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The Influence of Oral Motor Impairments on Cognitive Functioning

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Performance on neuropsychological tests requires both input and output. Examinees must take in information either auditorily or visually (input) and then produce some written, manual or oral response (output). Neuropsychologists are mostly interested in interpreting the meaning of the output in terms of higher-level cognitive functioning. However, in many neurological patients, the interpretation of such output is complicated by input and output problems, issues that have received some discussion in the neuropsychological literature for many years (Weintraub & Mesulam, 1985).

Regarding input, certain patients may have difficulty seeing or hearing the test stimuli, and thus the output they produce is not a clear reflection of the higher-order function that the test is designed to measure. For example, a patient who has primary problems with audition who cannot adequately hear a verbally presented story may perform poorly when asked to recall it; such poor performance may have nothing to do with the patient's verbal memory ability and may simply reflect the fact that the patient did not adequately hear the story. Regarding output, some patients have difficulty with fine-motor speed and coordination such that the output they produce on a neuropsychological task does not purely reflect the higher-order cognitive function that the task is designed to measure. To illustrate, a patient who has impaired fine-motor writing speed who is asked to perform an executive test such as a trail-making test may perform poorly; the impaired performance will very likely not exclusively reflect a deficit of higher-order cognitive functioning that the test is designed to measure but may also reflect the patient's fine-motor writing speed deficit.

Neuropsychologists are trained to be aware of the many confounding input and output factors in their interpretation of cognitive test results as a reflection of higher level cognitive functioning. An example of a common approach to

addressing an input problem (hearing) is simply to ensure that patients with such difficulties wear their hearing aids to the testing. It is also useful to include some very basic auditory processing procedures in the test battery to ensure that patients can actually hear adequately during the testing. In cases where rudimentary auditory processing problems are suspected, Lezak, Howieson, and Loring (2004) recommend asking examinees to tell whether two spoken words are the same or different, such as "cat" and "cap" or "vie" and "thy," and then use identical word pairs. As an example of a method for addressing an output problem associated with impaired rudimentary fine-motor speed, neuropsychologists often include measures in their test batteries (e.g., Symbol Copy Test from the Wechsler Adult Intelligence Scale–III [WAIS-III], Grooved Pegboard Test) to assess it directly so that they can gauge the impact of such deficits on higher-order tasks that require fine-motor speed. Alternatively, when a patient or patient group is known to have problems with rudimentary fine-motor speed, a test battery can be constructed to limit the number of tasks that depend on this skill. The most commonly used test battery in multiple sclerosis (MS), for example, the Minimal Assessment of Cognitive Functioning in Multiple Sclerosis (MACFIMS) (Benedict et al., 2002), includes tasks that mostly require only a spoken response as the output (e.g., Verbal Fluency, Judgment of Line Orientation, Paced Auditory Serial Addition Task [PASAT]).

Although many of these approaches involve creative ways of circumventing the potentially confounding influence of input and output problems on neuropsychological test performance, there is one deficit in output that has received relatively little attention: rudimentary oral motor speed. As with the MACFIMS battery, when patients have difficulty with manual motor skill, neuropsychologists have typically circumvented the problem by relying more on tasks that only require a spoken response. However, such an approach is not without its own problems, because many patients seen by neuropsychologists have problems with slow, dysarthric speech. When a task requires examinees to produce a rapid spoken response, they may perform poorly not because of a deficit in higher level cognitive functioning but because of more fundamental problems in making a rapid oral motor response.

With these considerations in mind, the focus of this chapter is on research examining the contribution of rudimentary oral motor speed to neuropsychological test performance. Research in this area is decidedly limited; however, it addresses a topic that is critical for clinical neuropsychologists to understand. We will first discuss the construct of dysarthria generally, then consider it more specifically in neurological populations. Following that we will discuss research that has examined the impact of slowed speech on neuropsychological tests requiring a rapid spoken response in neurological patients. Using the limited research available, we will present some evidence-based guidelines for assessing dysarthria formally in neuropsychological evaluations and then discuss how results of such an assessment can be interpreted. Some consideration of how to circumvent this difficulty will also be discussed and evidence-based guidelines for practice provided. Finally, we will suggest some future research directions and provide a case study to illustrate some of the principles discussed in the chapter.

DYSARTHRIA

Dysarthria encompasses a range of motor speech disorders that involve defective articulation from weakness, slowness, or incoordination of the speech musculature (Beeson & Rapcsak, 2006; Lezak et al., 2004). Dysarthria can occur with aphasia, but it is thought to reflect a defect in speech rather than language. There is a high range of variability in the severity of dysarthric speech, from slightly distorted articulation to nearly unintelligible speech.

