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## Identity matching in a person with Alzheimer's disease

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### ABSTRACT

In the present study, a 91-year-old woman with Alzheimer's disease participated. The purpose of the experiment was to study how repetitions of conditions affected correct responding in identity matching-to-sample. The participant was presented with identity matching training with three colors (yellow, blue, and red). It was alternated between (A) delayed matching-to-sample 0 s (DMTS 0 s) and (B) simultaneous matching-to-sample (SMTS). These two conditions were repeated in six phases in an ABABAB-design. In the second part of the experiment, the participant was exposed for the same six phases again but with another set of color stimuli (green, orange, and purple). The results showed that the number of trials needed to meet the criterion for training decreased as the conditions were repeated, also with the new set of stimuli.

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Dementia; Alzheimer's disease; simultaneously matching-to-sample; delayed matching-to-sample; identity matching; remembering

Worldwide, the estimated life expectancy has steadily increased. With the increasing life expectancy, the incidence of age-related diseases, such as dementia, has also increased. Worldwide, nearly 47 million people are affected by dementia, and it is estimated that the number will be over 131 million by 2050 (Prince, Comas-Herrera, Knapp, Guerchet, & Karagiannidou, 2016). Difficulties with remembering are the most distinct behavioral change in people with dementia. Alzheimer's disease is the most common cause of dementia, and it is initiated by protein abnormalities in the brain (Alzheimer's Association, 2018). Existing medical treatments only treat the symptoms in the early stages of the disease, but the changes in the brain are irreversible (Patterson, 2018).

Based on the large number of people affected by dementia, nonmedical treatments with a focus on early detection of the disease, interventions for measuring the progression of the disease, and interventions that focus on maintaining and retraining functional skills, would provide great individual and social benefits. However, research related to the rehabilitation of cognitive functioning or remembering in people with dementia is modest (e.g., Clare, 2008), and the efficacy of cognitive rehabilitation is discussed. A review of 11 randomized controlled trials (RCT) with cognitive training interventions indicate a minimal effect on cognitive function, moods or daily living. However, the quality of the RCTs have been questioned (e.g., Bahar-Fuchs, Clare, & Woods, 2013). Some other studies have concluded that cognitive training interventions are effective in for example training daily activities with the help of memory aids, electronic devices, calendar, notes to remember, etc. (e.g., Brodaty & Arasaratnam, 2012; Germain et al., 2018).

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Within behavior analysis, delayed matching-to-sample (DMTS) is a procedure used to study cognitive functioning such as remembering (Palmer, 1991). In a matching-to-sample (MTS) procedure, the sample and comparisons can be presented simultaneously on the screen (SMTS) or with a delay (DMTS). In SMTS, the sample stimulus is first presented; then, the participant responds to the sample, and the comparison stimuli are presented. Hence, the sample stimulus remains presented after the comparison stimuli appear. In DMTS, a sample is first presented; then, after responding to the sample stimulus, the sample disappears, and the comparison stimuli are presented after a delay (e.g., Arntzen, 2006; Blough, 1959). Remembering can be described as emitting a correct response to a comparison stimulus after a temporal delay between the offset of a sample stimulus and the onset of the comparison stimuli (White, 2013). The MTS procedure has been used to assess the progression of dementia (Fowler, Saling, Conway, Semple, & Louis, 1995), and in maintaining and retraining functional skills (Brogård-Antonsen & Arntzen, 2019; Cowley, Green, & Braunling-McMorrow, 1992; Ducatti & Schmidt, 2016; Steingrimsdottir & Arntzen, 2014).

