Multiple Oral Rereading (MOR) Treatment: Who Is It for?

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ABSTRACT: **Purpose:** The aim of this case study was to examine whether Multiple Oral Rereading (MOR) treatment was effective in improving the reading accuracy, rate, and comprehension of text-level materials in an individual presenting with deep alexia, moderate nonfluent aphasia, and moderate apraxia of speech.
Method: As in the standard MOR treatment procedures used in earlier studies (e.g., Beeson, 1998), the participant repeatedly read aloud a short story during treatment sessions and as homework until he met the treatment criterion. Then a new story was introduced. In the present study, oral reading accuracy was used as the treatment criterion instead of oral reading rate, which was used in earlier studies. The data consisted of oral reading accuracy, oral reading rate, and reading comprehension of the treatment materials as well as pre- and posttreatment assessment of oral reading accuracy and reading comprehension on external measures.
Results: Our participant's oral reading accuracy improved in both the treatment context and on external measures. However, his oral reading rate during treatment and his reading comprehension of treatment stories and external measures did not reveal meaningful changes.
Conclusions: The effect of the MOR treatment was limited in improving the reading ability of a client with deep alexia, Broca's aphasia, and apraxia of speech. Based on our review of past studies, we discuss the candidacy requirements and considerations for procedural modifications in adopting MOR treatment in clinical practice.

KEY WORDS: alexia, reading treatment, Multiple Oral Rereading treatment, oral reading, deep alexia

What if you wake up one morning and find out that you cannot read anymore? Things that made up a part of your smoothly flowing, almost unconscious, routine will turn into a series of nightmarish and exhausting struggles. You might panic when you realize that you do not understand what the notice from your bank says. You might feel painfully deprived when you cannot curl up and enjoy a good book before going to bed. Life would be boring, at a minimum, if one could not read newspapers, magazines, books, and electronic mail. Life would certainly be challenging if one could not read legal or financial documents and written instructions.

Although reading difficulty, referred to as alexia, has been described as one of the frequent features of aphasic syndrome (Webb & Love, 1983), the treatment literature for acquired alexia is rather sparse. In addition, the vast majority of the existing treatment approaches for alexia target improved reading at the single-word level (e.g., Conway et al., 1998; de Partz, 1986; Hillis & Caramazza, 1991; Matthews, 1991; Nickels, 1992; Rothi & Moss, 1992). Consequently, although many individuals with acquired alexia might naturally hope to regain their ability to read a connected text and likely consider it the ultimate treatment goal, few treatment methods have been developed to directly address that level of skill. Literature review uncovers only two treatments that have been repeatedly used to specifically improve text-level reading ability: Multiple Oral Rereading (MOR; Beeson, 1998, Beeson & Insalaco, 1998; Moyer, 1979; Tuomainen & Laine, 1991) and Oral Reading for Language in Aphasia (ORLA; Cherney, 1995, 2004; Cherney, Merbitz, & Grip, 1986).

The two treatments are similar in that both use repeated and assisted oral readings of sentences/paragraphs to achieve fluency. In addition, both treatments hypothesize that the fluency achieved through repeated oral reading will lead to automatic and rapid decoding of words in the

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text. The two treatments differ in their specific treatment steps and, to some degree, the level of linguistic material they use in treatment: The MOR treatment involves reading connected texts (i.e., typically consisting of multiple paragraphs), and the ORLA treatment uses either sentence or paragraph-level reading materials.

MOR treatment was originally developed for a client with pure alexia, a letter-by-letter reader (Moyer, 1979). As such, the treatment involves repeated oral reading of a given text as a means of facilitating whole-word recognition rather than letter-by-letter reading. In its essence, the treatment involves repeated and assisted oral reading of a selected text during weekly in-clinic treatment sessions and daily home practices (homework reading typically lasting 30 min) until the participant's reading rate improves to the criterion level. The criterion level in previous studies was often 100 words per minute (wpm). When the participant reaches the predetermined criterion reading rate, a new text is introduced and is read out loud repeatedly in the same manner. The underlying hypothesis of MOR treatment is that repeated reading of the same text makes word form recognition easy due to the top-down influence provided by the semantic and syntactic context, thereby resulting in improved or restored access to the orthographic input lexicon (Beeson & Insalaco, 1998). One should note that the focus of this treatment is increasing reading rate and accuracy, not reading comprehension ability. However, results of the previous MOR-based reading treatment studies suggest that improved reading comprehension ability is the natural byproduct of improved reading fluency.

Several researchers have shown MOR to be effective in increasing the reading rate of letter-by-letter readers (Beeson, 1998; Beeson, Magloire, & Robey, 2005; Moyer, 1979; Tuomainen & Laine, 1991). This treatment was also found to be successful in improving the reading ability of 2 individuals with anomic aphasia and alexia of mixed type (Beeson & Insalaco, 1998), as well as an individual with anomic aphasia and phonological alexia (Cherney, 2004). Although MOR has often been employed without any specific prediction on generalization pattern (beyond improved text-level reading outside the treatment session), some study participants also showed improvement in overall language ability and in reading speed for function words (Beeson & Insalaco, 1998; Orjada & Beeson, 2005).

However, not all participants who underwent MOR treatment benefited from this treatment. For example, 1 of the 3 participants with pure alexia in Tuomainen and Laine (1991) and 1 participant with residual aphasia and alexia in Mayer and Murray (2002) reaped limited benefit from the treatment. One possible explanation for these inconsistent results could be a mismatch of the treatment and the participant, in other words, the candidacy issue. This is an important item to consider given that MOR is one of the most viable treatments in the rehabilitation of reading comprehension in a clinical setting due to its heavy reliance on homework exercises (i.e., cost effectiveness) and its demonstrated success. Although the range of types of alexic individuals who successfully underwent MOR treatment has been expanding (e.g., pure, phonological, and mixed alexia type), the candidacy of participants who are likely to benefit from this treatment has not yet been clearly delineated. For example, Beeson and Insalaco (1998) stated that "text reading must require some criterion level of graphemic, phonological, and semantic-syntactic competence below which rehabilitation of text reading is unlikely" (p. 633). However, exactly what such a criterion level might be has not been established by subsequent studies.

