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BRIEF REPORT

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Analyzing conditions for recognizing pictures of family members in a patient with Alzheimer's disease

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Abstract

In the present study, an 89-year-old woman with the neurocognitive disorder Alzheimer's disease participated. The purpose was to study recognition of the participant's relatives' faces with the use of sorting tests and matching-to-sample (MTS) trainings and tests for emergent relations. The stimuli used were pictures of her relatives, their written names, and their family relationship. The study also focused on how responding to pictures of relatives changed over time. Therefore, the participant was presented with experimental conditions over three time periods. Time Period 1 included only sorting tests. In Time Period 2, which began 9 months after Time Period 1, the participant was presented with both sorting tests and conditional discrimination training and testing. In Time Period 3, which began 1 year after Time Period 2, both sorting tests and conditional discrimination training and testing were again presented. The results from Time Periods 2 and 3 showed that the percentage of stimuli sorted correctly was maintained over time. Additionally, the results from the MTS training and tests were maintained at the second follow-up periods.

KEYWORDS

conditional discrimination, matching-to-sample, neurocognitive disorder, sorting test, stimulus equivalence

1 | INTRODUCTION

Worldwide, 47 million people live with a neurocognitive disorder (NCD) today, and this number is estimated to nearly triple by 2050 (Prince, Comas-Herrera, Knapp, Guerchet, & Karagiannidou, 2016). A commonly used screening in clinical and research settings for cognitive impairment such as NCD is the Mini-Mental Test Examination (MMSE; Folstein, Folstein, & McHugh, 1975). The MMSE is a 30-point questionnaire where each question counts as one point. Age and education, among other factors, have been discussed as variables influencing on the MMSE score. A score from 30 to 24 indicates no cognitive impairment, a score between 18 and 23 indicates mild cognitive impairment, and a score from 10 to 17 indicates severe cognitive impairment (Tombaugh & McIntyre, 1992).

The most intrusive behavioral change in people with NCD is difficulties with remembering. In order to offer good care to people with NCD, knowledge about remembering and the individual's progression of the disease are important. Likewise, applying interventions to help individuals with NCD and their significant others are essential. Within behavior analysis, the matching-to-sample (MTS) or conditional discrimination procedures have been suggested as important contributions to the study of remembering (Palmer, 1991; Sidman, 2013). These procedures have been used for a long time in both applied and experimental studies within behavior analysis (e.g., Kirshner & Sidman, 1972; Sidman, 1969; Sidman, Stoddard, & Mohr, 1968).

MTS procedures are used to study phenomena such as complex human behavior, including the formation of concepts, language, and stimulus equivalence. Formation of equivalence classes can be useful in the description of cognitive processes. Furthermore, stimulus equivalence gives a description of formation of classes of stimuli without direct training. After training some stimulus relations, untrained relations can be tested. An example of an existing equivalence class could be the written word for “cat,” a picture of a cat, and a cat; despite of different modalities, all of the different stimuli leads to the verbal response “Cat” (Arntzen & Steingrimsdottir, 2014; Green & Saunders, 1998; Sidman, 1994). Stimulus equivalence is defined by the characteristic responding in accordance with reflexivity, symmetry, and transitivity and refers to the interchangeability of the stimuli. Conditional discrimination training can be presented as training stimuli A to B and B to C; then, in the test, responding to A in the presence of A and B in the presence of B will be in accordance with reflexivity. Furthermore, responding to A in the presence of B and responding to B in the presence of C will be in accordance with symmetry. Responding in accordance to transitivity would be choosing C in the presence of A (Sidman & Tailby, 1982).