A modest number of behavior analytic studies have been published in which participants with dementia have been presented with the MTS procedure to study variables influencing remembering. The stimuli in such procedure could be matched according to physical features of the stimuli, through identity matching, or by arbitrary matching, in which there are no physical similarities between the stimuli (Sidman & Tailby, 1982). Steingrimsdottir and Arntzen (2011a) employed a 30-point questionnaire called the Mini-Mental State Examination (MMSE) (Folstein, Folstein, & McHugh, 1975) to assess cognitive functioning in a man with Alzheimer's disease. He had an MMSE score of 10, indicating severe cognitive impairment. He was presented with conditions of identity SMTS and DMTS 0 s and with different numbers of comparison stimuli. The results showed that the accuracy (number of correct responses) increased when the number of comparison stimuli was decreased in SMTS. Hence, when the participant was presented with DMTS 0 s, the number of correct responses was at chance level, also with only two comparison stimuli. In another study (Steingrimsdottir & Arntzen, 2011b), an 84-year-old woman with dementia and an MMSE score of 20 (moderate cognitive impairment) was also presented with different MTS-procedures. The participant did not respond to mastery criterion when she was presented with arbitrary MTS, but when she was presented with identity SMTS and DMTS with 0 s, 3 s, 6 s, and 9 s delays, she met the mastery criterion. DMTS 0 s and DMTS 3 s were presented twice, and as the conditions were repeated, the number of trials to mastery criterion decreased. However, the accuracy decreased as the delays increased to 6 and 9 seconds.

Previous studies have also revealed that, in participants with dementia, correct responding in MTS training and testing is influenced by the length of the delay between the sample and the comparison stimuli (e.g., Arntzen, Steingrimsdottir, & Brogård-Antonsen, 2013; Steingrimsdottir & Arntzen, 2011a, 2011b). By alternating between SMTS and DMTS, it is possible to study whether the performance is intact with simultaneous presentation of the stimuli and impaired when there is a delay between the sample stimulus and the comparison stimuli. As such, Sidman (2013) suggested that the DMTS procedure could be used to identify what the person with dementia still remembers.

The aim of the experiment was to investigate whether there was a difference in responding in identity matching when a participant with Alzheimer's disease was presented with DMTS 0 s and SMTS conditions. Additionally, we wanted to explore how repetitions of these conditions affected the identity matching performance, measured in number of trials used to met the mastery criterion in the different training blocks. Finally, matching performance within session and between sessions were studied as function of repetitions of the two conditions (DMTS 0s and SMTS).

## **Method**

### ***Participant***

The participant, Mary, was a 91-year-old woman diagnosed with Alzheimer's disease. Mary had a score of 17 on the MMSE (see Folstein et al., 1975) at the start of the experiment. Mary had normal vision with the use of glasses and no problems seeing colors. She lived in a small apartment close to the nursing home and had a daycare service four days a week.

A consent form for participation was signed before the experiment started, as she was considered to be competent to give consent by her care personnel and family members. The consent form was formulated with simple sentences, specially adjusted for people with cognitive decline. One of the care personnel asked before each session if she wanted to participate or not. Mary said she enjoyed participating in the experiment, and she never refused to participate. The Norwegian Regional Ethics Committee (REK) had approved the experiment as a part of a larger research project.

Six years earlier, had Mary been presented with arbitrary MTS and the conditional discriminations were not established. At that time, she had an MMSE score of 21.

### ***Stimuli***

The stimuli used in the identity-matching training sessions were color stimuli presented in a 3.5 × 3.5cm square on the screen. Stimulus Set 1 contained the colors red, blue, and yellow and Stimulus Set 2 contained purple, green, and orange.

### ***Apparatus and setting***

The stimuli were presented on a Microsoft Surface Tablet (Microsoft Windows 10 pro). The participants used a Microsoft Surface Pen, 14.93 cm length, and diameter 0.97cm diameter to respond to the stimuli. Further, the MTS-tasks were presented through a custom-made MTS-program, which recorded all responses.

The experimental sessions were conducted in a small office with a desk and a chair. Mary sat on the chair next to the desk, and the experimenter sat on the floor, diagonally behind her on her left side.

## Pretraining

Before the experimental conditions were presented, Mary had a pretraining with tapping on the stimuli presented on the computer tablet. She was presented with ten trials with the stimulus, including the text “tap here” (in Norwegian).