Dysarthria in Neurological Populations

Dysarthria is extremely common in patients with neurological disorders, including Huntington's disease (Hartelius, Carlstedt, Ytterberg, Lillvik, & Laakso, 2003), stroke (Kent & Kent, 2000), Parkinson's disease (Sapir et al., 2001), traumatic brain injury (TBI) (Guo & Togher, 2008; Murdoch, Kuruvilla, & Goozee, 2012), HIV (McCabe, Sheard, & Code, 2002), and MS (Darley, Brown, & Goldstein, 1972; Hartelius, Runmarker, & Andersen, 2000; Mackenzie & Green, 2009; Tröster & Arnett, 2006), among others. Duffy (2005) reported on a study from the Department of Neurology at the Mayo Clinic from 1987–1990 and 1993–2001 where 54% of 10,444 individuals with acquired neurological disorders had dysarthria.

Psychomotor slowing, including slowing of speech, also occurs with normal aging and may impact performance on higher-level cognitive tasks (e.g., verbal fluency) that require rapid articulatory speed (Rodriguez-Aranda, 2003). Given the pervasiveness of dysarthria in neurological patients as well as in normal aging, it is surprising that relatively little research has been devoted to the possible influence of slowed, dysarthric speech on performance on neuropsychological tasks requiring a rapid oral motor response.

Dysarthria in MS

The French neurologist Charcot may have been the first to formally describe dysarthria in MS. He considered dysarthria (or "scanning speech") to be one of the three characteristic neurological symptoms of MS, the others being intention tremor and nystagmus (Charcot, 1877; Darley et al., 1972). He reported observing dysarthria in 22 of 23 cases he examined. As he described it, "the words are as if measured or scanned; there is a pause after every syllable, and the syllables themselves are pronounced slowly" (p. 192). More recent descriptions of dysarthria in MS characterize it as difficulty with articulation and slowed speech rate (Darley et al., 1972; Hartelius, Runmarker, & Andersen, 2000; Hartelius, Runmarker, Andersen, & Nord, 2000). Work with more representative MS patient samples than those available to Charcot indicates that dysarthria is not quite as pervasive as his case reports suggested; still, it has been found to be quite common. Consistent with findings for neurological patients more generally (Duffy, 2005), Hartelius, Runmarker, and Andersen (2000) reported dysarthria prevalence rates in MS ranging from 40% to 55%.

Dysarthria in MS has been shown to be associated with neurological disability (Darley et al., 1972; Hartelius, Runmarker, & Andersen, 2000) and MS course type (Hartelius, Runmarker, & Andersen, 2000), with primary and secondary progressive patients displaying greater levels of dysarthria than relapsing–remitting patients. In MS, dysarthria does not appear to be associated with age or duration of illness.

Dysarthria and Neuropsychological Test Performance in MS

MS is one disorder in which at least some research has been conducted investigating dysarthria and performance on higher-level cognitive tasks. Smith and Arnett (2007) examined these associations in a sample of MS patients with mixed course types. Given that dysarthria is extremely common in MS and that many neuropsychological tests recommended for use with these patients require rapid speech (e.g., PASAT, oral version of the Symbol Digit Modalities Test [SDMT], Controlled Oral Word Association Test [COWAT]), the goal of this study was to evaluate whether dysarthria was associated with performance on such tests. The authors reasoned that MS patients might have particular difficulty with such tasks, in part because of slow speech. In this study, dysarthria was measured via an examiner rating scale. With these considerations in mind, it was predicted that (a) observer ratings of dysarthria would be higher for MS patients than for controls; (b) MS patients would perform worse than controls on neuropsychological tests requiring a rapid spoken response; and (c) dysarthria ratings would be correlated with performance on neuropsychological tests requiring a rapid spoken response.

The study compared 97 MS patients and 27 demographically matched controls. Overall, patients were characterized as having a moderate level of disability, with their score on the Extended Disability Status Scale (EDSS) being 4.57 (1.56). A psychosocial interview was conducted before administration of the cognitive tests, and the following 4-point rating scale was used to make dysarthria ratings for both MS patients and controls: 1 = normal, nothing unusual about the participant's speech; 2 = mildly dysarthric, participant's speech generally normal, but some words slurred or difficult to understand, or speech notably slow; 3 = mildly or moderately dysarthric, with more than a few words difficult to understand or slurred, with occasional requests for repetition, or speech very slow; and 4 = moderately dysarthric, frequent requests for repetition necessary because of difficulty understanding participant's speech, or speech extremely slow. Very few participants were rated at 3 or higher, so ratings were dichotomized into "normal speech" (score of 1) and "dysarthria" (scores of 2–4).