Some studies have used MTS procedures and formation of equivalence classes in the study of remembering in older adults and people with NCD (Arntzen & Steingrimsdottir, 2014; Gallagher & Keenan, 2009; Pérez-González & Moreno-Sierra, 1999; Steingrimsdottir & Arntzen, 2011a, 2011b, 2014, 2015, 2016). Hence, MTS training and tests have been suggested as an additional approach to the MMSE of testing cognitive functioning (Gallagher & Keenan, 2009) and for measuring the progression of NCD such as Alzheimer's disease (AD) through repetitive training and testing over time (Steingrimsdottir & Arntzen, 2011a). Also, the training and testing in MTS format have been suggested as a tool to maintain skills over time (Steingrimsdottir & Arntzen, 2014).

In the study by Gallagher and Keenan (2009), 15 participants with NCD were trained four baseline conditional discriminations and tested for the emergence of two 3-member equivalence classes. The results showed correspondence between equivalence class formation and performance on the MMSE. The results showed that 90% of the participants with an MMSE score at 27 or above responded in accordance with stimulus equivalence. Furthermore, the participants that scored 26 or lower did not form equivalence relations.

In people with NCD, one of the most emotionally distressing behavioral changes for the patient and his or her significant others is the loss of recognition of faces. Sidman (2013) argued that a behavioral account of recognition of faces could be described as a relationship between dictated or written names, and the person or the picture of the person. Additionally, Sidman suggested that it might be possible to identify which relations are intact and which are not and to try to re-establish relations in face recognition by the use of MTS training and testing.

As far as the authors know, only a modest number of stimulus equivalence studies has focused on recognizing face stimuli. However, Cowley, Green, and Braunling-McMorrow (1992) conducted a study with three men with

brain injuries, whom all had difficulty in matching spoken words with written words and objects. With the use of MTS training, the participants were presented with stimuli including dictated names, faces, and written names. The results showed that two of the participants demonstrated the emergence of untrained relations after the conditional discrimination training. The authors called for experiments that include the maintenance of emergent relations. This study by Cowley et al. (1992) is relevant, even if it is challenging to compare traumatic brain injuries and NCD, because NCD is a progressive disease. Ducatti and Schmidt (2016) did an experiment with conditional discrimination training that included stimuli of the faces of the staff at the nursing home where the participants lived. The results showed that patients with NCD established conditional relations after systematical adjustments of the training procedure. The authors called for approaches to maintain skills in people with NCD.

Dymond and Rehfeldt (2001) emphasized the importance of supplemental measures, such as sorting tests, when studying emergent relations. On such measure is sorting of stimuli. The sorting or categorization of stimuli has been used as an additional measurement in a series of experiments that include MTS training and testing (e.g., Arntzen, Granmo, & Fields, 2017; Arntzen, Norbom, & Fields, 2015). In these experiments, has the order of MTS tests and sorting tests been manipulated. However, sorting tests have been presented before MTS training and testing to ensure that the participants do not partition the stimulus set into experimenter-defined classes beforehand. A test presented before the training can be used to identify relations between stimuli that have been weakened in people with NCD (Sidman, 2013; Steingrimsdottir & Arntzen, 2014).

In the present study, the participant was presented with class formation sorting tests, conditional discrimination training and testing of emergent relations with the participant's relatives as stimuli. The purpose of the experiment was to study the maintenance of face recognition as a function of presenting a sequence of sorting tests without any programed consequences. Also, to determine how the results on the sorting tests changed as a function of time. The class formation sorting test were presented 9 months later, in addition to conditional discrimination training and testing. Finally, both the class formation sorting test and conditional discrimination training and testing were presented again after 1 year.

2 | METHOD

2.1 | Participant

The participant, called Jane, was a woman diagnosed with AD. Jane was 89 years old, and her score on the MMSE (Folstein et al., 1975) was 14 at the beginning of the experiment. Such an MMSE score indicates severe cognitive impairment. No other tests for cognitive functioning had been carried out, and no information about the onset of the disease had been recorded. Jane lived by herself and had a daycare service for patients with NCD 4 days a week. Jane was considered to be competent to give consent by her relatives and her health care personnel. She signed a consent form to participate before the study began. The form was especially adjusted for people with cognitive impairment and included short sentences and no difficult terms. The form included information about the study, anonymity, and the right to withdraw at any time. Jane was also asked before each session if she wanted to participate.