In sum, the existing literature has reported the profiles of individuals who benefited from MOR treatment. However, our knowledge is limited in terms of the requirements as well as contraindications for applying MOR treatment to a specific clinical case. Therefore, further studies examining the effect of MOR treatment on participants with varying reading and speech/language characteristics are warranted.

In a similar vein, any treatment program developed in a research laboratory might need to undergo some degree of modification in order to be applied in a clinical setting. Many existing reports of successful cases employing MOR were reported by the same group of researchers (e.g., Beeson and colleagues) who applied the same standard procedures in each study. Mayer and Murray's study (2002), which applied a modified procedure, resulted in a lack of improvement. Although the reason behind the limited treatment effect in Mayer and Murray's study could be due to a variety of factors, including candidacy, their results lead one to question whether MOR is flexible in its clinical application. In other word, does MOR allow any modifications in its procedures without losing its effectiveness? Modifications could apply to the various aspects of the treatment such as the length of treatment, the level of the reading materials used, and the treatment criterion for introducing a new story, to name a few.

We discuss our case report in the following section with the above questions in mind. Specifically, we were interested in finding out the extent to which MOR accommodates an alexic individual with language and speech characteristics that are different from those of the previous participants. We were also interested in examining whether modifications to the MOR procedures, such as adopting reading accuracy as the criterion for introducing a new story, not reading rate, would lead to successful outcomes as in earlier studies. We chose to adopt a different criterion due to our participant's increased anxiety and error rate when faced with timed reading performance as a treatment criterion as well as his extremely slow initial reading rate.

This article describes the methods and outcome of modified MOR treatment applied to our participant with deep alexia, Broca's aphasia, and apraxia of speech. This individual had participated in a previous reading treatment study (Kim & Beaudoin-Parson, 2007) that trained his use of the nonlexical reading route (i.e., bigraph-syllable conversion). Following the earlier treatment, our participant demonstrated significantly improved reading of single words as well as improved oral reading and reading comprehension of paragraphs. Although the pattern of his reading and language impairments was somewhat different from that of earlier participants in MOR-based treatment studies, we expected that he would benefit from the treatment based on several factors: his success in the earlier single-word-level treatment program, his ability to apply bigraph-syllable

correspondences in reading, his ability to orally read and comprehend paragraph-level materials with some success (approximately 64% accuracy), and his motivation to improve his ability to read text-level materials. In terms of the modification of the treatment procedure, we expected that increased reading accuracy would lead to increased reading rate, allowing automatization of the decoding process to occur and consequently resulting in improved reading comprehension.

We conducted our case study with the following questions in mind:

- Will the MOR treatment improve the reading accuracy, rate, and comprehension of text-level materials in an individual presenting with deep alexia, nonfluent aphasia, and apraxia of speech?
- Will increased reading accuracy result in improved reading comprehension in our participant?

We expected that the client's oral reading accuracy would improve as a result of the MOR treatment. However, due to his apraxia of speech, we expected that his improvement in oral reading accuracy or rate, or both, would be somewhat limited compared to those seen in participants in earlier studies. Nonetheless, we expected that the improvement in oral reading accuracy as well as rate would positively impact his reading comprehension.

We discuss our results in the context of the findings of earlier studies. We hope this discussion will aid future research and clinical practice by providing context to the findings of MOR-based treatment outcomes and suggest further guidelines for the application of MOR treatment.

METHOD

Participant

PT is a 52-year-old, right-handed, monolingual male. He is a native speaker of English who received a bachelor's degree in aeronautical science and had worked as a U.S. Army pilot before his left middle cerebral artery lesion in 2002. PT was 40 months postonset when he began participation in this study. A CT scan performed 2 days postonset revealed a large area of decreased attenuation in PT's left temporo-parietal lobe consistent with infarct, as well as partial effacement of the left lateral ventricle.

Following his stroke, PT received inpatient speech-language therapy services at a rehabilitation hospital. Since his discharge from the hospital, he has continued to receive therapy twice a week at a university clinic. He also participated in a reading treatment study that used a bigraph-syllable pairing method in an attempt to improve his use of the nonlexical route (Kim & Beaudoin-Parsons, 2007). PT was recruited to participate in that study because he expressed a desire to be able to read important documents and newspapers and to search for information on the Internet. Having no family living with him, PT viewed his reading ability as correlated with his functional independence. Following the 8-month long bigraph-syllable pairing treatment, which involved two weekly sessions lasting approximately 50 min each, PT's reading of trained bigraphs and words improved. In addition, generalization to oral reading of untrained words and low imageability words were observed as well as some improvement in his reading comprehension accuracy of paragraph-level materials. However, further improvement was needed for PT to be able to independently read text-level materials with good comprehension. Therefore, treatment focusing on improving PT's reading of text-level materials, such as MOR, was deemed necessary for further rehabilitation of his alexia.

