LETTERS TO THE EDITOR

Computerized assessment of arithmetic computation skills with MicroCog

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In recent years, efforts have been made to computerize standard neuropsychological (NP) tests (Kane & Kay, 1992). This effort is in the service of increased productivity, lower costs, and an increase in the consistency of test administration. However, care must be taken to make sure the limitations of the computer interface do not compromise test validity.

Over the past year we have had extensive experience with the MicroCog Assessment of Cognitive Functioning, a computerized neuropsychological test battery published by the Psychological Corporation (Powell et al., 1993). MicroCog takes 1 hr to complete and incorporates 18 subtests. We have administered the MicroCog battery to over 164 subjects, including controls, substance abusers in early abstinence, and HIV seropositive individuals with and without severe cognitive deficits.

For the most part we are pleased with the computerized neuropsychological assessment as implemented in MicroCog. However, we believe the Computation test in MicroCog is invalid as a measure of arithmetic problem solving. In this subtest, subjects are presented with eight arithmetic calculation problems (addition, subtraction, multiplication, division). The answer must be formulated mentally, and entered on the keyboard, with keyboard entry made from left to right, and with no capability for entering intermediate results. There are two problems with this implementation. First, arithmetic calculations are executed from right to left. Second, intermediate calculations are often performed when calculations are carried out with paper and pencil (carrying in addition, digit by digit multiplication in multi-digit problems etc.). Thus, the Calculation subtest requires much of the work to be carried out by the subject in their head, with major demands on working memory.

The authors of MicroCog acknowledge that reverse keyboard entry places an added burden on working memory for subjects trying to complete the computation task. The authors state that for subjects who have the correct answer, this added burden of reversing their solutions for keyboard entry might result in longer response times. Our experience suggests that there is too heavy a demand on working memory in the Computation Test, resulting in its being an invalid assessment of calculation ability *per se*.

In an initial review of our data on the MicroCog battery, 19% of our subjects (32 out of 164) scored in the grossly impaired range ($<2\%$) on the Computation subtest. The high percentage of subjects scoring in the impaired range, and comments by subjects on the awkwardness of the method of entry for solutions, made us question the validity of this indication of impaired calculation ability. Subsequently, we administered a standardized paper and pencil test, the WRAT 3 Arithmetic test (Wilkinson, 1993), to 3 subjects (S1, S2, S3) who scored below the first percentile on MicroCog Computation. These subjects were all right-handed males with 16 years of education, ages 38, 39, and 51 years. All three subjects participated in the HIV study, and were screened for possible drug, alcohol, psychiatric, and medical histories that might have otherwise excluded them from the study. Two of the subjects were HIV-positive and asymptomatic; the third subject was HIV-negative. These three subjects received age-adjusted percentile scores on the WRAT 3 Arithmetic test of 93%, 79%, and 19%, none of which indicated clinical impairment. These results are contrary to their impaired scores on the MicroCog Computation test.

Each MicroCog subtest yields age- and education-adjusted scaled scores for accuracy (TS) and for response time (RT). As stated above, the authors of MicroCog suggest that entering solutions in reverse order may result in a longer response time due to the added burden on working memory. If this is the case, the subjects who received grossly impaired computation scores should exhibit longer response times on the computation subtest. In contrast with expectations, the three subjects exhibited average RT scaled scores, but below average TS scaled scores [S1: RT = 11 (63%), TS = 1 ($<1\%$); S2: RT = 9 (37%), TS = 2 ($<1\%$); S3: RT = 11 (63%), TS = 1 ($<1\%$)]. Thus, the added burden of working memory primarily resulted in reduced accuracy rather than longer response times in these subjects.

We conclude that although the MicroCog Assessment of Cognitive Functioning is a useful tool for objective and efficient assessment of cognitive function, the Computation subtest is invalid as a test of arithmetic computational skills. It is a challenge to create a valid computerized arithmetic computational test, because the traditional computer environment does not allow for the necessary steps, such as intermediate functions and right-to-left entry of solutions, required to accurately complete calculations.

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Comment on *Computerized assessment of arithmetic computation skills with MicroCog*

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My colleagues and I are delighted that Devivo et al. have found MicroCog to be clinically useful. We also are interested in hearing reports of the utility of particular elements of the battery. The authors raise an interesting question about the validity of the Math Calculations subtest as a measure of arithmetic problem-solving ability. They noted that some subjects complained about the difficulty in the left or right method of entry for the solutions, and 32 of 164 scored in the bottom 2%. They gave 3 of the subjects who scored below the first percentile on the MicroCog Math Calculations test the WRAT 3 Arithmetic. All achieved scores on the latter test well above their results on the MicroCog Math. From this study they concluded that Math Calculations is not a valid measure of arithmetic knowledge.

Overall, I find myself in agreement with the authors. During the construction of this subtest, we had the WAIS–R Arithmetic in mind, not a math achievement test. In fact, the correlation between MicroCog raw scores for Math Calculations and WAIS–R Arithmetic has been reported at .63 (Green et al., 1994). We viewed this subtest in the MicroCog battery not as an achievement test, but as a measure of what Salthouse has called working memory (1992, p. 40). Support for this idea comes from findings that Math Calculations have often factored with Numbers Forward and Backward and Immediate and Delayed Story Recall, as well as Tic Tac (Powell, 1994, pp. 55–58). These subtests require both concurrent storage and processing.

I am quite in agreement with Devivo et al. that a valid computerized arithmetic test that shows how the answer is obtained, and permits right-to-left entry of the solutions, would be a valuable contribution.

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