On the Use of Variations in a Delayed Matching-to-Sample Procedure in a Patient with Neurocognitive Disorder

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1 Introduction

The purpose of this paper is to give an introduction to a neurocognitive disease (NCD), dementia, and to briefly describe the use of a common assessment tool, the Mini-Mental State Examination (Folstein, Folstein, & McHugh, 1975). Then, we will describe conditional discrimination procedures, or matching-to-sample procedures, and how they have been used for research purposes within behavior analysis. For example, how fixed delayed matching-to-sample (FDMTS) and titrated delayed matching-to-sample (TDMTS) can be arranged to study variables important for analyzing short-term memory problems. Hence, we have conducted a study with a person diagnosed with dementia to illustrate how such TDMTS procedures can be arranged. We will argue that the delayed matching-to-sample (DMTS) procedures may be useful for identifying problems of short-term memory in people with dementia. Finally, we will discuss important studies within this research area and discuss further studies that will be important to conduct. In a more specific on focus of the present paper, we will argue that conditional discrimination procedures make it possible to (1) study the length of the delay of remembering in a participant and (2) map the progression of the disease.

1.1 Neurocognitive Disorder

Snarski et al. (2011) noted that in USA, older adults are the fastest growing age group and the prevalence of various NCD’s is increasing. In a 2009 report by the Alzheimer’s Association, it was estimated that approximately 35.6 million people would have an NCD diagnosis in 2010 (Prince & Jackson, 2009). Furthermore, it was estimated that by 2050, this number would increase to 115.4 million people. In the fourth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV), NCD was labeled as dementia (American Psychiatric Association, 2013) and was used as an umbrella term for various types of diseases caused by different organic conditions, all of which were characterized by memory loss. Because the term dementia is well known, these terms will be used synonymously in this paper.

All types of NCDs are chronic and irreversible (Prince & Jackson, 2009), and they are most often found in adults older than age 65 years. However, younger adults may be affected by NCDs as well. As stated in the World Alzheimer Report from 2009, there is an increased awareness of NCD diagnoses in people age 65 years or younger. This is partly confirmed in the DSM-V, wherein the younger patient group receives more recognition through the modified diagnostic criteria. However, it is a fact that the likelihood of being diagnosed with dementia increases with age, and it has been noted that the prevalence of dementia diagnoses approximately “doubles with every five-year increase in age” (Prince & Jackson, 2009).

In the USA and Canada, the DSM is the most frequently used diagnostic tool, while in most of Europe, the International Classification of Diseases (ICD) is most commonly used. The Cambridge Examination for Mental Disorders of the Elderly (CAMDEX) is the most commonly used diagnostic tool in the UK. World-wide the Mini-Mental State Examination (MMSE) is the most commonly used screening test for dementia (Folstein et al., 1975). The screening test is used to map the progression of the disease and also to evaluate the effect of therapeutic agents (O’Bryant et al., 2008). The screening test has seven categories: (1) orientation (time and place), (2) recall, (3) registration of words, (4) attention, (5) mental arithmetic, (6) language impairment, and (7) visual-spatial skills. Each category offers a certain number of points, and the total score is 30 points. The screening test is easy to administer, which may be the reason for its frequent usage.
Albeit Folstein et al. (1975) suggested certain cutoff points for different degrees of dementia, and there are variations in the literature regarding the scores that form the boundaries of cognitive impairment. For example, according to Snarski et al. (2011), if a person scores between 24 – 30, it is concluded that there are no signs of cognitive impairment. A score of 21 – 23 indicates that the person has mild dementia symptoms, and a score of 10 – 20 indicates that the person has moderate dementia symptoms. If a person scores lower than 9, it indicates severe cognitive impairment. However, O'Bryant et al. (2008) suggested that when taking education into consideration, a cutoff score of 27 would be more appropriate to identify people at the early stages of the disease. It is reasonable to ask whether the test is sensitive enough as a screening test. Hence, Tombaugh and McIntyre (1992) discussed the reliability and validity of the MMSE and concluded that the test was not sensitive enough to discriminate between patients at an early stage of the disease and those without dementia. Therefore, it may be suggested that additional measurements that provide objective information about each participant’s performance may be needed.

