognitive deficits observed in MS and that this measure has the potential to serve as a viable alternative to traditional measures of information processing speed currently in use with MS patients.

Keywords: Multiple sclerosis; Information processing speed; Reaction time; Computerized tests of information processing; CTIP

Convergent evidence gathered from a variety of neuropsychological measures suggests that the primary cognitive deficit in MS is an impaired ability to process information as quickly as healthy individuals (e.g., Archibald & Fisk, 2000; DeLuca, Chelune, Tulsky, Lengenfelder, & Chiaravalloti, 2004; Demaree, DeLuca, Gaudino, & Diamond, 1999; Denney, Lynch, Parmenter, & Horne, 2004; Kail, 1997, 1998; Rao, St. Aubin-Faubert, & Leo, 1989). Deficits in information processing speed (IPS) represent a significant impairment because they may negatively impact various other cognitive abilities. This premise has been formalized by DeLuca et al. (2004) in their Relative Consequence Model which proposes that the fundamental difficulty in processing speed experienced by MS patients consequently affects other cognitive functions, such as working memory. That is, inefficiencies in a variety of cognitive processes are a by-product of slowed IPS. This view is consistent with that of Salthouse (1996), who concluded that an age-related deficit in IPS is one of the major causes of cognitive decline in the elderly.

Unfortunately, the clinical assessment of deficits in IPS is burdened by the fact that relatively few neuropsychological tests effectively measure this capacity. Of these, the Paced Auditory Serial Addition Test (PASAT; Gronwall, 1977) is generally acknowledged to be the most sensitive (DeLuca, Johnson, & Natelson, 1993; Rao, 1986; Tombaugh, 2006). The PASAT involves the aural presentation of a series of single digit numbers and the test-taker must add the two most recent numbers and provide a verbal response during the inter-stimulus interval (ISI). Traditionally, four

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trials consisting of 61 digits are administered with each successive trial utilizing a shorter amount of time between the presentations of the digits (i.e. shorter ISIs). The rationale being that as progressively faster rates of stimulus presentations are introduced the individual's information processing system will be "pushed" until the individual is no longer able to efficiently respond. The inter-stimulus intervals commonly used are 2.4, 2.0, 1.6, and 1.2 s. Typically, the number of correct responses decline as the ISI becomes shorter. A specific version of the PASAT employing a 3.0 s ISI has been selected by the National Multiple Sclerosis Society Clinical Outcomes Assessment Task Force (Rudick et al., 1997) to measure neuropsychological function in the Multiple Sclerosis Functional Composite (MSFC). The MSFC is an outcome measure commonly used in MS clinical trials, and the PASAT is the only cognitive task included.

The effectiveness of the PASAT as a clinical measure may be restricted by several factors. Perhaps the most significant of these being that the PASAT is often reported to be a very frustrating and aversive task for most individuals, regardless of cognitive status (Lezak, 2004; McCaffrey et al., 1995; Tombaugh, 2006). A second potential disadvantage of the PASAT is that the test is prone to robust practice effects across a wide variety of neurological populations (Tombaugh, 2006). Additionally, performance on the PASAT is affected by various demographic variables such as age, education, and mathematical ability (Chronicle & MacGregor, 1998; Crawford, Obonsawin, & Allan, 1998; Sherman, Strauss, & Spellacy, 1997; Tombaugh, 2006). Also, some authors have noted the tendency of participants to implement a "chunking" strategy where any attempt to add consecutive digits is abandoned and instead an "alternate answer" approach of adding two numbers, skipping one, adding two numbers, skipping one, etc., is adopted (Fisk & Archibald, 2001; Snyder, Cappelleri, Archibald, & Fisk, 2001). This strategy can result in an inflated score.

In view of the above, it is important that alternative methods for evaluating processing speed are investigated. The current study aimed to evaluate the ability of a newly developed reaction time (RT) measure to assess information processing deficits in MS patients. The Computerized Tests of Information Processing (CTIP; Tombaugh & Rees, 1999) is composed of three RT tasks that measure the speed at which an individual responds to various types of stimuli. Time to respond is assumed to reflect the speed of various cognitive processes involved in completing each task. This approach is similar to those commonly used in cognitive psychology involving a variety of different reaction time procedures to measure cognitive processes.

The potential value of including RT tests in clinical assessments comes from a variety of sources suggesting that simple and choice reaction time procedures provide a quick, yet easy and valid, method that often reveals cognitive impairment even when normal performance is obtained on traditional neuropsychological tests (Bleiberg, Halpern, Reeves, & Daniel, 1998; Braun, Daigneault, & Champagne, 1989; Ferraro, 1996; Kujala, Portin, Revonsuo, & Ruutiainen, 1994). Further support for the clinical use of RT tests is provided by reports of relatively high test–retest reliability coefficients and split half coefficients (Godefroy, Lhullier, & Rousseaux, 1994; Hetherington, Stuss, & Finlayson, 1996; Stuss, Pogue, Buckle, & Bondar, 1994; Stuss et al., 1989). The clinical utility of RT measures rests not only with initial assessment for level of impairment but also with tracking recovery. RTs have revealed that recovery of function occurs in cross sectional and longitudinal research, over short (3–6 months) and extended time periods (5 years versus 10 years), in individuals with both mild and severe traumatic brain injury (TBI) (Felmingham, Baguley, & Green, 2004; Hetherington et al., 1996; Hugenholtz, Stuss, Stethem, & Richard, 1988; MacFlynn, Montgomery, Fenton, & Rutherford, 1984; Spikman, Timmerman, van Zomeren, & Deelman, 1999; van Zomeren & Deelman, 1978; Zwaagstra, Schmidt, & Vanier, 1996). Finally, the lack of practice effects observed for most RT tests make them ideal for serial examinations.

The three RT tests composing the CTIP progressively increase the amount of information to be processed. The most basic test, Simple RT, is often viewed as a pure IPS measure and can serve as a baseline for the other two tests, which represent choice procedures. The second task, Choice RT, involves concrete or literal processing where two choice stimuli remain the same over all trials. The third procedure, Semantic RT, involves conceptual processing where the items are varied between trials and a semantic or lexical search is required to respond. Unlike the PASAT, practice effects have not been observed with the CTIP, it is not anxiety provoking nor is performance affected by mathematical ability (Baird, 2004; Royan, Tombaugh, Rees, & Francis, 2004; Tombaugh, Rees, Stormer, Harrison, & Smith, in press). Past research has shown that the CTIP is sensitive to the effects of TBI (Rees & Tombaugh, 2001; Tombaugh, Rees, & Royan, 2001; Tombaugh et al., in press). Taken together, the factors listed above suggest that the CTIP may offer a viable alternative with which to study cognitive functioning in patients with MS.

The goal of the present study was to determine the sensitivity of the CTIP to cognitive deficits associated with MS. Two hypotheses were proposed. First, it was expected that MS patients would respond significantly slower than controls on the CTIP tests. Secondly, it was hypothesized that a complexity effect would emerge. That is, the more