Following his stroke, PT initially presented with global aphasia, which gradually evolved into mixed nonfluent aphasia. During testing for participation in the earlier reading treatment study, PT presented with a profile similar to that of moderate Broca's aphasia on the Western Aphasia Battery (WAB; Kertesz, 1982; aphasia quotient = 65.4), with the exception of more significantly impaired auditory comprehension (5.7/10). PT's spontaneous speech was often interrupted by word-finding difficulties. Although PT was able to employ a range of syntactic structures, his sentences were frequently ungrammatical due to missing nouns, verbs, and function words. His repetition (7.2/10) was also impaired. It was suspected that motor speech difficulty also contributed to PT's word production difficulty. PT's results from the Apraxia Battery for Adults—2 (ABA–2; Dabul, 2000) indicated a moderate apraxia of speech with highly inconsistent errors, which predictably increased as the length of his phonemic sequences increased.

Testing of PT's cognitive functioning, assessed by the Cognitive Linguistic Quick Test (CLQT; Helm-Estabrooks, 2001), indicated a mild level of cognitive deficit. Although his scores on the subtests employing nonverbal tasks to assess memory, executive functions, and visuospatial skills (e.g., clock drawing, symbol trails, design memory, mazes) were near perfect, his attention was judged to be in the "mild impairment" range. Overall, it appeared that PT's intellectual functioning was adequate to participate in the present study. PT reported corrected-to-normal vision (i.e., PT used glasses for reading) and adequate hearing acuity, although he refused to be screened for hearing acuity.

At the time of his participation in the current reading treatment study, PT was seen at a university clinic for individual therapy sessions twice a week for 50 min per session. Given PT's strong desire and need to improve his daily communicative functioning as much and as quickly as possible so that he could care for himself, it was deemed to be clinically inappropriate to recommend discontinuation of his clinic therapy. However, to minimize the potential impact of concurrent speech and language therapy on the results of the study, it was agreed that clinic sessions would not include any reading activity or written word stimuli during his participation in the present study. To this end, PT's treatment goals and activities for his clinic therapy sessions were closely monitored by the authors. A summary of PT's progress in his clinic therapy sessions during his participation in the present study is included in the Results section.

Pretreatment Reading Assessment

Word reading. PT's ability to read single words was assessed using selected subtests of the Psycholinguistic Assessment of Language Processing in Aphasia (PALPA; Kay, Lesser, & Coltheart, 1992). The results are presented in Table 1. Several patterns emerged from his performance. First, PT's auditory processing at the word level and his phonological working memory appeared to be generally well-preserved. We tested his ability to judge whether two words rhymed or not in both written and auditory formats; in the latter case, the words were read by the examiner. Although PT made errors on 26.7% of the pairs in written format, his performance on the auditory version was 95% correct. For success on the auditory version of the task, the two words must be held temporarily in storage while the relevant parts of the words are segmented and compared. In addition, PT's repetition of nonwords, a task that is often used to assess the functioning of phonological working memory, was 93.3% accurate. Therefore, it can be surmised that PT's phonological working memory as well as his auditory input processing and segmentation skills are generally intact.

Second, although attenuated from the pretreatment performance before his participation in the prior reading treatment study, imageability continued to be a major factor influencing PT's reading accuracy. For example, his reading of low imageability words (52.5%) on the Imageability and Frequency Reading subtest was still poorer compared to that of high imageability words (95%) regardless of frequency. In addition, PT continued to demonstrate a part-of-speech effect: His reading of function words (i.e., functors) was disproportionately impaired compared to his reading of nouns, adjectives, and verbs. However, when imageability was controlled across word classes (i.e., all low imageability words), his reading of function words (7/20 correct) was comparable to his reading of nouns (6/20). This result indicated that the reason behind the seeming part-of-speech effect was the imageability effect.

Third, PT produced several types of reading errors. Table 2 presents PT's error-type distribution in single-word reading on selected PALPA subtests. Visual/phonological errors (e.g., reading *concept* as *concern, welfare* as *farewell,* and *appear* as *apparel*) were the most frequent, constituting 57% of his errors. Omission errors constituted the second most frequently occurring error type (17%), followed by semantic substitutions (e.g., reading *feather* as *tickle, brandy* as *wine, stench* as *stink*) at 15%. PT also produced a small number of morphological errors (e.g., reading *gravity* as *grave, meet* as *met, nerve* as *nervous*). Unclassifiable errors included producing a response that was not related to the target semantically, phonologically, or visually (e.g., reading *grief* as *chill*).

Finally, PT was very poor at nonword reading. When analyzed at the phoneme level, his accuracy in producing correct phonemes in the nonwords increased from 28% (24/84 phonemes) to 54.8% (46/84 phonemes) as a result of the previous bigraph-syllable pairing treatment (especially, improved correct reading of the first syllable of the nonwords). However, he still could not read most of the nonwords correctly in their entirety due to the presence of bigraph-syllable pairs on which he had not been trained. All of these characteristics (i.e., difficulty reading low imageability words, nonwords, and function words and production of semantic, visual/phonological, and morphological paralexias) suggested that PT's reading profile, despite attenuated imeageability effect and improved use of the

Table 1. PT's pre- and posttreatment reading scores on selected subtests of the Psycholinguistic Assessment of Language Processing in Aphasia (PALPA; Kay, Lesser, & Coltheart, 1992).