## Sessions

All of the sessions were conducted between 11:30 am and 1:00 pm, and each session consisted of 90 trials. When the participant was presented with more than one session per day, the sessions were separated with a pause of 15 minutes. The results were collected over seven weeks.

## Design and conditions

Mary was presented with 12 phases of identity matching (see [Table 1](#)). The first six phases were presented in an ABABAB-design, where the A-conditions were DMTS 0 s, and the B-conditions were SMTS. Stimulus Set 1 was used in both conditions. The last six phases were presented in an A1B1A1B1A1B1-design, with the same conditions, although Stimulus Set 2 (see [Table 1](#)) were used.

## Instructions

At the start of each session, Mary was presented with a sheet of paper with written instructions, which she read aloud. The instructions were available for Mary during the entire session. The instructions were written in Norwegian, saying:

A picture or text will be presented at the top of the screen. Choose the picture or the text by tapping the screen. Then, three other pictures will be presented at the corners of the screen. Choose the picture or the text that you think is correct by tapping it. You will be told whether you have chosen the correct or wrong picture/text, but that will stop after a while. It is important that you pay attention to the feedback you get. Good luck!

If Mary did not respond to the stimuli on the screen within 10 seconds, or if Mary asked what to do, the experimenter prompted pressing the sample stimulus by saying “tap on

**Table 1.** Overview of Phases 1–12.

	Phase	Type of Matching	Stimuli	Comparison Presentation
A	1	Identity	Red, Blue, Yellow	Delay 0 s
B	2	Identity	Red, Blue, Yellow	Simultaneously
A	3	Identity	Red, Blue, Yellow	Delay 0 s
B	4	Identity	Red, Blue, Yellow	Simultaneously
A	5	Identity	Red, Blue, Yellow	Delay 0 s
B	6	Identity	Red, Blue, Yellow	Simultaneously
A1	7	Identity	Purple, Green, Orange	Delay 0 s
B1	8	Identity	Purple, Green, Orange	Simultaneously
A1	9	Identity	Purple, Green, Orange	Delay 0 s
B1	10	Identity	Purple, Green, Orange	Simultaneously
A1	11	Identity	Purple, Green, Orange	Delay 0 s
B1	12	Identity	Purple, Green, Orange	Simultaneously

the one in the middle,” or, when the comparisons were presented, the experimenter said, “tap the one that you think is correct.”

### ***Identity matching training***

In the SMTS, a sample stimulus was presented in the center of the computer screen. After Mary tapped on the sample stimulus with the touch pen (observing response), three comparison stimuli were presented randomly in the corners, leaving one corner blank. Both the sample stimulus and the comparison stimuli were on the screen at the same time. After responding to one of the comparison stimuli, a programmed consequence was presented in the center of the screen for 1,500 ms. The programmed consequences were written text. If Mary responded to the identical comparison, words (in Norwegian) such as “Super,” “Good,” “Fantastic,” etc. were presented on the screen. The words used as programmed consequences had shown to have an increasing effect on Mary’s behavior in other contexts. If she responded to a non-identical comparison, the word “Wrong” was presented on the screen. The word used as a programmed consequence had shown to have a decreasing effect on Mary’s behavior in other contexts. After the programmed consequence was presented, the screen went white for 500 ms, before a new sample was presented. Thus, the inter-trial interval was 2,000 ms. The number of correct responses was presented in the bottom right corner during the training but not during the last training block (see details below).

In DMTS 0 s, all of the parameters were similar to those for SMTS, except for the presentation of the comparison stimuli. Hence, the sample stimulus disappeared once Mary tapped it, after which three comparison stimuli were immediately presented in the corners of the screen.

