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Use of Conditional-Discrimination Training in Remembering Relatives in a Man with Alzheimer's Disease

Anette Brogård-Antonsen, Erik Arntzen

Oslo Metropolitan University, Norway

Abstract

In this study, a 72-year-old man with Alzheimer's disease and a Mini-Mental Status (MMS) score of 25 participated. The participant was presented for class-formation sorting tests and conditional-discrimination training sequences and tests with portraits of close family members, their names, and family relationships as stimuli. The purpose of the study was to identify intact relations between stimuli, stimulus control issues and thereafter reestablish relations between stimuli. In the sorting tests, intact and weakened stimulus relations were identified. In addition, the results showed how correct stimulus control was reestablished after tailoring the conditional-discrimination training after the participant had shown systematical incorrect responding to some of the presented stimuli.
Key words: conditional discrimination, matching-to-sample, dementia, sorting test, stimulus control.

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Novelty and Significance

What is already known about the topic?

- The matching-to-sample (MTS) procedure has been used in some studies with people with dementia.
- Earlier results have shown that through individual adjustments of the MTS-procedure, people with dementia can increase and maintain correct responding.

What this paper adds?

- The results show how a person with Alzheimer's disease can relearn functional skills that have been weakened as a consequence of the disease.
- This paper is a practical demonstration of how recognition of relatives can be trained in a person with dementia.

One of the most apparent changes associated with dementia diseases, such as Alzheimer's disease (AD), is problems with cognitive behaviors. Problems with cognitive behaviors, such as remembering and learning, can impact daily living skills and the ability to recognize close family members, clearly creating an emotionally challenging situation for both the afflicted individual and their loved ones. Worldwide, forty-seven million people live with dementia, and the number of people affected is estimated to be more than triple by 2050 (Prince, Bryce, Albanese, Wimo, Ribeiro, & Ferri, 2013). Considering the number of people affected, identifying effective interventions is critical for both the individual and the social community. Useful interventions directed at maintaining and reestablishing functional skills are essential to meet the growing challenge presented by the increasing number of people with dementia.

Sidman (2013) suggested the use of conditional-discrimination procedures, such as matching-to-sample (MTS), for training functional skills in people with dementia. Training functional skills with a person with dementia were presented in a study by Steingrimsdottir and Arntzen (2014). In the study, the participant underwent arbitrary matching-to-sample (MTS) training and testing with the use of pictures of familiar

* Correspondence: Anette Brogård Antonsen, Oslo Metropolitan University, Department of Behavioral Science, PO Box 4 St. Olavs Plass, 0130 Oslo, Norway. E-mails: anettebrogaard@msn.com -- https://orcid.org/0000-0003-3137-6206. Erik Arntzen: erik.arntzen@equivalence.net -- https://orcid.org/0000-0002-8471-1058

stimuli related to eating (fork, knife, and spoon), clothes (jeans, sweater, and skirt), and hand washing (soap, nail brush, and a picture of hands washing). For example, a picture of a fork could be presented as a sample stimulus, and after the participant responded to the sample, pictures of a knife, a sweater, and a nail brush could be presented as comparisons. In this case, responding to the picture of a knife would be correct. The results showed that the participant did not respond in accordance with the experimenter-defined classes (e.g., fork-knife). However, after adjusting the MTS procedure, the participant responded in accordance with identity matching with both color stimuli and familiar stimuli. In the identity matching training, a picture of a fork was presented as a sample stimulus, and after a response to the sample stimulus, a picture of a fork and knife was presented.

Functional skills such as recognition of faces may also be affected in people with dementia. The behavioral definition of the recognition of faces was, by Sidman (2013), suggested being described as the relation between dictated or written names and people or pictures. Moreover, Sidman also suggested that a test for stimulus equivalence could be used to identify intact and weakened stimulus relations and following retraining deteriorated relations. Stimulus equivalence refers to the stimuli's interchangeability and is defined as the features of reflexivity, symmetry, and transitivity. After training conditional discriminations AB and BC, responding in accordance with reflexivity would be to choose A in the presence of A, B in the presence of B, and C in the presence of C. Furthermore, responding in accordance with symmetry would be to respond to A in the presence of B, and to B in the presence of C, and lastly, responding in accordance with transitivity would be to respond to C in the presence of A (Sidman & Tailby, 1982).

In some earlier studies, the reestablishment of relations between written texts, objects, and pictures in patients with aphasia was explored (Mohr, Sidman, Stoddard, Leicester, & Rosenberger, 1974; Sidman, 1971). Cowley, Green, and Braunling-McMorrow (1992) presented MTS-training for three men with brain injuries, in which the participants matched names, faces, and written names of the staff who worked where the participants lived. After the training, the participants were tested for untrained relations, and the results showed correct responding to relations that had not been presented in training. In another study with participants with dementia, Ducatti and Schmidt (2016) had conditions including stimuli such as written names, faces, names, and professions. The participants established arbitrary relations between stimuli after adjustments of the MTS procedure, such as errorless training and a gradual increase in the number of comparisons.