Subtest (Subtest number)	*Pretreatment*	*Posttreatment*
Real Word Repetition (7)	23/24	24/24
Nonword Repetition (8)	28/30	28/30
Word Rhyme Judgements: Auditory (15)	57/60	59/60
Word Rhyme Judgements: Written (15)	44/60	53/60
Imageability and Frequency Reading (31)	59/80	57/80
	High imageability = 38/40	High imageability = 39/40
	Low imageability = 21/40	Low imageability = 18/40
Grammatical Class Reading (32)	46/80	43/80
	Noun = 12/20	Noun = 12/20
	Adjective = 15/20	Adjective = 10/20
	Verb = 12/20	Verb = 14/20
	Functor = 7/20	Functor = 7/20
Grammatical Class Reading with Imageability Controlled (i.e., all low imageability) (33)	13/40	19/40
	Noun = 6/20	Noun = 12/20
	Functor = 7/20	Functor = 7/20
Spelling-Sound Regularity Reading (35)	44/60	49/60
	Regular = 20/30	Regular = 27/30
	Exceptional = 24/30	Exceptional = 22/30
Non-word Reading (36)	3/24	2/24
Written Synonym Judgments (50)	52/60	47/60
	High imageability = 29/30	High imageability = 27/30
	Low imageability = 23/30	Low imageability = 20/30
Word Semantic Association (51)	18/30	21/30
	High imageability = 11/15	High imageability = 13/15
	Low imageability = 7/15	Low imageability = 8/15

Table 2. Distribution of error types in single-word reading on selected subtests of the PALPA.

	Error type				
Subtest #	*Semantic*	*Visual/phonological*	*Morphological*	*Omission*	*Unclassifiable*
31	3	12	1	4	1
32	2	21	1	4	6
33	5	13	0	8	1
35	5	10	1	0	0
Total	15	56	3	16	8
Percentage	15	57	3	17	8

Note. PALPA subtest 31 = Imageability and Frequency Reading; PALPA subtest 32 = Grammatical Class Reading; PALPA subtest 33 = Grammatical Class Reading With Imageability Controlled; PALPA subtest 35 = Spelling-Sound Regularity Reading.

nonlexical route as a result of the previous reading treatment study, continued to be generally consistent with the diagnosis of deep alexia.

Paragraph reading. To assess PT's oral reading of paragraph-level material, we administered portions of the Gray Oral Reading Tests—4th Edition (GORT–4; Wiederholt & Bryant, 2001). The GORT–4 requires the participant to read aloud passages of increasing length and difficulty, yielding reading rate (fluency), accuracy, and comprehension scores. For pretreatment testing, the first 10 stories from Form A of the GORT–4 were used. As shown in Table 3, a great number of both content and function word errors were present in PT's reading. Out of the 935 words that were presented in all 10 stories read, 646 were read incorrectly (68.8%). Among the errors, 303 words (46.9%) were content word errors, and 343 words (53.1%) were function word errors. The majority of PT's reading errors were those of omission (339/646 errors = 52.5%) and substitution (264/646 = 40.9%).

Despite PT's poor oral reading ability, he was occasionally successful at abstracting the gist of the story from the words he recognized correctly. His average comprehension score for the shorter stories (Stories 1 through 5) was 68%, dropping to 60% for the longer and more complex stories (Stories 6 through 10). PT's comprehension accuracy suggested that his current reading abilities would not support reading comprehension of daily reading materials for adults such as newspapers and documents. It was hoped that training PT's reading ability at the paragraph level would improve his reading comprehension of text-level materials, leading to a functional reading ability that would meet his daily reading needs.

METHOD

Treatment

In an effort to improve PT's text-level reading, we adapted and used the MOR treatment that was originally introduced by Moyer (1979) and was subsequently used by several researchers (e.g., Beeson & Insalaco, 1998).

Materials

Treatment materials consisted of passages from the Scientific Research Associates Reading Laboratory series (SRA; Parker & Scannell, 1998), similar to those used in earlier studies that employed MOR (e.g., Beeson & Insalaco, 1998). The series is divided into 12 levels, with 12 stories per level consisting of a mix of fiction and nonfiction. As the level increases, the stories become lengthier and more difficult. Due to PT's interest in more scientific topics, only nonfiction stories consisting of grade level 2.0–2.2 reading materials were used for training.

Procedure

Training method. Treatment was conducted by the second author. The training involved clinician-supported repeated oral reading of a short story. The clinician corrected reading errors and provided assistance as needed. PT typically read a new story twice during the first session that the story was introduced and then repeatedly read the story during home practice, which lasted 30 min each day. PT

Table 3. PT's reading of passages on the Gray Oral Reading Tests—4th Edition (GORT–4; Wiederholt & Bryant, 2001) across pre-, mid- and posttreatment assessments.

	Pretreatment	*Midtreatment*	*Posttreatment*
Total number of errors	646/935 (68.8%)	369/933 (39.6%)	396/935 (42.4%)
Omissions	339	25	94
Substitutions	264	341	290
Additions	43	3	12
Errors by word type			
Content word errors	303	176	188
Function word errors	343	193	208
Comprehension accuracy	32/50 (64%)	30/50 (60%)	34/50 (68%)

was responsible for logging his practice hours at home on a weekly reading log provided by the clinician. As mentioned earlier, instead of the reading rate criterion that was often used in earlier studies, we adopted the accuracy criterion of producing less than six oral reading errors before introducing a new passage. On three occasions, to reduce PT's frustration, a new story was introduced even though his reading of the previously read story contained more than six errors (maximum eight errors).

Two additional accommodations were made to facilitate PT's accuracy in oral reading. First, words that resulted in repeated errors (e.g., primarily function words such as *the, of,* and *their*) were put into a word list for practice in isolation. PT was encouraged to review the list during his home practice. Second, because PT lived alone, a tape recording of the story was provided to serve as feedback during his home practice. He was instructed to occasionally play the recording in between his readings to ensure the accuracy of his oral reading in order to prevent him from habitually misreading words without correction.

Although not used as a treatment criterion, PT's initial reading rate of each story was documented to examine whether his reading rate improved across readings of new stories. Similarly, PT's comprehension of the content of each story was assessed using five multiple-choice questions during the following session. These questions were designed to assess PT's understanding of main ideas, details, and inferential materials. During this task, the five questions were placed in front of PT, and he was instructed to point to his choice as they were read aloud by the clinician.