The training for both the SMTS and the DMTS 0 s conditions included four training blocks of 30 trials (presenting each color ten times) and a fifth block with 90 trials. In the first four blocks, the mastery criterion was 90%. In the first training block, programmed consequences were presented for every response. Once Mary met the mastery criterion, the programmed consequences were reduced to 75% (Training Block 2) of the responses in the block, and further to 50% (Training Block 3) and 0% (Training Block 4) of the responses. If the mastery criterion was not met, the training block was presented again. The fifth training block had 90 trials with no programmed consequences. When the participant met the mastery criterion in Training Block 3, Training Blocks 4 and 5 followed without interrupting the session after 90 trials. Extended trials in the last session of the conditions were used with the purpose of not starting a new session in extinction. Training Block 5 in Phase 2 (SMTS) was not presented immediately following Training Block 4. The participant was presented for Training Block 5 in the following session, where she had a high number of incorrect responses. The high number of incorrect responses were presumably caused by the presentation of the MTS without programmed consequences, and the use of extended trials in the last part of the training was therefore implemented (*see results*).

### ***Guidelines for interruption of the phase and the experiment***

The progression in training was evaluated after the fourth session (360 trials) to ensure that she had an increase in mastery. In the fourth session, if the percentage of correct responses was lower than 33.3% (chance level), the phase ended. If the

percentage of correct responses was between 33.3% and 50%, the last 50 trials were divided into two, and the difference between correct responses for the two halves was compared. If the percentage had increased with more than 10 percentage, the phase continued. A difference of 10 percentage points or less indicated no substantial progression in training, and the phase ended. Additionally, if there were over 50% correct responses, the training continued, and, subsequently, the training was evaluated after every third session. The training continued if the percentage of correct responses increased by five percentage points compared with the last evaluation.

The session would end if Mary asked for it. Moreover, it was stated that, if she showed any signs of discomfort, the session would stop and evaluate further participation in the experiment.

## Results

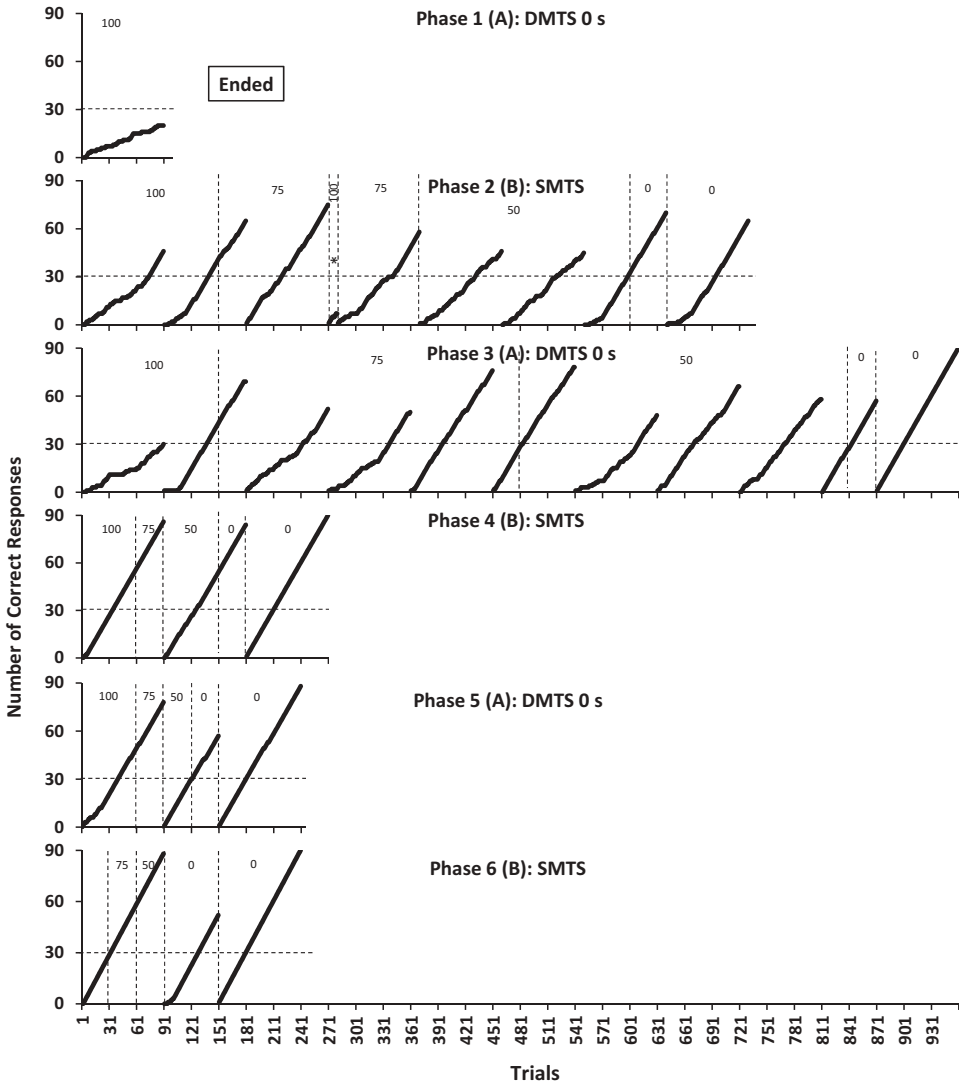
Tables 1 and 2 show the results from Phases 1, 2, 3, 4, 5, and 6 (ABABAB) and Conditions 7, 8, 9, 10, 11, and 12 (A1B1A1B1A1B1), respectively. Each cumulative curve represents one session. In the first phase, Mary was presented with DMTS 0 s. This phase ended after only one session because Mary showed small signs of frustration through sighing, looking back and forth at the experimenter, and saying: “Everything I do is wrong.” In addition, the results showed that she responded at chance level. When Mary was presented with the second phase (SMTS), she had 46 of 90 correct responses in the first session, and the correct responses increased during the last part of the session. This pattern in which her correct responses increased during each session, was almost the same for all of the sessions in Phases 2 (SMTS) and 3 (DMTS 0 s) (see Figure 1).