Also, in Brogård-Antonsen and Arntzen (2019), written names, family relationships, and portraits of relatives were used as stimuli in a study with a woman with AD. The results from the study showed how trained relations were maintained over time. The participant was presented with sequences of sorting tests and conditional-discrimination trainings and tests over three time periods, separated with nine and 12 months. Sorting tests have been used to assess stimulus class formation in several stimulus equivalence studies (e.g., Arntzen, Dechsling, & Fields, 2021; Dickins, 2015; Sigurðardóttir, Mackay, & Green, 2012). The results in Brogård-Antonsen and Arntzen (2019) showed how the performance in the sorting tests and conditional-discrimination trainings and tests were maintained over time. Written names, relation to the participant, and the persons themselves were used in a study by Aggio, de Oliveira Teixeira, and de Rose (2020). In Aggio *et alia* (2020) new relations between stimuli were established with the use of maintained relations in the conditional discrimination training. Although, when the number of comparison stimuli was increased to three, the accuracy in the test decreased.

Given the increasing number of people with dementia, the amount of behavioral analytic research focusing on cognitive functioning in this group has been moderate (Aggio, Ducatti, & de Rose, 2018; Trahan, Kahng, Fisher, & Hausman, 2011). The aim of the presented experiment was to study the recognition of the participant's relatives. With the use of class formation sorting tests and training and testing of conditional discriminations, intact and deteriorated relations between stimuli such as relatives' portraits, written names, and family relationships were identified. It was also of interest to investigate how adjustments of the conditional-discrimination training could reestablish relations between stimuli that had weakened, before testing for stimulus equivalence.

Method

Participant

The participant was a 72-year-old male, referred to as John, with AD. John had a Mini-Mental State Examination (MMSE) score of 25, indicating mild cognitive impairment, at the start of the experiment (Folstein, Folstein, & McHugh, 1975; Mitchell, 2017).

The participant had previously been exposed to arbitrary conditional-discrimination training with abstract stimuli, though conditional discriminations had not been established. John was also earlier presented for three sorting tests with all the stimuli cards from the 14 relatives (42 stimuli), where he was given all the stimuli in a stack and was asked to "sort the cards". He did not sort the stimuli in any of the experimenter-defined classes.

Stimuli, Apparatus, and Setting

The stimuli used in the present experiment were names of John's relatives (A-stimuli), their family relationship to John (B-stimuli), and photo portraits of family members (C-stimuli) (see Figure 1). In the class-formation sorting test, the stimuli were presented as laminated cards, measuring 13 cm x 8.5 cm. The font was Calibri, and the capital letters were 1.5 cm high. The training and tests of the conditional discriminations were presented in a custom-made MTS-program running on a Microsoft Surface Tablet (Microsoft Windows 10 pro). The stimuli measured 3.5 cm x 3.5 cm when presented on the tablet screen. John used a Microsoft Surface Pen (14.93 cm in length, with a diameter of 0.97 cm) when he responded to the stimuli on the screen.

The experiment was conducted in the apartment where John lived with his wife. When John sorted the cards in the class formation sorting test, he sat on a couch by the coffee table. When working on the computer tablet, John sat on the couch with a cushion on his lap, where the computer tablet rested. The experimenter sat beside John on his right side in both the class formation sorting tests and when he worked on the computer tablet.

All the sessions were conducted between 10:30 a.m. and noon.

Design

In the presented study, we presented four class-formation sorting tests; Sorting Tests 1 and 3 were identical, and Sorting Tests 2 and 4 were identical. Thereafter, we arranged eight conditions, each containing a conditional discrimination training and test: Conditions 1–4, Conditions 5–7; Adjusted Training 1–3, and Condition 8. See text below and Figure 2 for further descriptions.