With this scale, even most of these moderately disabled MS patients (n = 65, 67%) were rated as having normal speech, with the other 32 (33%) patients showing some level of dysarthria but none showing severe dysarthria (rating of 4). All but one control participant was rated as having normal speech; this one individual was rated as mildly dysarthric (rating of 1). Consistent with the first prediction, it is not surprising that chi-squared analysis showed that significantly more MS

participants than control participants were dysarthric: $\chi 2$ (1, $N = 124$) = 9.28, $p < .005$.

In addition to measuring overall intellectual functioning, measures requiring a rapid speech response were employed, including the COWAT, Oral Symbol Digit Test, and the Visual Elevator subtest from the Test of Everyday Attention. Consistent with the second prediction and most prior work in MS, patients performed significantly worse than controls on all of these tasks. Additionally, regression analyses that controlled for variables on which MS patients and controls differed were conducted to examine the association between dysarthria ratings and rapid speech tasks, and significant associations ($p < .05$) were found for all tasks. Finally, performance on the tasks was compared between MS patients with normal speech ($n = 65$) and those with some dysarthria ($n = 32$). In each case the dysarthria group performed worse, with effect sizes ranging from small (COWAT = .44), to medium (Visual Elevator = .72), to large (Oral Symbol Digit = .84).

The Smith and Arnett (2007) study demonstrated that, at least on the basis of examiner dysarthria ratings, MS patients displayed greater dysarthria than controls, and dysarthria was significantly correlated with performance on all neuropsychological tasks requiring rapid speech. Also, even within the MS sample, dysarthric patients performed significantly worse on these tasks than patients with normal speech, with effect sizes ranging from small to large. With this said, the study nonetheless had some significant limitations, including the use of subjective dysarthria ratings, the possibility that the examiners' perception of patients' overall disability may have affected dysarthria ratings, and the fact that no tasks without rapid speech demands were used. This last factor is important because the association between dysarthria and task performance found in the study may have been due to dysarthria simply being a marker for disability and overall cognitive decline such that it would be associated with any cognitively demanding task, regardless of oral motor demands.

In a follow-up study (Arnett, Smith, Barwick, Benedict, & Ahlstrom, 2008), some of the limitations of Smith and Arnett's (2007) study were addressed by using an objective performance-based measure of dysarthria, adding tasks that did not have rapid speech demands, and including a larger control group. The predictions for the study were analogous to those in Smith and Arnett's study, with the additional prediction that the measure of dysarthria would be unrelated to neuropsychological tasks without rapid speech demands.

Fifty definite MS patients were included in the study, most of whom had either a relapsing–remitting ($n = 29$) or secondary progressive ($n = 14$) course. The measure of dysarthria used was a task known as the Maximum Repetition Rate of Syllables and Multisyllabic Combinations (MRR; Kent, Kent, & Rosenbek, 1987). This task is commonly used in the speech and language literature and in clinical settings to measure rapid speech. The MRR had also been previously recommended for inclusion in a consensus neuropsychological battery known as the MACFIMS that was designed for use with MS patients (Benedict et al., 2002), but prior to Arnett et al.'s (2008) study the MRR had never been examined empirically in MS. In reviewing tests of speech production, Kent and colleagues (1987)

noted that "the monosyllabic triad [pa], [ta], [ka] has become a clinical standard" (p. 379) for which the greatest amount of normative data is available. The MRR involves having examinees repeat syllables as quickly as they can in one good breath lasting at least 6 seconds. Examinees repeat the syllables "pa," "ta," and "ka" in separate trials, then have a final trial in which they repeat "pa-ta-ka" in sequence. Syllables per second is the central measurement of this task.

In Arnett et al.'s (2008) study, the neuropsychological tasks requiring rapid speech included the COWAT (Benton & Hamsher, 1989), Animal Naming (Strauss, Sherman, & Spreen, 2006), the oral version of the Symbol Digit (Smith, 1982), and the PASAT (Rao et al., 1990). Tasks that did not require rapid speech were the California Verbal Learning Test, 2nd edition (CVLT-II; Delis, Kramer, Kaplan, & Ober, 2000) and the Brief Visual Memory Test–Revised (BVMT-R; Benedict, 1997). Depression and fatigue were also measured, respectively, by the Beck Depression Inventory, 2nd edition (BDI-II; Beck, Steer, & Brown, 1996) and the Fatigue Severity Scale (Krupp, LaRocca, Muir-Nash, & Steinberg, 1989), to measure the potential impact of these secondary factors on the test results.