At the 75% level of programmed consequences, between Sessions 3 and 4 in Phase 2 (SMTS), Mary had a pause from the experiment of 18 days. Because of this break, she was presented with 10 trials of training with 100% programmed consequences, before she continued the training at the 75% level.

In Figure 1, most of the curves show incorrect responding occurring at the beginning of the session and increased correct responding towards the end of the session. This pattern of responding changed as the conditions were repeated, and in Phases 7–12, the cumulative curves showed a steady increase through all sessions (see Tables 2).

Mary was presented with SMTS in Phase 2, which was the first condition in which she met the mastery criterion after 630 trials. In Phase 3 (DMTS 0 s), the total number of trials was 870. In both Phases 2 (SMTS) and 3 (DMTS 0 s), the number of trials to meet the mastery criterion during the training blocks increased as the programmed consequences decreased from 75% and 50%. However, in the following phases, the number of trials to mastery criterion gradually decreased to the minimum number of trials needed in all of the training blocks in the three last phases (see Figure 1).

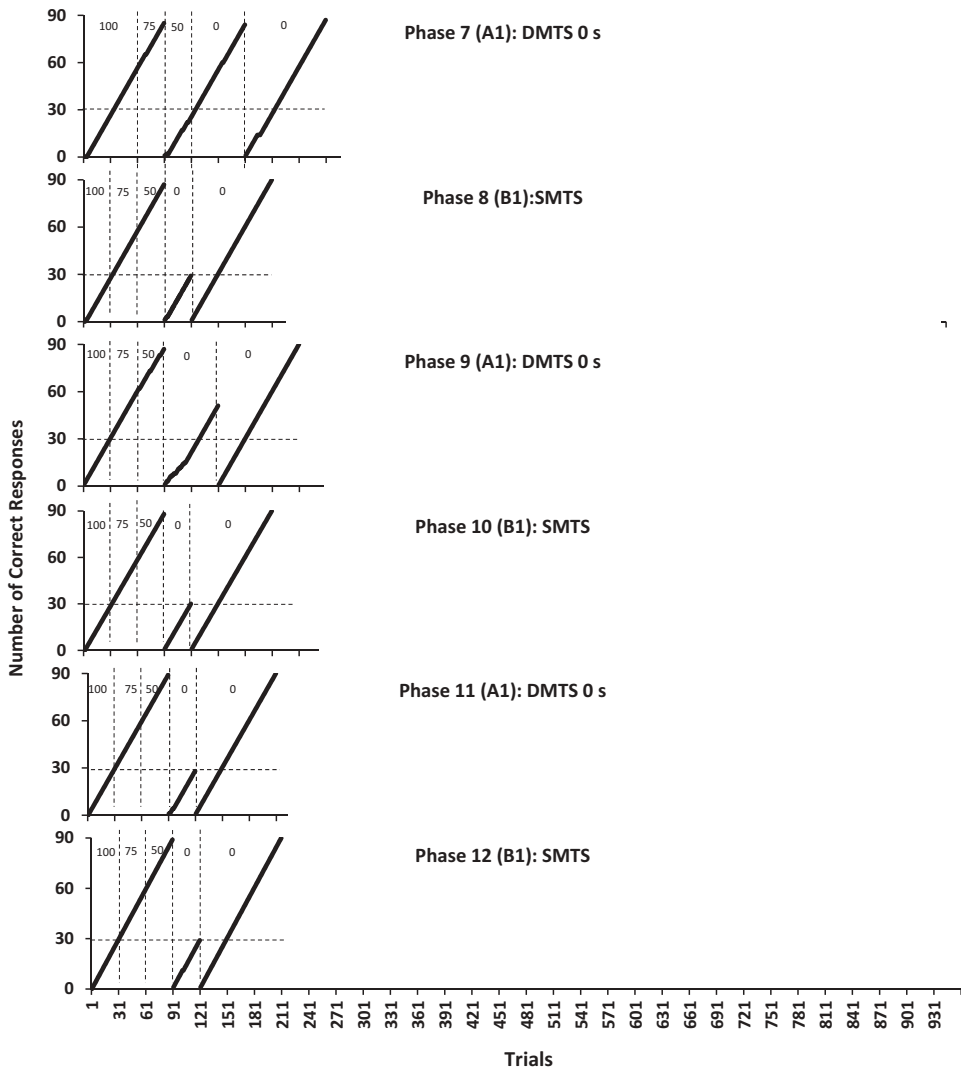
To study if the accuracy decreased in training when the stimuli were changed, another set of color stimuli were presented in Phases 7–12. The level of trials to mastery criterion increased slightly from Phases 6 (SMTS) to Phase 7 (DMTS 0 s). Mary used only the minimum number of trials needed in Phase 8 (SMTS). The number of trials increased slightly in Phase 9 (DMTS 0 s) but stabilized at the minimum number of trials needed in the last three phases.