2.2 | Criterion to terminate an experimental session

The guidelines for interruption described that if Jane showed any signs of discomfort, the session would be stopped and further participation in the experiment would have to be evaluated. Also, if Jane requested it, the session would end, which did not happen.

2.3 | Stimuli, apparatus, and setting

The stimuli used in the experiment were photo portraits of three relatives of the participant, written words indicating the family relationship to Jane (e.g., oldest son, youngest son, and son-in-law), and the family members' written names (see Figure 1).

In the class formation sorting tests, the stimuli were presented as laminated cards, 12.5 × 8.5 cm in size. Furthermore, in the conditional discrimination training, the stimuli were presented on a Microsoft Surface Tablet (Microsoft Windows 10 pro). Jane responded to the stimuli with a Microsoft Surface Pen, 14.93 cm in length, and 0.97 cm in diameter. The conditional discrimination training was presented with a custom-made MTS program developed and used in several experiments the second author's lab. The MTS program presented the stimuli and the programed consequences, and recorded all responses. The size of the stimuli presented on the screen was 2 × 3 cm. At the bottom left corner, the number of correct responses was shown.

The class formation sorting tests were conducted in a meeting room at the nursing home. The room had two tables. One of the walls had windows that led out to a backyard. Jane sat on one side of the tables with her face to the window, and the experimenter sat on the other side of the table facing Jane. Jane had her back to the other table.

The conditional discrimination training was conducted in a small office with a desk and two chairs. Jane sat on one of the chairs next to the desk with the computer tablet, and the experimenter sat 1 m diagonally behind Jane, on her left side.

2.4 | Time Period 1

The different experimental conditions were presented over three time periods, starting with Time Period 1 (see Figure 2).

2.4.1 | Class formation Sorting Test 1

The stimuli were presented in a table-top format. Jane was given a stack of stimulus cards, which were shuffled between each presentation. The instruction was “Sort the cards” (in Norwegian). The stack of stimuli was presented six times on the same day.

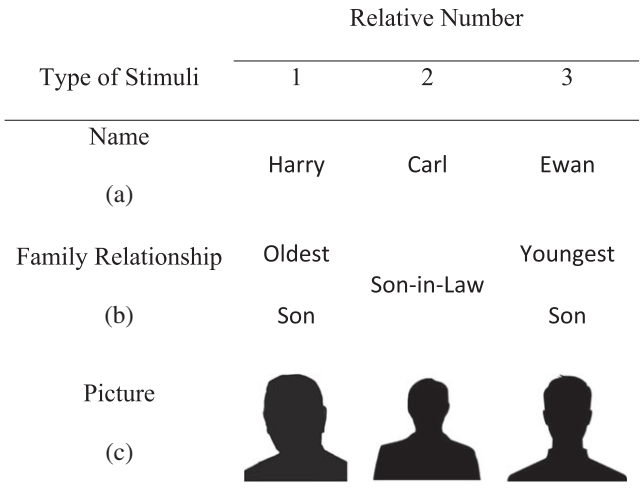

FIGURE 1 The stimuli used in the experiment. Each relative had their number and three different types of stimuli. The family relationship (B stimuli) used in the experiment was written in Norwegian, and the pictures were portrait photos but are not presented for reasons of anonymity