Consistent with predictions, the MS group performed significantly more slowly across the MRR tasks (mean = 4.57 syllables/sec) compared with controls (5.06 syllables/sec). Thus, the MS participants produced, on average, about half a syllable less per second then controls. Although this may not seem clinically relevant, it is worth considering these findings in a broader temporal context. Such a difference would add up to 30 fewer syllables produced per minute in MS patients, 1800 fewer syllables per hour, and 43,200 fewer syllables per day. Thus a difference of half a syllable per second could have profound implications on the amount of speech a typical patient is able to produce in a given day. Also consistent with predictions and with prior MS research, the MS group performed worse on all neuropsychological tasks, including the tasks not requiring a rapid speech response, compared with controls. With the exception of the COWAT ($p < .07$), all group comparisons met traditional levels of statistical significance ($p < .05$).

Regarding the relationship between the MRR task and the neuropsychological tests requiring a rapid speech response, regression analyses (controlling for relevant demographic variables) revealed a significant relationship (semipartial correlations) with all tasks, including the Symbol Digit ($sr = .32$), combined PASAT ($sr = .25$), COWAT ($sr = .35$), and Animal Naming ($sr = .26$). Thus the effect sizes, using Cohen's (1992) guidelines, were small (PASAT, Animal Naming) to medium (Symbol Digit, COWAT). The correlation between the MRR and the tasks without rapid speech demands were lower in the case of the CVLT-II ($sr = .00$) but comparable for the BVMT-R ($sr = .22$). To determine whether group effects on the neuropsychological tasks would be reduced when controlling for differences in oral motor speed, regressions were conducted in which the MRR was entered in before the group effect. In the case of the neuropsychological tasks requiring rapid speech, group effects were reduced as follows: Symbol Digit ($sr = .32$ to .24), PASAT ($sr = .20$ to .14), COWAT ($sr = .22$ to .14), and Animal Naming ($sr = .33$ to .26). With the PASAT and COWAT, initially significant group effects were reduced to being statistically not significant. For the neuropsychological tasks not

requiring rapid speech, group effects were reduced as follows: CVLT-II (sr = .25 to .20) and BVMT-R (sr = .28 to .24). Group effects remained significant regardless of the control of MRR performance for these latter tasks.

A final set of analyses was conducted to evaluate factors that might underlie group differences in rapid speech. As noted, the multivariate group effect for the MRR in the initial analyses was highly significant, $F(1, 98) = 7.95$, $p < .01$. When ANCOVAs were conducted, this effect was reduced to being nonsignificant (ns) when the fatigue measure, $F(1, 97) = 1.33$, ns, and the depression measure, $F(1, 97) = 1.92$, ns, were used as covariates.

The results of this study showed that (a) MS patients display objectively slower speech than controls; (b) slow speech is correlated with neuropsychological tasks requiring a rapid spoken response; (c) some of the MS patients' deficits on neuropsychological tasks requiring a rapid spoken response are due to their slower speech; and (d) the greater depression and fatigue in MS compared with controls fully accounts for their slower speech. The findings raised a number of intriguing interpretive possibilities. First, it may be that the greater depression and fatigue characterizing MS patients leads to slow speech, which in turn contributes to their poor performance on neuropsychological tasks requiring rapid speech. This suggests the possibility that treatment of depression in MS patients could lead to improved speech rate and ultimately contribute to better performance on such tasks. A second explanation for these findings is that slowed speech may be a marker for the extent of neuropathology present. Neuropsychological test performance in MS patients has been shown to be highly correlated with measures of neuropathology, including lesion load and atrophy (Feinstein et al., 2010). As such, slow speech and performance on neuropsychological tasks requiring rapid speech, as well as depression and fatigue, could be correlated given the underlying effects of neuropathology.

A final implication from this study is that eliminating manual or written motor responses from a neuropsychological test battery will not entirely remove the impact of primary motor deficits on test performance. Since MS patients and many other neurological patient groups commonly have dysarthria, clinicians who do not control for such basic speech impairments may erroneously conclude that patients have more severe cognitive deficits than they actually do and consequently make recommendations that are misleading and inaccurate. Ideally, neuropsychologists would develop tasks that allow for a more systematic control of oral motor slowing, making it possible for a clearer picture of the nature of the cognitive difficulties characterizing MS patients to emerge. Until that time, however, systematically measuring oral motor speed in clinical evaluations will be critical.