**Figure 1.** The figure presents Mary’s cumulative curves in Phases 1–6, where the color stimuli red, blue, and yellow were used. Each curve represents one session. The dashed lines indicate the shift between the different training blocks. The numbers, 100, 75, 50, and 0, in the graph indicate the percentage of programmed consequences within different phases. \* due to an uncontrolled circumstance, Mary had an 18-day pause in training. She was therefore, presented for 10 trials of training with 100% programmed consequences.

Comparing the number of trials to the criterion used in SMTS and DMTS 0 s, DMTS 0 s required more trials than SMTS in the first three phases. A similar, but smaller difference was also seen in the first phases when the participant was presented for the new set of stimuli.





**Figure 2.** The figure presents Mary’s cumulative curves in Phases 7–12, where the color stimuli orange, purple, and green were used. Each curve represents one session. The dashed lines indicate the shift between the different blocks of training. The numbers, 100, 75, 50, and 0, in the graph indicate the percentage of programmed consequences within different phases.

**Discussion**

The purpose of this study was to investigate how the participant responded to identity matching with a recurring presentation of DMTS 0 s and SMTS conditions. We wanted to compare the matching performance within the session and between sessions. Hence, to explore if it was possible to achieve a steady level of correct responding, and, through repetitions of conditions, to reduce the number of trials needed to reach mastery criterion.