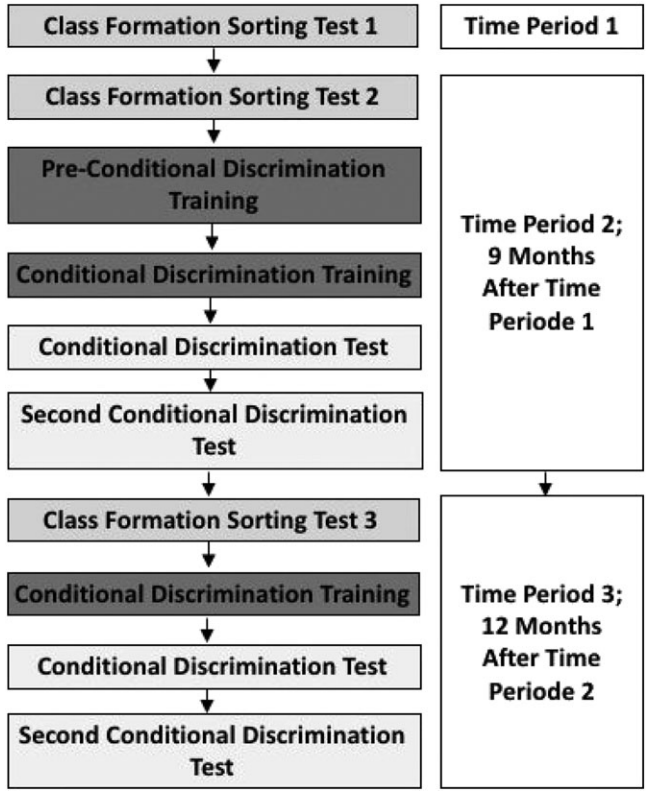

FIGURE 2 The figure shows the order of the different conditions presented to Jane. The medium-gray boxes are the formation sorting test presented table top, the dark boxes are the conditional discrimination training (CD), and the light gray boxes are the conditional discrimination tests

When the participant asked questions related to the task such as "Who is this?" or "Is this Ewan's wife?", the experimenter answered, "I'm not sure" or "I don't know." Furthermore, the sorting test ended when she stopped sorting the cards and held her hands together for 5 s or told the experimenter that she had finished. Finally, the experimenter took a picture of the cards. A class or group was defined as when the stimuli cards were placed on top of each other in a stack clearly separate from one another.

2.5 | Time Period 2

Time Period 2 began 9 months after Time Period 1.

2.5.1 | Class formation Sorting test 2

A sorting test similar to Sorting Test 1 was presented.

2.5.2 | Conditional discrimination training and test

Pretraining

To ensure that Jane was able to respond to the stimuli presented on the tablet screen, she was trained to tap the stimuli by presenting the text "Tap here" (in Norwegian). The pretraining included 40 trials.

Instructions

Before each session of conditional discrimination training, Jane was presented with a written instruction on a sheet of A4 paper. The sheet with the instructions was placed next to the computer tablet and was available during the training. The instructions in Norwegian were as follows:

> *"A picture or text will be presented in the center of the screen. Choose the picture or the text by tapping the screen. Then three other pictures or text will show up in the corners of the screen. Choose the picture or the text you think is correct by tapping it. You will be told if 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 Jane asked questions during the session, such as "Where should I tap?" or "What should I do now?" when only the sample was presented, the experimenter answered: "Tap in the middle." When both sample and comparison stimuli were presented, the experimenter answered: "Chose one of the stimuli in the corners that you think is the correct one."

Training

A sample stimulus was first presented in the center of the screen. Following tapping the sample stimulus, the comparison stimuli were presented. Both sample stimulus and comparison stimuli were presented simultaneously on the screen until Jane tapped one of the comparison stimuli. After 78 trial, the presentation of stimuli was changed from having the sample presented in the middle and the comparisons in the corners of the screen to presentation of the comparisons in a square closer to the sample. The change was made because it was observed that Jane did not attend to all the stimuli on the screen when the comparisons were presented in the corners.

When Jane responded to one of the comparison stimuli, a programed consequence was presented on the screen for 1,500 ms. If Jane had responded to the correct stimulus, a written blue text such as "Correct," "Great," or "Super" appeared in the middle of the screen. If the response was incorrect, the text "Wrong" was displayed. Jane could read with comprehension and understood the meaning of the written consequences. Following the programed consequences, the screen was blank for 500 ms before a new trial was presented.