In addition, it is worth mentioning that although there are drugs that affect dementia progression by delaying the process (Geldmacher et al., 2006), there is currently no cure for dementia (e.g., Buchanan, Christenson, Houlihan, & Ostrom, 2011; Trahan, Kahng, Fisher, & Hausman, 2011). Therefore, Buchanan et al. (2011) have argued that experimental studies should be performed where the main goal is rehabilitation, to preserve the skills that the patient already has in his repertoire. The authors suggest that one of the domains that needs to be trained in each individual is remembering.

1.2 Matching-to-Sample

Conditional discrimination procedures, or matching-to sample (MTS) procedures, have been frequently used to study complex human behavior (e.g., Cumming & Berryman, 1965; Sidman, 1994). In an MTS procedure, each trial starts with the presentation of a sample stimulus, and upon a response to the sample stimulus, two or more comparison stimuli are presented (see Figure 1). In this paper we have focused on identity matching. However, another type of matching is arbitrary matching which is commonly used (see for example Arntzen, 2012). The correct choice of comparison stimulus depends upon which sample stimulus was presented. The trial ends with programmed consequences for correct or incorrect choices, and an inter-trial-interval (ITI) is implemented before the start of the next trial.

There are several variables that can be manipulated when designing an experiment that uses MTS procedures (for an overview, see Arntzen, 2012). As noted by White (2013), when the studied topic is either remembering or forgetting, the delay between the offset of a sample stimulus and the onset of comparison stimuli (the temporal distance) is what “defines the behavior as remembering or its converse, forgetting” (p. 411). Therefore, the focus of this chapter will be on delayed MTS procedures (DMTS). Following that is a description of two different DMTS procedures: (1) DMTS, where there is a fixed delay between the offset of the sample stimulus and the onset of the comparison stimuli throughout the training, and (2) titrated DMTS (TDMTS), where the length of the delay changes (increases or decreases) as a function of the participants’ correct or incorrect responses, respectively (see Figure 2).

1.3 Fixed DMTS Procedure

The fixed DMTS procedure has a long history as a procedure for studying remembering (Cumming & Berryman, 1965; Paule et al., 1998) with both human participants (e.g., Arntzen, 2006; Arntzen & Vie, 2013; Constantine & Sidman, 1975; Steingrimsdottir & Arntzen, 2011) and nonhumans (e.g., Blough, 1959; Foster, Temple, Mackenzie, Demello, & Poling, 1995; Jackson & Buccafusco, 1991).
When using fixed DMTS, the length of the delay remains fixed across training trials. For example, if an experimenter uses this type of procedure to study remembering, the experimenter sets out with a certain number of training trials, such as a block of 36 trials, with a fixed 0-s delay between the offset of the sample stimulus and onset of the comparison stimuli. Thereafter, when the participant has responded correctly to 90% or more trials, the delay is increased to 2 s for the next block, then an increase to 4 s, etc. For example, Fowler, Saling, Conway, Semple, and et al. (1997) did a study where they used DMTS with a fixed delay to differentiate between a normal control group, a group who had dubious dementia, and a group who had early dementia of the Alzheimer type. The study had four MTS conditions: (1) simultaneous matching, (2) 0 s delay, (3) 4,000 ms delay, and (4) 12,000 ms delay. The authors concluded that the DMTS procedure might be “sensitive to cognitive decline at an earlier stage than standardized tests such as the WAIS-R and WMS-R” (p. 145). Furthermore, the authors concluded that DMTS is “sensitive to
continued cognitive decline in early [dementia of Alzheimer’s type] over a relatively brief period” (p. 145).

**Figure 2.** On the left is an example of DMTS identity with a fixed delay. On the right panel is an example of TDMTS identity with delay changing as a function of correct/incorrect responses.