In another study, Mackenzie and Green (2009) examined the association between dysarthria and performance on higher-level cognitive tasks in MS patients. The study included 24 patients with "chronic progressive MS" and 24 matched controls. Participants were administered a "cognitive-linguistic" battery of tests in the form of the Arizona Battery for Communication Disorders of Dementia (ABCD). The adaptation of this battery used by these investigators included 15 subtests

measuring the domains of mental status, episodic memory, linguistic expression, and linguistic comprehension. Dysarthria was measured with the Assessment of Intelligibility of Dysarthric Speech (AIDS) test. This test involves 22 sentences, varying in length from 5 to 15 words. Sentences are presented in written form and read aloud by the examiner, and then examinees read the sentence. Participants receive a point for every correctly articulated word, with scores ranging from 0 to 220. Within the MS group, the overall ABCD score was highly correlated with the AIDS score (r = .64). Because most of the subtests on the ABCD do not require rapid speech, and dysarthric patients performed poorly even on tasks requiring very little productive speech, these authors suggested that the association between the ABCD and AIDS score was most likely not mediated by motor speech deficits. On the one task that did require rapid speech, a generative naming task, the authors noted anecdotally that most of the participants finished generating words well before the 1-minute completion time. Still, they did not report on the quantitative association between performance on the generative naming task and overall AIDS score, so it is unclear whether objectively measured dysarthria was associated with this rapid speech task in their study. The authors acknowledged that in cases where dysarthria affects the rate of speech, the number of words generated on such a test would likely be reduced.

Slowed Speech and Neuropsychological Test Performance in Aging

In a study on aging, Rodriguez-Aranda (2003) examined the contribution of psychomotor factors to verbal fluency performance. This investigator suggested that, instead of higher-order cognitive processes, such as memory/executive skill, bringing about diminished verbal fluency, the well-documented psychomotor slowing with age may in fact be responsible for poor verbal fluency performance in the elderly. She noted the absence of any neuropsychological studies examining basic psychomotor mechanisms involved in verbal tasks requiring word production, such as verbal fluency tasks. Thus Rodriguez-Aranda designed a study to explore the extent to which rudimentary tasks of writing and reading were associated with written and oral verbal fluency task performance, respectively.

This study included 101 adults ranging in age from 20 to 88 years, divided into five age groups (20–39, 40–59, 60–69, 70–79, and 80 years and older). To measure simple oral motor speed, the Word-Reading Stroop test, involving the reading of 100 words in black ink, was used. Simple writing speed was measured by presenting examinees with an 18-word list and asking them to copy it as quickly as possible. Oral verbal fluency was measured with the COWAT and a category fluency test (animals, fruits, and professions). Written verbal fluency was measured using the Thurstone Word Fluency Test. This test involved having participants write as many words as possible that begin with the letters *S* and *K*, with a 4-minute time limit for each. The written semantic task required participants to write as many words as quickly as they could in 1 minute from a particular category (vegetables, sports, and farm animals).

Results showed that older age groups performed significantly worse on the oral semantic fluency task and both of the written fluency tests (phonemic and

semantic). Significant age-related differences were also observed on the tasks of reading and writing speed, with declines most evident after age 60. When the author examined the oral semantic verbal fluency results, controlling for their measure of simple oral motor speed (word reading trial from the Stroop), the age effect remained significant, although the magnitude of the overall age group effect was reduced by approximately half ($F = 8.93$, $p < .0001$ without the covariate, and $F = 4.83$ with reading speed as the covariate). For both written fluency tasks, highly significant age group effects were reduced to being statistically nonsignificant when the author controlled for writing speed. Finally, and of greatest relevance to this chapter, the author found highly significant correlations between the measure of basic oral motor speed (word reading trial from the Stroop) and performance on both the COWAT ($r = .40$) and the category fluency ($r = .44$) test. Handwriting speed was even more highly associated with both the written phonemic fluency ($r = -.60$) and written semantic fluency ($r = -.64$) test.

Rodriguez-Aranda's (2003) study is provocative. It suggests the possibility that a significant proportion of the age-related decline in verbal fluency tasks may be due to age-related reductions in the more rudimentary skill of psychomotor speed. The study findings further underscore the importance of measuring rudimentary psychomotor speed in neuropsychological evaluations of patients presenting with age-related cognitive problems. One limitation to the study is that, although the psychomotor tasks chosen are designed to be relatively automatic, they may be more cognitively demanding than they first appear. For instance, while the Stroop Reading task measures articulatory speed, it also has significant visual scanning and sustained attention demands. Also, verbal-fluency tasks have significant sustained attention demands over a time period similar to that required to read a Stroop page (45 seconds) in the Golden version of the Stroop used in the study. With these limitations in mind, athough Rodriguez-Aranda's data are intriguing, they cannot be unambiguously interpreted as reflecting a clear contribution of rudimentary oral motor speed to verbal-fluency performance.