At the end of every session, PT was also given a short current event news article selected by the clinician. The article typically came from an online news site (e.g., Fox News or CNN) and often contained news that PT had already watched on TV. PT read these articles as homework. He was not instructed to read aloud or read repeatedly. During the next session, the clinician asked PT three to five multiple-choice comprehension questions related to the news article. This additional assignment was devised to help PT maintain his motivation for repeated oral reading practice of the SRA stories because it took him multiple sessions to meet the criterion for each story.

Pre-, Mid-, and Posttreatment Assessments

Selected subtests of the PALPA and selected (i.e., the first 10 of 13) stories from the GORT–4 were administered for pre- and posttreatment assessment. The GORT–4 stories were also administered during the midtreatment assessment, which occurred 6 months after initiation of treatment. In order to control for learning effect, two versions of the test (Form A and Form B) were used alternately across the three assessments (A-B-A). Finally, the WAB was re-administered at the termination of the current treatment to assess whether there was a generalized improvement in PT's language abilities.

Data Analysis and Reliability

During treatment, data on PT's oral reading accuracy, reading rate, and reading comprehension accuracy were collected for analysis. The criterion for successful treatment was < 5% oral reading errors on the initial reading of two new stories consecutively introduced. The first author observed approximately 50% of the treatment sessions (i.e., every other session) to ensure adherence to treatment protocol. Any disagreement in the scoring of the treatment session performance, although infrequent, was discussed and agreed on between the first and second authors.

The research protocol was approved by the University of Rhode Island's Institutional Review Board on Human Subjects and was monitored by the University's Compliance Office.

RESULTS

Treatment was terminated after 70 sessions over a period of 9 months without PT meeting the treatment criterion. During this time, PT completed reading 14 stories of the SRA series, ranging in number of words from 103 to 223 (M = 146.2 words).

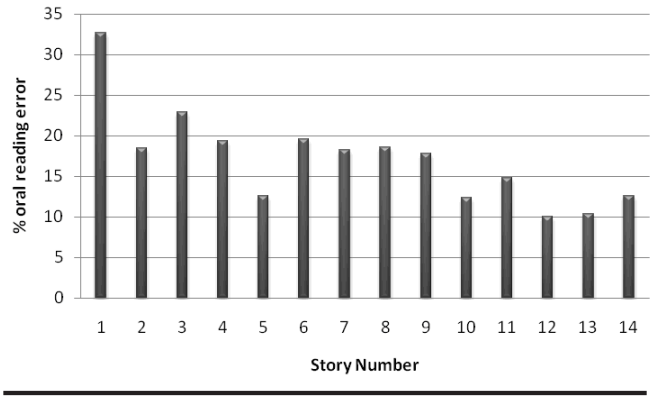
Oral Reading Accuracy, Rate, and Reading Comprehension in Treatment

As shown in Figure 1, throughout the treatment period, PT's oral reading accuracy of a new story improved slowly but steadily. The mean percentage of reading errors he made during the initial reading of the first four stories (M = 23.4%, SD = 42.6) was significantly greater than that for the last four stories (M = 11.9%, SD = 5.0), $t(3) = 4.59$, p = .009.

Comparison of PT's mean reading rate on his first reading of new stories introduced earlier during the treatment (i.e., mean reading rate of the earlier three stories = 4.7 wpm, SD = 0.19) to that of the last three stories (M = 6.27 wpm, SD = 0.36) also showed that his reading rate improved over time, $t(2) = -3.39$, p = .03. As indicated earlier, this measure was not used as a treatment criterion.

Finally, we compared PT's reading comprehension accuracy of the stories read at the beginning and end of the

Figure 1. Percentage of oral reading errors on PT's initial reading of the 14 Scientific Research Associates stories that were read during the treatment session.



study. Unexpectedly, the mean correct number of answers (out of total five questions asked) for the first four stories (M = 4.25, SD = 0.25) was greater than that for the last four stories (M = 3.75, SD = 2.25), $t(3) = 0.77$, $p = .24$. However, this difference did not reach statistical significance. PT's mean reading comprehension accuracy of the stories used in treatment was 76%.

Performance on External Measures

Single-word oral reading on the PALPA subtests. Table 1 shows PT's pre- and posttreatment reading performance on selected subtests of the PALPA. PT showed improved reading on two of the four single-word reading subtests (i.e., Subtests 33 and 35). The improvement on Subtest 33 was significant (McNemar's test: $\chi^2 = 4.17$, $p = .04$), whereas the improvement on Subtest 35 only approached significance ($\chi^2 = 3.20$, $p = .07$). In addition, PT demonstrated significantly improved performance on the written version of the Word Rhyme Judgment subtest ($\chi^2 = 7.11$, $p = .007$), suggesting improved reading (albeit done silently) of words. As expected, no improvement occurred on PT's reading of nonwords. His performance on tasks examining his semantic knowledge of words was variable, showing an improvement on one (Subtest 51) and a decrease on the other (Subtest 50), although none of these comparisons was significant. Finally, PT's reading accuracy of function words did not improve, as shown by his performance on PALPA Subtests 32 and 33.

Paragraph oral reading and reading comprehension. We also analyzed PT's oral reading accuracy of the 10 GORT–4 stories across three administrations. As shown in Table 3, PT's oral reading accuracy of these stories improved significantly from the pre- to midtreatment assessment (from 68.8% error rate to 39.6%; $\chi^2 = 275$, $p < .0001$); however, his reading accuracy decreased mildly from the mid- to posttreatment assessment (from 39.6% error rate to 42.4%; $\chi^2 = 25.04$, $p < .0001$). On the other hand, PT's comprehension accuracy of the GORT–4 stories did not improve from pre- to midtreatment assessment (from 32/50 questions answered correctly to 30/50 correct) and increased slightly from the mid- to posttreatment assessment (from 30/50 questions answered correctly to 34/50 correct), although neither comparison was significant.