The conditional discrimination training was presented in a many-to-one training structure, where Jane was first trained to match the pictures (C-stimuli) to the names (A-stimuli), AC relation. When she reached the mastery criterion of 90% correct responses in a block, she was presented with matching the pictures (C-stimuli) to family relations (B-stimuli), BC relation. The blocks with the AC and BC training consisted of 15 trials, five trials of each trial type. When she met the mastery criterion of 90% correct responses in the BC training, she was presented with a mix of AC and BC trials. The probability of programed consequences was gradually reduced to 75%, 25%, and 0% in the blocks when she had met the 90% mastery criterion. All the blocks with mixed trial types consisted of 30 trials each, with five trials of each trial type. The minimum number of trials in the training was 150.

All the sessions were conducted between 12:00 p.m. and 1:00 p.m., and each session consisted of 90 trials, with a duration between 10 and 15 min. The sessions were conducted at the daycare service, and the results were collected over 18 days.

Test for emergent relations

When Jane met the mastery criterion for the training, she was presented with a test of emergent relations without programed consequences, which included both trained and untrained relations. In this test, Jane was presented with the following trials in a mixed block: 15 AC and 15 BC trials (baseline probes), 15 CA trials and 15 CB trials (symmetry probes), and 15 AB and 15 BA trials (transitivity/equivalence probes). The second test for emergent relations was employed 1 week after the first test.

If Jane did not reach the criterion of 90% correct responses in the test, she was presented with the conditional discrimination training and test over again. The retraining began directly with a mix of AC and BC trials, with five trials of each trial type. The minimum number of trials in the second training was 120 trials.

2.6 | Time Period 3

Twelve months after the start of Time Period 2, Time Period 3 began.

2.6.1 | Class formation Sorting Test 3

A sorting test similar to Sorting Tests 1 and 2 was presented.

2.6.2 | Instructions and conditional discrimination training and test

Instructions and the conditional discrimination training and test were the same as in Time Period 2. The data were collected over 8 days.

3 | RESULTS

3.1 | Class formation sorting tests

The sorted classes were defined as cards placed in a stack, clearly separated from one another. The percent of correctly sorted classes of relatives is stable at 77.7% in Class Formation Sorting Tests 1 and 2. The percent of correctly sorted relative classes increased to 87.7% in Class Formation Sorting Test 3.

In Class Formation Sorting Test 1, Jane sorted all the stimuli correctly in Presentations 2, 3, 4, and 6. The errors were made in Presentations 1 and 5. In Presentation 1, she sorted the classes as follows: A1B1C1C3, A2B2C2, and A3B3. In Presentation 5, she sorted the classes as follows: A1B1C1A3B3C3 and A2B2C2.

Furthermore, in Class Formation Sorting Test 2, presented 9 months later, Jane sorted all of the cards correctly in Presentations 1, 2, 5, and 6. Jane sorted the stimuli incorrectly in Presentations 3 and 4. In Presentation 3, she sorted the classes as follows: A3B3C3C1, A2B2C2, and A1B1. In Presentation 4, Jane sorted the classes as follows: A1B1C1, A3C3, and A2B2C2B3.

In Class Formation Sorting Test 3, presented 12 months after Class Formation Sorting Test 2, Jane sorted the cards correctly in Presentations 2, 3, 4, and 5. The errors were made in Presentations 1 and 6. In Presentation 1, Jane sorted as follows: A1B1C1, A3B3C3, A2C2, and B2. In Presentation 6, she sorted as follows: A1B1C1, A3B3CB3, A2C2, and B2.

An interobserver agreement in the Class Formation Sorting Test 3 showed 100% agreement. The interobserver agreement was calculated by using agreements/agreements + disagreements × 100 (Kazdin, 2011).