FUTURE RESEARCH DIRECTIONS

As noted earlier, dysarthria and slowed speech have been demonstrated in many neurological patient groups and they increase with age. However, there is little empirical research examining the relationship between basic rapid speech tasks and neuropsychological tests that require a rapid spoken response. Consensus guidelines in MS suggest the use of a rudimentary oral motor speech task (the MRR, as described above) in evaluations where patients present with evidence of dysarthria or slowed speech. However, there do not appear to be clear recommendations for addressing this issue in other neurological disorders.

Given the pervasiveness of dysarthria and slowed speech across neurological patient groups and aging, research is needed that uses rudimentary speech tasks in a variety of patient groups and examines the extent to which they are associated with commonly used neuropsychological tasks that require rapid speech (e.g., PASAT, Verbal Fluency Tasks, Oral Symbol Digit Test). Clinical

neuropsychologists are well-versed in recognizing the importance of manual motor difficulties and the likely contribution they have on performance of neuropsychological tasks requiring manual manipulation or writing. However, less attention is paid to the possibility that slow and dysarthric speech can confound the interpretation of neuropsychological tasks that require rapid speech. Although research at this stage of our understanding is too limited to make unequivocal recommendations for future study, employing rudimentary oral motor tasks such as the MRR is preferable to relying on tasks (such as the Stroop Reading trial) that have cognitive demands other than the simple rate of speech.

EVIDENCE-BASED RECOMMENDATIONS

Research on the relationship between neuropsychological tasks requiring rapid speech and rudimentary oral motor speech tasks is extremely limited. The bulk of relevant published studies appear to be in the MS literature, with one additional study on aging. It is premature to make firm recommendations for practice. However, a few tentative recommendations and guidelines can be offered.

As noted earlier, the MRR task described above has been widely used in the speech and language literature and in clinical settings to measure rapid speech and is considered the clinical standard for which the greatest amount of normative data is available (Kent et al., 1987). Given that it has also been found to be significantly associated with neuropsychological tasks requiring rapid speech in at least one study with a neurological patient group (Arnett et al., 2008), it could be useful in clinical evaluations of other disorders. A reasonable guideline would be for clinicians to include the task in evaluations in which patients are observed to have slow and dysarthric speech. If patients perform poorly on the MRR task relative to normative data, then the extent to which such difficulties may have contributed to their performance on those neuropsychological tasks requiring rapid speech can be considered.

Regarding the use of a normative reference group that could be relevant for some disorders, Arnett and colleagues (2008) presented data for the MRR task on 50 healthy Caucasian controls with a mean age of 51.9 (9.3) years and educational level of 14.7 (2.1) years. On the basis of these reference data, standard MRR scores could be calculated for patients with comparable demographic characteristics. For younger, as well as geriatric patients, Kent and colleagues (1987) included normative data on the MRR from several published studies that could be used to calculate standard scores.

The Appendix at the end of this chapter provides instructions and a record form for the MRR that we developed for our MS study described earlier in the chapter (Arnett et al., 2008). The task requiring examinees to repeat the "pa-ta-ka" sequence can usually be recorded manually without difficulty on the record form. However, in our experience, it can be difficult to accurately record the number of specific phonemes (e.g., "pa" spoken repeatedly). Thus we recommend that, for the specific phoneme trials, examiners also record the examinee's spoken response with a recorder that makes it possible to slow down the response so that an accurate

record can be made later. Alternatively, if this technology is not readily available or there are time constraints, recording only the "pa-ta-ka" trial would be reasonable, as performance on this trial is highly correlated with individual phoneme trials.

CASE STUDY

The following case study highlights themes presented in this chapter. In particular, this case study describes a patient who performed normally on a rudimentary oral motor speech task (the MRR, as described above) but scored in the impaired range on complex neuropsychological measures that require rapid speech. These latter tasks can be less ambiguously interpreted as reflecting deficits in higher-level cognitive functions and instead as reflecting problems with slowed speech.