Although the results from Fowler *et al.* (1997) are very interesting, it has been noted that the DMTS procedure may have an unwanted floor and ceiling effect (Han, Pierre-Louis, Scheff, & Robinson, 2000; Wenger & Kimball, 1992; Wenger & Wright, 1990). Hence, in a 2-s DMTS procedure where the participant responds correctly on all trials, it could be that the delay is not long enough to assess the longest delay the participant can remember. Hence, if the delay had been increased to 4 s, and the participant was still 100% correct on all trials in that experimental condition, it might be concluded that there were
ceiling effects in the 2-s condition. Despite having increased the delay for additional 2 s, the experimental condition may still show a ceiling effect. However, by using the TDMTS procedure, these problems can be decreased.

1.4 Titrated DMTS Procedure

In the TDMTS procedure, the length of the delay is adjusted depending on the participant’s responses, increasing when he or she responds in accordance with the experimenter-defined accuracy criterion and decreasing when he or she does not (Cumming & Berryman, 1965; Scheckel, 1965). TDMTS is also known as adjusting DMTS (Rosenberger, Mohr, Stoddard, & Sidman, 1968; Sidman, 2013).

TDMTS has been used to study remembering in a variety of settings. For example, Ferraro, Francis, and Perkins (1971) used the TDMTS procedure with young children of various age groups to study difference in responding as a function of increasing delay. When the children made two correct responses in a row, there was a 2-s increase in the delay. Their results showed that the youngest children in the experiment did not respond correctly when the delay was longer than 0 s, whereas the oldest children in the study responded correctly when delays were even greater than 40 s. Furthermore, in a study with nonhumans, the TDMTS procedure was used to study the effect of amnestic drug administration on rats’ performance (Han et al., 2000). The authors concluded that by using TDMTS, one can “differentiate deficit patterns of amnestic drugs, and can isolate the effects of motivational side effects of drugs from working memory measures” (p. 93).

In a study by Arntzen, Steingrimsdottir, and Antonsen (2013), TDMTS was used with a patient diagnosed with dementia. The patient had first been exposed to several DMTS experimental conditions ranging from 0 – 12,000 ms. The results showed that the participant solved the DMTS task in accordance with the experimenter-defined criterion when the delay was up to 12,000 ms. However, the participant did not do so when the delay was increased to 12,000 ms. Therefore, a TDMTS procedure was used for evaluation of possible floor and ceiling effect observed in the DMTS with fixed delay. The changes in the length of delay were evaluated based on blocks of six training trials. If the participant made six out of six correct responses, the delay increased by 250 ms. If the participant made one or more errors in one block, the delay decreased by 250 ms. The results showed that over the course of approximately 1,700 training trials, the range of the titrated delay turned out to be from 7,500 ms to 12,250 ms.

In our experiment, we asked two research questions: (1) Is there a difference in matching performance when using either a 500 ms or 100 ms step size value during an identity TDMTS procedure? (2) Is it possible to find a maximum level of a delay between samples and comparison by employing an identity TDMTS procedure?

2 Method

2.1 Participant

Peter was a 62-year-old man diagnosed with dementia. His MMSE (Mini Mental State Examination; Folstein et al., 1975) was 23 at the time of the study. He lived at home but spent his days at a day care center for people with NCD. According to health care personnel and his kin, he was considered to be able to sign a consent form. Therefore, he signed the informed consent to participate in the study. The consent form provided information about the nature of the project, assured that the data would be anonymized, and explained his right to withdraw at any time from the study. Peter enjoyed participating throughout the
study. Furthermore, he stated that he was happy being able to contribute to increasing understanding of NCD diseases and that it was a nice addition to the activities offered at the day care center.

2.2 Setting, Apparatus, and Stimuli

The experiment was run in a quiet room at the day-care center where Peter was during the daytime. The room was approximately 7 m² and had two tables and three chairs. Peter sat at one of the tables, where an HP laptop (Microsoft Windows 7 Professional 2009, Genuine Intel® CPU T200 @ 1.83GHz, 1GB RAM) that was used to present the MTS tasks was placed. Due to a technical problem, the computer was changed (after the first three conditions, see description under Experimental Design) to an HP Computer (Microsoft Windows 7 Professional 2009, Intel® Core ™ i5-2540 M CPU @ 2.60 GHz, 4 GB RAM). A custom-made MTS program developed by Cognitive Science Partners in collaboration with the first author was used to present the stimuli on the screen and recorded the participants’ responses. Since Peter had extensive experience using computers, he used a computer mouse to submit his answers. The stimuli that were used were three abstract shapes (see Figure 3).