3.2 | Conditional discrimination training and tests

3.2.1 | Time Period 2

As can be seen in Table 1, Jane used 195 trials to finish the first conditional discrimination training. Furthermore, when she was presented with the following test (Test 1), she responded according to the mastery criterion when the transitivity/equivalence relations were presented but failed by one response to meet the mastery criterion for

TABLE 1 Number of trials used to reach criterion and the test

Time Period	Number of Trials Training 1							Test 1			Test 2			Training 2					Test 3		
	BSL	BC	Mix	75%	50%	0%	Total	BSL	SYM	TR/EQ	BSL	SYM	EQ	Mix	75%	50%	0%	Total	BSL	SYM	TR/EQ
2	60	15	30	30	30	30	195	-	26	**28**	-	20	24	30	30	30	30	120	**30**	**29**	**29**
3	15	15	30	30	30	30	150	**27**	**30**	**30**	**28**	**29**	**29**								

Note. The table presents the number of trials needed to reach criterion in training and the number of correct trials in the test. Test 2 was presented 1 week after Test 1. BSL refers to the baseline relation; SYM: symmetry relation; TR/EQ: transitivity-equivalence relation. In the test was Jane presented for 30 trials of each trial type.

Bold numbers indicates where the participant reached the criterion of mastery in the test.

Due to a program error, baseline relations were not tested in Tests 1 and 2 in Time Period 2.

the symmetry relations. One week after the first test, Jane was presented with a new test (Test 2), and she did not respond according to the mastery criterion for any of the tested relations. Due to a program error, baseline relations were not presented in Tests 1 and 2.

Because Jane did not respond to criterion in Tests 1 and 2, she was presented for a new conditional discrimination training, and she used 120 trials to meet the mastery criterion. In the following test, she responded according to the mastery criterion on 90% of all the tested relations.

3.2.2 | Time Period 3

In the conditional discrimination training in Time Period 3, Jane used 150 trials to meet the mastery criterion (see Table 1). In the test for untrained relations, she responded according to the mastery criterion for all relations in both Test 1, presented immediately after the training, and in Test 2, 1 week later.

4 | DISCUSSION

In the present study, the participant was presented with repetition of training and testing over three time periods. The purpose was to study the maintenance of the participant's performance on the class formation sorting tests with no programed consequences when these tests were presented over three time periods. Moreover, it was of interest to study if it was possible to identify weakened relations and possible training opportunities. Finally, to maintain intact relations between stimuli by employing MTS training and tests.

Each time period began with the presentation of a sorting test. Several sorting tests were presented before the conditional discrimination training to find out if there was a change in responding as a function of presentation of the stimuli, based on the assumption that the classes of stimuli were part of the participant's repertoire. The results from the sorting tests of the three time periods showed an increase in percentages of correctly sorted stimuli from Time Period 2 to Time Period 3. This finding may be somewhat unexpected considering that the participant had AD, a disease where progressive loss of remembering can be anticipated.

When the conditional discrimination training began in the present experiment, the experimenter (the first author) noticed that it seemed as if Jane did not observe all the stimuli, despite all the stimuli being presented simultaneously on the screen. Previous experiments have suggested that people with AD have a reduction of visual sensitivity and that the visual field reduces as the disease progresses (e.g., Javaid, Brenton, Guo, & Cordeiro, 2016; Trick, Trick, Morris, & Wolf, 1995). Based on these assumptions, the location of the stimuli on the screen was changed. Hence, the distance between the stimuli was reduced, and they were placed closer together in the center of the screen. Under these new conditions, Jane responded more accurately.

The number of trials needed to reach the criterion decreased from Time Period 2 to Time Period 3, which may indicate that the relations between the stimuli had been strengthened. In addition, the results from the test of untrained relations had a much better outcome in the follow-up condition, which again is surprisingly given the fact that Jane had AD. These results may suggest that repetitive training and testing have maintained the relations between the stimuli over time.