Finally, PT's aphasia quotient on the WAB, obtained at the termination of the current treatment program, showed a slight improvement (from 65.4 to 67.5) from his scores before his participation in the prior reading treatment.

PT's Progress in Clinical Therapy Sessions

The clinical therapy sessions conducted during PT's participation in the present study addressed the following areas: auditory comprehension, noun retrieval, conversation, number processing, verb retrieval, and sentence elaboration. Review of PT's clinical progress reports revealed that, among the skills targeted, PT demonstrated modest improvement in noun retrieval. His naming of categories when provided with three within-category item names, with clinician cue, improved from 76% to 90%. PT also showed slight improvement in his verb retrieval and sentence elaboration skills. PT's accuracy in naming a verb given a picture stimulus and using the verb in a complete sentence improved from 72% to more than 80% toward the end of his therapy. Another area that showed slight improvement was his number skills (i.e., number naming, matching, and writing). Treatment to improve the clarity of PT's conversational message by rephrasing to ensure listener comprehension yielded an inconsistent performance pattern. We were not able to objectively determine whether PT made any progress toward the goal of improving his auditory comprehension ability (e.g., answering yes/no or *wh*-questions). In sum, while participating in the current reading treatment study, PT demonstrated modest improvement in his noun retrieval, verb retrieval, sentence elaboration in a structured context, and number processing skills in his clinical therapy.

DISCUSSION

Our first research question was whether the MOR treatment would improve the reading accuracy, rate, and comprehension of our participant. The results of our case study were unexpectedly inconsistent in terms of PT's progress in oral reading accuracy, oral reading rate, and reading comprehension. MOR treatment definitely improved PT's oral reading accuracy. This was observed in his reading of the materials used in the treatment context and in his performance on external measures. As his treatment progressed, PT produced fewer errors in his first oral reading of newly introduced stories used in the treatment. Although PT did not show improvement on all of the PALPA subtests that we administered, he demonstrated improved oral reading accuracy on some of the subtests. Finally, his oral reading of the GORT–4 paragraphs showed a substantial decrease in the number of errors he made from the pre- to midtreatment assessment, although the number of errors slightly increased from the midtreatment to the posttreatment assessment. Overall, it appears that MOR was effective in increasing the oral reading accuracy of our participant with deep alexia, nonfluent aphasia, and apraxia of speech.

However, this pattern did not apply to PT's reading rate and reading comprehension. Although PT's reading rate was not used as a treatment criterion in the present study, we recorded his initial reading rate of each new story throughout the treatment period in order to examine his progress on this measure. PT's initial reading rate of new stories showed statistically significant change from the early stage of his treatment to the final stage (4.7 wpm to 6.27 wpm); however, this statistical significance may not be clinically meaningful at all. Compared to normal adult oral reading rates (150–200 wpm; Rayner & Pollatsek, 1989) and the improved reading rate achieved by most earlier MOR participants (i.e., 35–71 wpm), PT's reading rate at the end of the 70 treatment sessions continued to be painfully slow.

In addition, not only did PT not improve on his comprehension of the treatment stories, but he also failed to show improvement in his reading comprehension of the GORT–4 stories across the three assessments. Therefore, there was

no evidence of improved reading comprehension ability during or following the treatment.

This observation answers our second research question, that is, whether increased reading accuracy would result in improved reading comprehension. For our participant, improved reading accuracy alone was not sufficient to lead to improved reading comprehension. It appears that increased reading rate, or both increased reading rate and reading accuracy, are required to result in improved reading comprehension at the text level.

Finally, unlike participants in some earlier MOR-based treatment studies, PT did not show improved accuracy in reading function words on the PALPA subtests. Although his aphasia quotient on the WAB showed slight improvement (from 65.4 to 67.5), this was not deemed to be clinically meaningful. Therefore, there did not appear to be generalization of the treatment effect to PT's other language abilities.

To summarize, our findings suggest that the effect of the MOR treatment was limited in improving the reading ability of a client with deep alexia, Broca's aphasia, and apraxia of speech. Treatment improved the reading accuracy of our participant but not his reading rate or reading comprehension. In retrospect, it appears that certain aspects of the design of our case study may have contributed to this limited treatment outcome. First, although other treatment variables (such as the level of the reading materials) might be modified and adapted, the criterion of increased reading rate to a predetermined rate (of 50–100 wpm at least, based on the results of existing studies) may not be rejected (as was done in the present study) or even substantially modified because it is the central focus of the treatment. In addition, a more recent MOR-based treatment study (e.g., Beeson et al., 2005) suggests that intact or fully recovered letter processing ability is required for successful MOR treatment. We did not examine PT's letter processing ability carefully at the time he began the treatment. Therefore, it is possible that PT's letter processing ability was less than optimal, possibly deterring his progress in treatment.

In light of our unexpected results, we decided to carefully examine the outcomes of past MOR-based treatment studies in an attempt to more completely describe the characteristics of optimal candidates for the treatment (and the contraindications thereof). Table 4 summarizes the client characteristics and the treatment variables of all published MOR-based treatment studies of which we are aware. Although many studies reported successful results, there were several studies, including ours, that resulted in a less than successful outcome. In addition, although not included in the table, we also gleaned similar information from the oral reading treatment studies that employed the ORLA treatment (i.e., Cherney, 1995; Cherney et al., 1986; Orjada & Beeson, 2005). We believed that a careful comparison of client characteristics and treatment variables between successful and less than successful studies would not only help us interpret our findings but also provide much-needed guidelines for the application of the MOR treatment for future research and clinical practice. Review of the table reveals that, despite diverse profiles of participants and their progress, there are also some commonalities among studies, especially among those with limited success.