![Figure 3. Stimuli used in both conditions of the study.](image)

2.3 Procedure

2.3.1 Behavior Recorded

The computer program recorded Peter’s responses. The recordings gave the experimenters information about which comparison stimulus Peter clicked on, if the chosen comparison stimulus was defined as correct or not by the experimenter, and finally the reaction time (RT) from the presentation of the comparison stimuli until a choice was made.

2.3.2 Pre-test

Peter was given a deck of nine cards, with three pictures of each stimulus that would be used during the subsequent experimental conditions. He was asked to categorize the cards.

2.3.3 Pre-training

Before starting the experimental conditions, Peter did pre-training and practiced the identity matching-to-sample behavior required during the experimental conditions. The stimuli that were used during the pre-training were color stimuli: yellow, blue, and, red. The stimuli were presented at the same locations as
they would be in the subsequent experimental conditions, with the sample stimulus in the middle of the screen and the three comparison stimuli in each corner with one corner blank. A response to the sample stimulus was followed by the offset of the sample and an immediate presentation of the comparison stimuli (0 s DMTS).

2.3.4 Experimental Design

There were two experimental conditions in the experiment arranged as a withdrawal design (ABAB). In the A-condition, there was a 500 ms change in the delay depending upon the participant’s responses, while in the B-condition, there was a 100 ms change in the delay. Peter was first exposed to the A-condition, followed by the B-condition. Then, the A-condition was reintroduced, followed by another exposure to the B-condition.

2.3.5 Instruction

All text, the instructions at the start of each experimental session and the programmed consequences for each trial, were originally in Norwegian. The instructions stated: “A stimulus will appear in the middle of the screen. Use the mouse to click on it. Then, three other stimuli will be presented. Choose one of them by using the mouse. If you choose the one we have defined as correct, words such as good, super etc. will appear on the screen. If you choose an incorrect stimulus, the word incorrect will appear on the screen. In the lower right corner you will see the number of correct responses. Please do your best to get everything right. Thank you and good luck!” The last instruction on the screen was: “Press here when you are ready to start.”

2.3.6 Experimental Conditions

Apart from a change in the length of the titration delay, the experimental conditions (A and B) were identical across conditions. Each experimental condition started with a presentation of the sample stimulus in the middle of the screen. The 0-second DMTS condition was the same as in the pre-training. The three comparison stimuli were presented randomly, one in each corner, with one empty corner. If the participant chose the experimenter-defined correct comparison stimulus – the one that was identical to the sample – programmed consequences such as “super” and “true” were presented, whereas if the choice was incorrect, the programmed consequence “incorrect” was presented. The inter-trial interval (ITI) was set to 2,000 ms throughout the experiment, with a 1,500 ms display of programmed consequences. As depicted in Figure 1, one training trial begins with the presentation of the sample stimulus and ends with the ITI. The computer program was set to offer a break after every fiftieth trial, and the participant could choose whether to take the break or continue with the experiment.

The training trials were presented in blocks of six trials. For evaluation of whether there should be an increase or decrease in the length of the delay between the sample and the comparison stimuli, the computer program checked how many correct trials there were in the six-trial block. If six out of six correct trials were correct, the delay was increased. If five or fewer trials in a block were correct, the delay was decreased. In the A conditions, the length of the delay was increased or decreased by 500 ms, whereas in the B-condition, the length of the delay increased or decreased by 100 ms. Each trial was presented twice in each block, with a random order within each block.