Background and Presenting Concerns

Ms. P, a 56-year-old divorced, Caucasian, right-handed woman, was referred by Dr. J for an evaluation of increased cognitive difficulties that had developed over the past year or so. These manifested as memory problems, being forgetful, mixing up numbers, having difficulty focusing and concentrating, losing her train of thought, and forgetting names of people. She had always had a difficult time remembering names, but this problem had become more acute in the past year. A close friend of Ms. P's had also reportedly noticed an increase in her cognitive difficulties over the past year. Ms. P expressed concern about developing cognitive difficulties, in part because her mother was diagnosed with dementia at a relatively early age, 65. Ms. P attributed part of her cognitive difficulties over the past year to the increased scrutiny she experienced on her job. She was acutely aware of this increased scrutiny and that it had been distracting to her. She had been recently terminated from her job. Since then, she had noticed an improvement in her cognitive problems, now that she was not under such constant, intense scrutiny. Ms. P noted that, in addition to affecting her performance on the job, her cognitive difficulties had been affecting her social relationships, as well as her ability to maintain her household and do chores around the house.

Ms. P has a history of depression for which she is currently taking Zoloft, ongoing problems with chronic pain from a prior injury to her left leg, and intermittent migraine headaches. Her social and developmental history is unremarkable. She was a somewhat above-average student in high school and completed 4 years of college with a 2.5 GPA. Ms. P is a remitted alcoholic, having been sober for almost 20 years. She denied any other significant history of substance abuse and denied any regular current caffeine or tobacco intake.

Behavioral Observations

Ms. P was seen on one occasion for the interview and neuropsychological testing. She was appropriately and casually dressed and was oriented, alert, and cooperative throughout. Ms. P spoke fluently with normal prosody, rate, volume,

and clarity and was able to comprehend all testing procedures. She recounted her history in a detailed manner. Her affect was generally euthymic, though she did become appropriately tearful momentarily when recounting the work-related difficulties she had encountered over the past several months.

On testing Ms. P clearly appeared to be putting forth good effort. This was corroborated by an objective test of effort administered. She responded to task difficulty in good humor, often laughing when she did not know the answers to things or when she had difficulty. Overall, the test results were thought to be an accurate reflection of Ms. P's current level of cognitive functioning.

Results, Interpretation, and Recommendations

In relation to her likely high-average premorbid level of cognitive functioning based on her high-average performance on measures of crystallized verbal intellectual functioning (WAIS-III Verbal Comprehension Index), Ms. P displayed a few select cognitive difficulties. In particular, she scored in the impaired range on measures of auditory and visual processing speed and verbal fluency (COWAT, PASAT, Symbol Digit), as well as on the first two learning trials of a measure of visual memory (BVMT-R). She further displayed impaired performance on a measure of right-sided fine-motor coordination (Grooved Pegboard). Ms. P also scored significantly below expectations (low average), but not in the impaired range, on a measure of visual processing speed (Digit Symbol—Coding), on the first two trials of a verbal learning task (CVLT-II), on measures of visual processing speed and sustained attention (Comprehensive Trail-Making Tests 2 and 4), and with her nondominant hand on a measure of fine-motor coordination (Grooved Pegboard).

What might account for these cognitive difficulties that Ms. P displayed? At the time of the evaluation, Ms. P reported mild levels of depression, so this is one possible contributor to her difficulties. High levels of fatigue are likely to play a greater role, however, as Ms. P reported fatigue levels at the 99th percentile on the Fatigue Severity Scale. Fatigue can affect sustained attention and processing speed, and most of the tasks on which she displayed difficulties had significant processing speed and sustained attentional demands. Many of the tests on which Ms. P scored in the impaired range (COWAT, PASAT, Oral Symbol Digit) also had rapid speech demands. However, Ms. P did not display any evidence of slow or dysarthric speech in conversation, and she performed in the average range on a test of rudimentary oral motor speed (MRR task). As such, her difficulty on the task, which required a rapid oral motor response, cannot be attributed to a more basic problem with slow speech.

Ms. P's history of alcoholism must also be considered. Although she has been sober for nearly 20 years, she did engage in heavy drinking for a number of years. Given that chronic alcohol use is associated with some of the difficulties she displayed on testing, it is possible that Ms. P's history of alcoholism is a contributor to her difficulties. However, this explanation for her problems seems less likely than her current fatigue.

As noted earlier, a significant concern that Ms. P expressed at the time of the evaluation was that her development of cognitive difficulties might reflect the early manifestations of dementia. At present, however, Ms. P does not show cognitive problems suggestive of Alzheimer's dementia. The latter is more typically characterized by difficulty learning new information as well as rapid forgetting. Furthermore, naming problems are often very salient in the early stages of Alzheimer's. In contrast to this, Ms. P's naming skills were excellent; she also displayed good learning of information with repetition and showed excellent retention of information on all measures of memory and learning administered. Thus there is nothing about her current pattern of difficulties to suggest that they are a precursor to more serious cognitive impairments that would more typically characterize a dementia such as Alzheimer's.