The Relationship Between Reading Accuracy, Reading Rate, and Reading Comprehension

First, we considered the relationship between reading accuracy, reading rate, and reading comprehension. As discussed earlier, MOR does not specifically address reading comprehension. Instead, it focuses on increased reading rate with high reading accuracy. Although it does not focus on reading comprehension during the treatment period, it has been reported that many participants were able to resume pleasure reading once their reading rate (with accompanied high reading accuracy) increased sufficiently (although what is "sufficient" appears to vary among individuals).

What is the mechanism that is responsible for increased reading rate? Moyer (1979) explained that words are read faster in context than in random lists. This is probably due to the syntactic/semantic constraints available in context that permit faster processing of the component words. Beeson (1998) referred to this manner of rapid decoding of words facilitated by contextual information as using a "top-down strategy," which obviates the need for serial identification of each letter. Repeated reading of the same text further increases the fluency of the decoding process. This, in turn, leads to improved comprehension because of the attentional resources that are now available for meaning comprehension.

This hypothesis, to some degree, is borne out by Cherney et al's observation (1986) of the relationship between reading rate and reading comprehension. For the 5 nonfluent aphasic participants in their ORLA-based treatment study, any change in their reading comprehension scores was preceded by an increased rate of reading responses (i.e., decrease in the time required to complete the task), not by increased accuracy of responses. This observation lends support to the theory that rapid and more automatic decoding allows one to direct one's attention to comprehension of meaning. In this respect, the lack of increase in PT's reading rate combined with the extremely slow pretreatment reading rate would not have allowed rapid decoding to occur and, consequently, would not have allowed him to engage the top-down strategy for meaning comprehension. As shown in Table 4, all participants in the successful MOR-based studies demonstrated a noticeable increase in reading rate, whereas participants in the unsuccessful MOR-based studies demonstrated a lack of increase in reading rate (except for Mayer and Murray's 2002 participant, who showed increased reading rate at least for difficult text) regardless of their initial reading rate. This observation naturally leads to a discussion of the factor(s) that affect the reading rate in the context of the MOR treatment.

Factors That Influence the Reading Rate

The most apparent difference between successful and unsuccessful participants was the presence of oral production difficulty, labeled as "speech difficulty" in Table 4. Although none of the successful participants presented with any speech difficulty, all 3 unsuccessful participants presented with some type of oral production difficulty. Tuomainen and Laine's (1991) participant and our participant presented

Table 4. Client characteristics and treatment variables of published Multiple Oral Rereading-based treatment studies.

Article	*Alexia type (# of participants)*	*Language difficulty*	*Speech difficulty*	*Initial reading rate*	*Final reading rate*	*Cognitive impairment*	*Grade level of materials*	*Length of treatment*	*Generalization*[a]
Successful									
Moyer (1979)	Pure (1)	No	No	48 wpm[b] (66 spm[c])	94 spm	Not reported	5–6	4 months	Yes
Moody (1988)	Pure (1) Phonological (2)	No (2) Anomic (1)	No	19, 24, 26 spm for Patient 1, 2, 3	52, 32, 49 spm for Patient 1, 2, 3	Not reported	Not reported	15 weeks	Not tested
Tuomainen & Laine (1991)	Pure (2)	No	No	P1: 85 spm P2: 75 spm	P1: > 150 spm P2: 110 spm	Not reported	High school level	P1: 6 months P2: 6 months	Not reported
Beeson (1998)	Pure (1)	No	No	11 wpm	~ 35 wpm	Not reported	2.5–6.0	6 months	Yes
Beeson & Insalaco (1998)	Mixed (2)[d]	Anomic aphasia	No	P1: 31 wpm[e] P2: 54 wpm[e]	P1: 66 wpm P2: 71.5 wpm	Not reported	P1: not reported P2: 3.5–4.0	Pt1: 10 months Pt2: 3 months	Yes
Cherney (2004)	Phonological (1)	Anomic aphasia	No	34.6 wpm	44 wpm	Not reported	not reported	18 weeks	Not reported
Beeson et al. (2005)	Pure (1)	Anomic aphasia	No	37.3 wpm	56.6 wpm	Not reported	3.0–3.5	32 weeks	Not reported
Unsuccessful									
Tuomainen & Laine (1991)	Pure (1)	No[f]	AOS[g]	~40 spm	~40 spm	Severe visuo-spatial and memory deficit	5–6	3 months	No
Mayer & Murray (2002)[h]	Attentional (1)	Residual fluent	Yes (pt. report)	101.3 wpm for easy & 53 wpm for difficult	99 wpm for easy & 99 wpm for difficulty	Impaired attention and working memory	8–13	11 sessions	No
Kim & Russo (2007)	Deep (1)	Broca's	AOS	4.7 wpm	6.27 wpm	Mild attention impairment	2–2.2	70 sessions	No

[a]Positive generalization includes improvement in any skills other than those specifically trained in treatment (e.g., improved function word reading speed, improved skills in other aspects of speech and/or language ability). [b]wpm = words per minute. [c]spm = syllables per minute. [d]Their first participant showed the symptoms of pure, deep, and surface alexia. [e]Only the results from the MOR treatment (not the subsequent Phrase Formatted Text treatment) were considered. Reported reading rates are the average of easy and difficult level reading materials that are separately reported by the authors. [f]Tuomainen and Laine's participant showed no language impairment but visuospatial and memory deficits as well as symptoms of depression. [g]AOS = apraxia of speech. [h]This study used an alternating treatment design in which MOR and working memory treatment were alternately provided.