The criterion for an asymptotic level was set as follows: The computer searched for a response pattern in which the two values were the same in three consecutive pairs of blocks, creating a clear up/down
pattern of increase/decrease in the length of the delay. After minimum of 21 training blocks, the computer program started to search for this asymptotic level of responding. Upon identification of such a pattern, the computer continued to present the lowest value of the pair for the three blocks to ensure stability of the responses. If the participant correctly responded to six out of six trials in these three training blocks, the computer program terminated the session. If the participant did not respond correctly during the stability measures, the computer was programmed to go back to look for the asymptotic level again.

3 Results

The results show a quite different response pattern depending on the step size employed. As shown in Figure 4, there was a much more varied response pattern with the longer step size (500 ms) than with the shorter step size (100 ms) for the first conditions (A1 and B1). These findings were replicated in the second conditions (A2 and B2). Furthermore, the highest value before the asymptotic level was found in Condition B2 (100 ms).

![Figure 4](image)

*Figure 4.* The four panels show the level of titrating values for the different conditions in the present experiment. The upper panels show the titration values when the step size is 500 ms, while the lower panels show the titration values when the step size is 100 ms. A1 and B1 indicate the first condition with step sizes 500 ms and 100 ms, respectively. A2 and B2 indicate the second condition with step sizes 500 ms and 100 ms, respectively.

Secondly, the results showed that stability was reached at a 0 ms delay in the first A condition (A1), at 1,800 ms in the first B condition (B1), at 4,500 ms in the second A condition (A2) and at 6,800 ms in the second B condition (B2).

Further analysis of the data revealed some systematic errors. In the first experimental condition (A1), the participant made the most errors when Stimulus 2 was the sample stimulus. The results showed that the incorrect responses were related to Stimulus 1 as the participant clicked on Stimulus 2 as the comparison stimulus instead of Stimulus 1 as the comparison stimulus (correct according to the experimenter-defined classes). However, in the second experimental condition (B1), he gave no incorrect responses when Stimulus 1 was a sample stimulus, only a few errors—7—when Stimulus 2 was the sample stimulus, and even fewer—3—when Stimulus 3 was the sample stimulus. Again, most of the errors were clicking on Stimulus 1 as the comparison stimulus when Stimulus 2 or 3 was the correct choice. In A2
(500 ms), the number of errors when the Stimulus 2 was the sample increased again to 88 incorrect responses, 16 incorrect responses to Stimulus 1 and 14 incorrect responses to Stimulus 3. The analysis of the errors showed that the participant had clicked on Stimulus 1 as the comparison stimulus most frequently when Stimulus 2 or 3 was the correct choice. In the last experimental condition (B2, 100 ms), the highest number of incorrect responses was when Stimulus 2 was presented as a sample stimulus. However, the incorrect responses were more evenly distributed between the other two incorrect comparisons (Stimulus 1 and 3).

As shown in Table 1, there was a higher RT when the participant made incorrect responses compared to correct responses. This finding holds for all conditions.

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Total RT</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Correct</td>
</tr>
<tr>
<td>A1 (500 ms)</td>
<td>2,98</td>
</tr>
<tr>
<td>B1 (100 ms)</td>
<td>2,41</td>
</tr>
<tr>
<td>A2 (500 ms)</td>
<td>2,32</td>
</tr>
<tr>
<td>B2 (100 ms)</td>
<td>2,57</td>
</tr>
<tr>
<td>Average</td>
<td>2,57</td>
</tr>
</tbody>
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*Note. One extreme score was deleted because the participant was engaged in another behavior not relevant to the MTS task.*

Table 1. The table shows the average RT from the presentation of the comparison stimuli until a response was given, for each experimental condition. All numbers are shown in milliseconds (ms). RT: reaction time.