### ***Within and between session performance***

The continuous registration of the participant's responding within the sessions is presented in the cumulative curves in Figures 1 and 2. The cumulative curves provide essential information about when the incorrect responding occurred in a session (e.g., Fahmie & Hanley, 2008). Visual inspection of the cumulative curves, especially for Phases 2 and 3, shows the slowly increasing curves at the beginning of the session before the curves become steeper at the end of the sessions. The incorrect responding at the start of the sessions may indicate that stimulus control had been deteriorated between the sessions and that some repetitions were needed until correct stimulus control was reestablished. After several repetitions of the procedure, the number of incorrect responses decreased between sessions, which indicated that stimulus control was intact from the beginning of the session in both SMTS and DMTS 0 s.

Mary reached the mastery criterion in all phases, except for Phase 1 (DMTS 0 s), which was interrupted after only one session. All the phases, except Phase 2 (SMTS), included an extended number of trials in the session when she met mastery criterion in Training Block 3 (50% programmed consequences). Training Blocks 4 and 5 (both with 0% programmed consequences) were presented without interrupting the session. As mentioned earlier, Phase 2 did not include an extended number of trials in the end of the phase. In Phase 2 was Training Block 5 presented in a separate session. In this training block, Mary had 65 of 90 correct responses, which may have been caused by the lack of programmed consequences in the beginning of the session. As seen in the cumulative curve for the last session in Phase 2 (see Figure 1), most of the incorrect responses were at the beginning of the session.

### ***SMTS and DMTS 0 s conditions***

The results show that identity matching was established in both SMTS and DMTS 0 s conditions through repetitions of these conditions. Although, when comparing the number of trials to meet the mastery criterion in the different SMTS and DMTS 0 s conditions, Mary used a higher number of trials in Phase 3 (DMTS 0 s) than Phase 2 (SMTS). Assumingly, the participant has to behave differently when responding correctly to the comparison in SMTS compared with DMTS because the sample is no longer present. Sidman (1969) suggested that some behavior had to fill the gap between the offset of the sample and the presentation of the comparisons. Lowenkron (1988) discussed how a common response to the relations may facilitate correct responding, for example, by repeating the name of the sample, and when the sample stimulus disappears, and comparison stimuli appear, the stimuli selected are the one that evokes the same response, so-called joint attention.

These differences in number of trials between SMTS and DMTS 0 s were also seen in the first three phases when the new stimulus set was presented. This finding is in accordance with other studies with participants with dementia (Sahgal, Galloway, McKeith, Lloyd, S., & et al. 1992; Steingrimsdottir & Arntzen, 2011a, 2011b). However, Saunders et al. (2005) did not find the effect of increased number of trials for DMTS 0s in senior citizens.

Additionally, the participant in the present study had a high number of incorrect responses in Phases 2 (SMTS) and Phase 3 (DMTS 0 s), when the programmed consequences were reduced. The lower accuracy when the programmed consequences were reduced, is in accordance with the findings in other studies with participants with dementia (e.g. Ducatti & Schmidt, 2016; Steingrimsdottir & Arntzen, 2011a). Moreover, as the phases were repeated, the number of trials needed to meet the mastery criterion in training was stabilized at the minimum level of correct responses in Phases 10–12. The level of correct responses was not affected by the change of stimuli set, and the results showed identity matching performance with a new set of color stimuli.

### **Tailoring of tasks**

Positive effects of interventions are more likely when tailoring tasks based on the individual's performance (Bahar-Fuchs et al., 2013). Functional-based interventions as a treatment of behavioral symptoms in people with dementia have been suggested as the first recommended treatment (Dyer, Harrison, Laver, Whitehead, & Crotty, 2018). The present study is an example of how tasks can be individually tailored. The participant had earlier been presented with arbitrary matching without meeting the mastery criterion. She was, therefore, presented with identity matching, which is a presumably easier task. Further, the participant did not meet the mastery criterion in the first phase (DMTS 0 s) with identity matching and was, for that reason, presented with the next level of a presumably easier task, in the second phase (SMTS). As a result, the tailored tasks were designed such that the number of trials to criterion was reduced, and the number of correct responses increased, as the conditions were presented in a reversed design.