Due to a program error, Jane was not presented for the baseline relations in Tests 1 and 2 in Time Period 2. These two tests were the only tests where the participant did not meet the mastery criterion. In all the other tests, where the baseline relations were included, did Jane respond to the mastery criterion. Based on these results, it is reasonable to imply that the inclusion of baseline trials in the MTS test may have affected the outcome. The effects of the inclusion of the baseline trials in the test will entail presentations of these discriminations over again, which may lead to that the remaining discriminations are more rapidly acquired (Saunders, Drake, & Spradlin, 1999).

Earlier studies where faces have been used as stimuli in people with NCD have in general had the purpose of investigating why people with NCD stop recognizing other people. In these studies, it is stated that the changes in the brain are the cause of why he or she does not recognize other people anymore (De Winter et al., 2016; Snowden, Thompson, & Neary, 2004). There is no focus on the functional relation between the stimuli (e.g., face and name), as an attempt to maintain or reestablished the relations. However, the present study contributes to the understanding of assessment of obtaining, identifying, and reestablishing functional skills in people with NCD, as argued by Sidman (2013).

The use of recurring presentations of the same conditions over several time periods is especially suited when studying how the behavioral repertoire changes in a person with a progressive disease such as NCD. Also, the individual benefits must be taken into account; therefore, the experimental setting must be considered as a positive and meaningful activity. When conducting experiments with people with any sort of cognitive impairment, the responsibility as an experimenter is especially important given the participants' need and communication skills. Hence, guidelines for interruption were created, and a small number of trials were presented in each session to avoid fatigue.

It has been implied that cognitive training and rehabilitation in people with NCD have not shown strong effects (e.g., Bahar-Fuchs, Clare, & Woods, 2013; Clare & Woods, 2004; Kallio et al., 2018). Although, it has been underlined the importance of evaluating individual rehabilitation interventions for persons with NCD because the effects of these interventions have had promising results. The present study is an example of a tailored training procedure where the stimuli used are of substantial importance for both the participant herself and her close relatives. The implications of the findings could be important when adjusting procedures for other individuals in which the purpose is to maintain functional skills.

4.1 | Limitations and future research

It is not possible to draw any solid conclusion from the present study, as the results are based on the performance of only one individual. For future studies, it would be of interest to use the procedure with other participants with a higher MMSE score and to include more follow-up conditions as the NCD disease assumingly progresses. What is important to have in mind when doing experiment with people with NCD in later stages is that these experiments are very time-consuming. It is essential to take into account the individual needs to avoid fatigue, which leads to short sessions with and a small amount of trials.

In addition, studies with tests for generalization with the use of other stimuli such as auditory stimuli (listener repertoire), other pictures of relatives or relatives in vivo, and a test in which the participants are asked to provide the name of the stimuli (tact repertoire) would have great applied value.

The results from the pretraining showed that the participant in the current study seemed to have a higher accuracy when the comparison stimuli were presented closer to the sample in the center of the screen, which calls for experiments in which the positions of the sample and comparisons are systematically manipulated in people with NCD.

Finally, the results from the present study show differences in the outcome on the test for stimulus equivalence when the baseline relations were included and not. To identify how the inclusion or not of the baseline relation in the test could affect the emerged relation, tests with and without baseline relation interspersed could be presented for persons with NCD.

4.2 | Conclusion

In the present study, a person with AD was trained and tested over three time periods. The study is a practical demonstration of the use of the conditional discrimination procedure to study changes in functional skills in a person with NCD over time (Gallagher & Keenan, 2009). Furthermore, the study demonstrates how the procedure can be used, as

suggested, to maintain and identify deteriorated relations between stimuli (Steingrimsdottir & Arntzen, 2014). The results from the class formation sorting tests and the MTS testing do not show any substantial differences from Time Period 1 to Time Periods 2 and 3, as the results are almost similar. Nevertheless, the present study contributes to the knowledge of the use of MTS procedures in people with NCD, how repetitive measuring and training can identify changes in cognitive functioning and, even better, how some individuals maintain skills.

CONFLICT OF INTEREST

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. The present study is part of a project approved by the Norwegian Regional Ethical Committee.

INFORMED CONSENT

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

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