4 Discussion

The purpose of the study was twofold: (1) to study the effect of using two different step sizes in the increased or decreased length of the delay of either 500 ms or 100 ms step sizes and (2) to find the maximum level of delay between the sample and a comparison in a person with dementia. The results from the pre-test, which used the same stimuli used later in the experiment, showed that Peter categorized the stimuli by their physical similarities. This revealed that he could do identity matching in a simultaneous matching-to-sample arrangement. Similarly, the results from the pre-training showed that he could do color matching with a 0-s delay. Taken together, these findings are important because the decrease in accuracy during the 100-ms and 500-ms conditions could not have resulted from a lack of correct matching behavior per se but rather from an issue related to stimulus control. The main findings from the present experiment were that a short step size value (100 ms) resulted in a smoother response pattern and a higher asymptotic value than a longer step size (500 ms). Finally, the RT results showed that the participant responded faster in correct choices than in incorrect choices. Thus, the participant did not respond quickly and randomly, which is in accordance with other findings (e.g., Amtzen, Braaten, Lian, & Eilfsen, 2011).
The analysis of errors suggests that the matching behavior was not under optimal stimulus control. Thus, the sample did not control for the correct comparison choice across the delays. In further experiments, an extended phase with a 0 s delay should be included before starting the titration. However, it seems that the participant’s responses in the current experiment were quite similar across the step size conditions.

The nature of the procedure, that is, the increases or decreases in delay as a function of the participant’s correct or incorrect responses, respectively, provides an important contribution to the study of remembering in patients with dementia. By using TDMTS procedures, the length of the delay at one point can be identified, allowing for an additional measure at a later point. This information could help people working with patients or their family to understand the progress of the disease and take that into consideration when adjusting the environment to best fit the participants. Because relatively few studies have used a titrating delay with humans (see for example Lian & Arntzen, 2011; Sidman, Stoddard, Mohr, & Leicester, 1971), the present study extends the knowledge of the use of such procedures. For example, Lian and Arntzen (2011) showed that with children, the FDMTS was more efficient in establishing conditional discriminations than was the TDMTS. However, the probability of minimizing the floor and ceiling effects has been argued as one of the advantages of using TDMTS compared to FDMTS (Wenger & Kimball, 1992; Wenger & Wright, 1990). These effects are further minimized using a TDMTS procedure when titrating up to an asymptotic level (Arntzen et al., 2013).

In a study by Arntzen et al. (2013), the authors found that when using DMTS with a fixed delay between the offset of the sample stimulus and the onset of comparison stimuli, the participant could respond accurately when the delay was 10,000 ms but not when the delay was 12,000 ms. As mentioned earlier, by using the TDMTS, the floor and ceiling effects of the fixed DMTS were removed, and the results showed that the delay varied between 7,500 ms to up to 12,250 ms. It should obvious that because the asymptotic titration procedure was adapted to set the maximum delay between the sample and the comparisons for each individual, the procedure used in the present experiment was superior to FDMTS. However, as mentioned, there are other procedural variables that should be studied further to fully understand the variables that can affect TDMTS responding. For example, Kangas, Berry, & Branch (2011) found that higher titration values led to more variation in responding, whereas lower titration values resulted in more stable responding. The results from the current study are in accordance with their results. Hence, future studies may evaluate what constitutes an asymptotic level of correct responding (the number of pairs of up-and-down patterns), what are the different steps for the titration of the delay between sample and comparisons, and how many trials should be the minimum requirement before starting to look for an asymptotic level pattern of responding (criterion) for when to start searching for up-and-down patterns. Furthermore, as far as the authors know, no studies with dementia patients have used TDMTS procedures and arbitrary matching. In contrast to identity matching, arbitrary matching can give more knowledge about the deterioration of complex types of behavior, such as concept formation, the generative nature of language, etc. Responding to comparison stimuli in a DMTS procedure may be considered a form of remembering because behavior is brought under control of stimuli that, at the time of reinforcement, are no longer present in the situation (Palmer, 1991). The results support the assumption that TDMTS could be a useful procedure to study variables that influence remembering in dementia patients.

Carrying out experiments with people with dementia can be quite time-consuming. Given that dementia is a progressive disease, if an experiment extends over a longer period of time, it may lead to validity problems (Shadish, Cook, & Campbell, 2002). Therefore, it may be advantageous that this type of
research is conducted within a short time period to reduce the risk of confounding variables affecting the results.