with specific motor speech difficulties, whereas Mayer and Murray's (2002) participant subjectively reported difficulty associated with oral reading tasks. Their participant felt that oral reading tasks forced him to focus on the motoric aspects of reading aloud, preventing him from paying attention to the meaning. In light of this observed commonality, one can speculate that the presence of moderate oral production impairment interferes with automatization of the oral reading/decoding process despite repeated exposure, resulting in little attentional resources left for comprehension of meaning. The "slow reading rate" due to oral production difficulty in these cases would not "allow one to recognize [a] sufficient number of words quickly and automatically enough to permit them to be chunked into a syntactic/semantic unit within the limits of short term memory capacity" (Moyer, 1979, p. 143). The report that Cherney's (1995) participant who did not benefit from ORLA in terms of improved reading comprehension also presented with severe apraxia of speech with Broca's aphasia appears to provide further support to this speculation.

The second commonality among the participants with limited improvement is the presence of some level of concomitant cognitive deficits. Although most of the successful studies did not specifically report any cognitive impairments (although we do not know whether a cognitive test was given or not in such studies), all 3 less successful participants had some type of cognitive deficits: Mayer and Murray's (2002) participant presented with impaired attention and working memory, Tuomainen and Laine's (1991) participant was reported to have severe memory and visuospatial deficits, and our participant showed mild impairment of attention on a screening test. Decreased attention and/or short-term memory has been known to affect the reading performance of some individuals, especially at the text level. To illustrate, Coelho's (2005) participant improved her comprehension of text-level materials following the treatment on her attentional processes without specific reading treatment. Therefore, it is plausible that impaired cognitive ability, especially impaired attention, could have influenced the outcome of the MOR treatment in the less than successful cases.

Except for the two variables mentioned above, participants and studies do not show a clearly converging pattern on any of the other variables we reviewed. Although the treatment was initially developed for pure alexic individuals with a letter-by-letter reading pattern, participants with other types of alexia have also benefited from the treatment. Similarly, although all successful participants presented with no aphasia or mild fluent-type aphasia, participants with limited improvement were divergent in their aphasia type (none, mild fluent, Broca's). Initial reading rate does not seem to necessarily predict the outcome, either. Although our participant's initial reading rate was the slowest of all of the participants reviewed, an individual with a reading rate as slow as 11 wpm improved in Beeson (1998) and as rapid as 100 wpm did not benefit from the treatment in Mayer and Murray (2002). The grade level of the reading materials used also does not seem to be closely related to the outcome. Successful studies used reading levels as low as 2.5 and as high as high school reading materials, and unsuccessful studies used reading levels as low as 2nd-grade and as high as 13th-grade reading materials. Finally, length of treatment did not seem to differ substantially between the successful and unsuccessful studies, although Mayer and Murray's duration of treatment appears to be somewhat shorter than that of the other studies. Most MOR-based studies reported at least 3 months of treatment duration.

Candidacy for MOR and Contraindication

Based on our review of past studies, we present a list of requirements (and contraindications) for optimal candidates for MOR treatment as well as some procedural considerations.

First, the technique is best suited for pure alexic clients with letter-by-letter reading pattern, demonstrated by the letter length effect. However, it will likely benefit individuals with mild fluent-type aphasia and mixed type of alexia if their single-word reading accuracy and comprehension is good and slow reading rate is their main complaint. Second, participants should demonstrate well-preserved or recovered letter identification and letter naming abilities (Beeson & Henry, 2008). Third, fairly good oral reading accuracy and comprehension of single words is required. Fourth, the participant should not demonstrate moderate or severe oral production difficulty, whether formally diagnosed (such as apraxia of speech) or subjectively reported. Fifth, the participant should not show cognitive deficits, especially of attention, upon examination.

In addition, there are some procedural considerations to note. First, it is essential that there is some indication of increase in reading rate during the early phase of the treatment (i.e., within first 4–6 weeks) regardless of how slow the initial reading rate is. Second, a criterion reading rate (of at least 50–100 wpm) for practiced texts should be used for introducing a new story (Beeson & Henry, 2008). Third, most successful MOR-based studies reported a homework schedule of at least 30 min a day. Finally, MOR appears to show positive effects when it lasts at least 3 months or longer (with a weekly session lasting 30–60 min).

There are caveats to be kept in mind in terms of how our list was compiled. First, there are irregularities in the client data used in compiling the list because the data came from different studies. For example, one cannot be sure whether successful participants did not have cognitive deficits or whether it was simply not tested and reported. Second, it is likely that the outcome of a treatment is influenced by the interaction of multiple factors associated with the participant(s) and the treatment variables rather than by a single factor. We do not know the respective contribution of each factor or how they might interact. However, we believe that our list provides more detailed guidelines in applying MOR to clinical cases than previously described. We view our list as a starting point for further elaboration.

CONCLUSION

MOR is one of the few text-level reading treatments that greatly appeals to clinicians. First, it sets the target reading

level close to the ultimate goal of most clients (i.e., text level). Second, it is feasible to implement in a clinical setting due to its heavy reliance on homework exercises (i.e., cost effective). Therefore, it is very important to carefully consider the issues related to candidacy and procedural modifications in implementing this efficient treatment. Although successful MOR-based treatment studies provide us with some information on candidacy, failed applications of the program inform us even more. Future research that further examines the candidacy and procedure issues of MOR-based treatment is warranted. In addition, an alternative text-level reading comprehension treatment method needs to be developed for individuals with alexia and concomitant oral production difficulty who wish to improve their ability to comprehend text-level materials. Such an alternative method should avoid burdening their oral production mechanism.

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