Poor effort on testing also cannot be invoked to explain Ms. P's difficulties, as she appeared to be putting forth excellent effort throughout testing; an objective measure of effort administered corroborated this impression. The impairments seen on objective neuropsychological testing are consistent with Ms. P's report of a high-average level of cognitive difficulties in her daily life. Her friend's perception of a high level of cognitive difficulties in Ms. P's daily life is also consistent with the objective neuropsychological findings.

Although Ms. P displayed difficulty primarily on measures of processing speed and sustained attention, she showed significant strengths on several tasks. She scored in the high-average range or above on measures of immediate and delayed recall of meaningful verbal information (Logical Memory I & II), learning with repetition and consistency of recall when learning nonmeaningful verbal information (CVLT-II), and learning with repetition on a visual memory task. These strengths should help Ms. P circumvent some of the cognitive difficulties she displays.

Recommendations for Ms. P included (1) pharmacological and nonpharmacological treatment of fatigue, (2) psychotherapy for depression, (3) use of an electronic planner and organizer, (4) work on developing compensatory strategies using cognitive strengths (e.g., repetition), and (5) medical workup to explore possible treatment for her lack of appetite.

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Appendix

Maximum Repetition Rate Tests—Instructions and Record Form

Test Materials: Record Form, Recording Device, Stopwatch

Administration: **"FOR THIS NEXT TEST WHAT I'D LIKE YOU TO DO IS TO SAY THE SYLLABLE 'Pa' AS MANY TIMES AS YOU CAN AND AS QUICKLY AS YOU CAN IN ONE BREATH. WHEN I SAY 'GO', *TAKE A DEEP BREATH,* AND YOU CAN BEGIN SAYING THE SYLLABLE. SO YOU WOULD GO LIKE THIS."** (Demonstrate by taking a breath, then saying 9 syllables quickly and clearly ["Pa-Pa-Pa-Pa-Pa-Pa-Pa-Pa-Pa"]. When you're finished, say the following:) **"TRY TO DO THE VERY BEST YOU CAN FOR AT LEAST 6 SECONDS IN ONE BREATH. BE SURE TO TAKE A GOOD BREATH, AND SPEAK AS CLEARLY AS YOU CAN. ARE YOU READY? OK, REMEMBER, SAY 'Pa-Pa-Pa' AS FAST AS YOU CAN. *TAKE A DEEP BREATH,* READY?"** (Start recording.) **"GO!!"** (Start stopwatch and mark each "Pa" syllable on the record form as it is performed by the subject. When the subject stops, stop the stopwatch immediately and record the number of "pa's" and the time on the record form. Also, be sure to stop recording). **REPEAT FOR "TA" AND "KA."**

"FOR THIS NEXT TEST WHAT I'D LIKE YOU TO DO IS TO SAY THE SEQUENCE 'pa-ta-ka' AS MANY TIMES AS YOU CAN AND AS QUICKLY AS YOU CAN IN ONE BREATH. AGAIN, WHEN I SAY 'GO', *TAKE A DEEP BREATH,* AND YOU CAN BEGIN SAYING THE SEQUENCE. SO YOU WOULD GO LIKE THIS." (Demonstrate by taking a breath, then saying 9 syllables quickly and clearly ["Pa-ta-ka-Pa-ta-ka-Pa-ta-ka"]. When you're finished, say the following:) **"TRY TO DO THE VERY BEST YOU CAN FOR AT LEAST 6 SECONDS IN ONE BREATH. BE SURE TO TAKE A GOOD BREATH, AND SPEAK AS CLEARLY AS YOU CAN. ARE YOU READY? OK, REMEMBER, SAY 'Pa-ta-ka-Pa-ta-ka-Pa-ta-ka' AS FAST AS YOU CAN. *TAKE A DEEP BREATH,* READY?"** (Start recording.) **"GO!!"** (Start stopwatch and mark each "Pa-ta-ka" syllable on the record form as it is performed by the subject. When the subject stops, stop the stopwatch immediately and record the number of "pa-ta-ka's" and the time on the record form. Also, be sure to stop recording.)

MAXIMUM REPETITION RATE TEST SCORING

Syllable(s)	No. of Syllables	Time	Syllables per Second
PA			
TA			
KA			
	No. of Triads	**Time**	**Triads per Second**
PA-TA-KA			

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