A topic related to the quite high number of sessions in each condition is the possibility of reducing the number of sessions. Some of the issues to take in consideration for further experiments are (1) the programmed consequences, (2) the criterion for increasing or decreasing the delay, and (3) how the instructions are employed. First, regarding the programmed consequences used in the present experiment, it is not quite clear what effect the text stimuli such as “super” and “incorrect” had on the participant’s matching behavior. Second, we used performance within a block of six trials to evaluate an increase or decrease in the delay. It could be that blocks of 12 or 18 trials would reduce the number of errors and therefore decrease the total number of sessions. Finally, further research should include an assessment of preferences (e.g., LeBlanc, Raetz, Baker, Strobel, & Feeney, 2008; Ortega, Iwata, Nogales-Gonzalez, & Frades, 2012). More specific instructions could also affect the matching behavior. However, the purpose of such studies as in the present experiment is to shape the matching behavior by contingencies arranged and not by rules or instructions. In more applied settings, the use of rules or instructions could be useful.

The present experiment was arranged as a withdrawal design, or what is commonly labeled a reversal design. It is a group of designs that are called single-case research designs or within-participant research designs. These designs ensure that each participant is in control of himself or herself. Hence, one of the main characteristics of this type of design is repeated measures within each participant, in contrast to what is usual in group designs (e.g., Kazdin, 2010). The use of single-case research designs is called for in work with dementia patients because such designs are useful for adapting individual treatments and providing an understanding of functions of behavior (e.g., Brooker, Snape, Johnson, Ward, & Payne, 1997). A withdrawal single case research design, as used in the present study, is quite different from what is commonly referred to as a single-case design (e.g., Bakker et al., 2010); in the former, we have experimental control. It is also important to emphasize that this type of design is much more useful than group designs with regard to adapting individual treatments.

Although drawing a firm conclusion from the current experiment is a bit premature, future studies should investigate the possibility of using TDMTS procedures with dementia patients to study the possibility of training remembering behavior. At this point, it is important that the study be replicated with more participants to see whether the same results would be obtained from other participants. When more replications have been done, it will be easier to be specific on how TDMTS procedures would be suitable for the assessment of cognitive impairment in applied settings. A related issue to the need for replication is the issue of experimental control in the present experiment. Because we have arranged the conditions as ABAB, we also need replication with the conditions arranged as BABA.

The purpose of this research project was not to replace any assessment tools currently used, for example, the MMSE (see Sheean, 2012 for an overview of different assessment tools for dementia). Nevertheless, we will argue that TDMTS procedures could be an additional tool for studying important variables in short-term memory in dementia patients. Thus, we need more replications to be more specific about the how the TDMTS procedures can be used as an assessment tool in applied settings.

Limitations with the current experiment are that it does not include any parameters for evaluating the neurobiological bases of memory impairment, and one could also argue that it does not include performances of non-demented age-matched controls. However, we will argue that the first issue, although interesting, was not a part of this research project. In addition, the second issue is related to the fact that the authors have not found any studies with elderly participants that titrate delay to an asymptotic level.
In summary, based on the previous discussion, we argue that when more knowledge is gained on the effect of other variables that affect DMTS responding, the different DMTS procedures may be useful in applied settings. For example, these procedures can be used to identify changes in or the progression of dementia, or, as already stated, they may help to identify earlier stages of dementia (Fowler, Saling, Conway, Semple, & Louis, 1995). Moreover, it appears that it is possible to use TDMTS procedures to find out details about time spans for remembering in a dementia patient in the performance of simple tasks, such as identity matching. Finally, the present experiment shows how TDMTS may be used to study important aspects of what has traditionally been characterized as short-term memory. This knowledge could in turn lead to procedures that could be used in training mnemonic techniques in people with dementia. In summary, the current experiment showed that the TDMTS procedure was more effective with a smaller (100 ms) than with a longer (500 ms) step size. The experiment was arranged as a within-participant research design and a withdrawal design and, thus, shows quite good experimental control. However, it is necessary to do more replications with a variety of people with dementia to increase the generality of the findings.

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References