Another adjustment of the procedure was changing of time between training blocks. Hence, Training Blocks 4 and 5 were done without interrupting the session when the mastery criterion was met in Training Block 3. After Phase 2, Training Blocks 3, 4, and 5, were presented in one session. This adjustment was made because Mary had only 65 of 90 correct responses in Phase 2 when Training Block 5 (with no programmed consequences) was presented at the beginning of a new session.

### **Application**

Furthermore, the MTS procedure has been suggested to be used in the development of behavior technology to help patients with dementia to remember and reestablish functional skills that have been deteriorated (see Aggio, Ducatti, & de Rose, 2018). It has earlier been suggested that the MTS procedure could be used to study the progression of dementia and also as a useful tool to screen for cognitive functioning. Sidman (2013) suggested that the use of DMTS may give us information about remembering and forgetting in people with dementia. For example, the use of identity matching and delay between the sample and comparison stimuli, could make it possible to study the progression of dementia and the behavioral effects of medical interventions. Further knowledge about how different delays (Saunders, Chaney, & Marquis, 2005; Steingrimsdottir & Arntzen, 2011a, 2014), type of matching and stimuli (Arntzen et al., 2013; Camara, Ducatti, & Schmidt, 2017; Steingrimsdottir & Arntzen, 2011b), and number of comparisons (Steingrimsdottir & Arntzen, 2011a) affect correct responding

in the conditional-discrimination procedure in older adults and older adults with dementia are essential for developing procedures to be used in more applied settings.

The present study contributes to the knowledge of how the repetitions of MTS based conditions may improve the performance in a person with dementia. Furthermore, the findings from this study may be important when developing interventions to maintain the ability to remember relations between stimuli that are important to each individual with dementia.

### ***Limitations and further research***

There are some limitations in the present study. First, the results would be strengthened with more participants in future studies. Second, the experiment does not include a preference test for potential reinforcers. Such an assessment should be included in future experiments. Third, because dementia is a progressive disease, the length of the period in which the data were collected, could pose a threat to external validity. When collecting data over longer periods in participants with dementia, successful systematic replications in other participants can be difficult due to individual changes in cognitive functioning. Therefore, short periods of data collection could be advantageous.

Because dementia is a progressive disease, where the progression of the illness varies from person to person, already published studies need to be replicated in more participants. To assess for generalization of the MTS-training, it would be of interest to study how participants with dementia respond when presented novel stimuli in an identity matching test after the MTS-training and test (see, Camara et al., 2017; Steingrimsdottir & Arntzen, 2011a). Furthermore, it is important to replicate earlier studies which have employed MTS training and tests with longer delays (Steingrimsdottir & Arntzen 2011b), and showed maintenance of matching performance over time (Brogård-Antonsen & Arntzen, 2019). In sum, the studies suggested above would gain more knowledge about the use of the MTS-procedure to detect behavioral changes related to the progression of the disease.

### ***Summary***

The participant was presented with a series of DMTS 0 s and SMTS conditions. Positive effects of the procedure were observed both within and between sessions. The within-session analysis showed that correct responding increased from the first part of a session towards the end of a session at the beginning of the experiment. The between-session analysis from the first part of the experiment showed that the identity matching performance that was established at the end of the sessions was deteriorated between the sessions. This pattern of deterioration was reduced after several repetitions of conditions and coulsented multiple times, the number of trials needed to meet the mastery criterion was stable at the minimum number of trials. And finally, the number of correct responses was not impeded by the change of stimuli used, as shown by matching performance with different color stimuli.

## Disclosure statement

The authors declare that there is no conflict of interest.

## Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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## Informed consent

Informed consent was obtained from all individual participants included in the study.

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