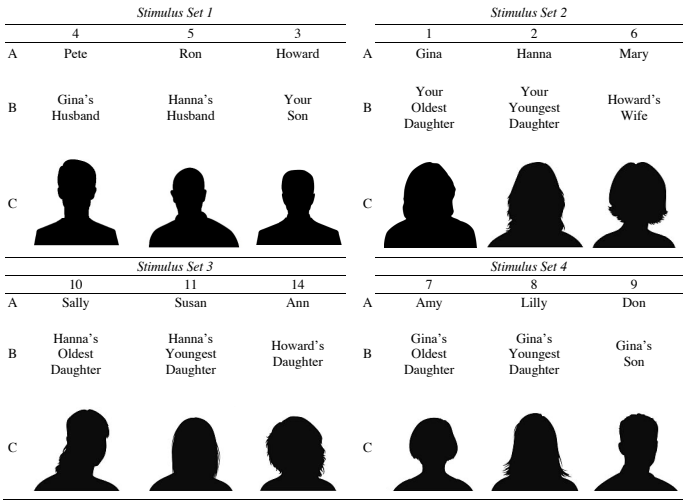

Figure 1. Different stimulus sets used in the conditional-discrimination training. The A-stimuli were the names, the B-stimuli were the family relationships, and the C-stimuli portraits of the relatives. The portraits are not presented for reasons of anonymity. The text on the B-stimuli was written in Norwegian, further, the C-stimuli was in black and white. In the class formation sorting test, the participant was presented for additionally two classes of relatives. These two relatives were twins, and due to lack of logical labeling of which of them that were oldest and youngest, the classes were not presented in the training. Pictures retrieved from Google®.

Class Formation Sorting Test

To study how John sorted the individual relatives' stimuli (portrait, name, family relationship) before the training of the conditional discriminations, he was presented with four sorting tests with all the stimuli cards from 14 relatives (42 stimuli) (see Figure 2). With the purpose of making clear distinctions between the sorted groups, fourteen boxes were presented in a row in front of the participant. In Sorting Tests 1 and 3, the experimenter placed one C-stimulus (portrait) in each box, with the portrait facing up. The stimuli left (A- and B-stimuli) were stacked and given to John. The experimenter asked John: "Can you sort these cards?" In Sorting Tests 2 and 4, the experimenter placed one A-stimulus (name) in each box, with the written text facing up, and the remaining stimuli were stacked and given to John, who was asked to sort the cards. No consequences were presented during the tests. If John asked what to do, the instruction was repeated. When John said he was finished sorting the cards, the experimenter took a photo of the completed sorting.

Instructions

In all conditions, before each conditional discrimination training and testing started, John was given written instructions on a sheet of paper, which was available to him during the entire session. The instruction was originally written in Norwegian and was as follows:

> "A picture or text will be presented in the middle of the screen. Choose the picture or the text by tapping the screen. Then, three other pictures will be presented in 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 John had any questions regarding where to tap, the experimenter answered, "Tap on the one in the middle" when the sample was presented, and when the comparisons were presented, the experimenter answered: "Choose one of those in the corners that you think is the correct one."

Conditional-Discrimination Training

In the conditional-discrimination training, a sample stimulus was presented in the center of the screen. When John tapped the sample stimulus, as an observing response, the sample stimulus remained, and three other comparison stimuli were presented simultaneously in the corners of the screen, leaving one corner blank. After responding to one of the comparison stimuli, a programmed consequence was presented for 1500 ms. If John responded to the correct comparison stimuli, written text such as "Correct," "Great," or "Super" was presented in the center of the screen. If John responded incorrectly to the comparison stimuli, the text "Wrong" was presented. After the programmed consequence disappeared, the screen was blank for 500 ms before John was presented for a new trial, starting with a new sample stimulus.

The conditional-discrimination training was arranged in a many-to-one training structure (see (see Arntzen, 2012, for an overview of training structures) and each condition with conditional-discrimination training was divided into six phases. In the first phase, John was trained to match the portraits as comparisons (C-stimuli) to the names as samples (A-stimuli). The training was presented in blocks with 15 trials, where each trial type (A1/C1C2C3, A2/C1C2C3, A3/C1C2C3) was randomly presented five times (see Table 1). When John met the mastery criterion of 90 % correct responses in the block, he was presented with the next training phase. In the second training phase, John was trained to match the portrait (C-stimuli) to the family relationship (B-stimuli). The blocks consisted of 15 trials with the trial types B1/C1C2C3, B2/C1C2C3, and B3/C1C2C3. When the criterion for mastery of 90 % was reached, John was given a mix of both AC and BC trials (third phase). This phase and the rest of the phases contained blocks with 30 trials. As the mastery criterion of 90 % was met in Phases 4, 5, and 6, the probability of programmed consequences was gradually reduced to 75 %, 25 %, and 0 % of the trials in the blocks, respectively. In total, the minimum number of trials needed to get through all the training phases was 150 trials.

Adjusted Conditional Discrimination Training

If John did not progress from one phase of the training to the next after 60 trials, an adjusted training was introduced (see Conditions 5–7 below). The conditions with adjusted conditional discrimination training were arranged in the same training structure, containing the same training phases as described earlier. After the adjusted training was conducted, the interrupted condition was presented over again in a separate condition.

Conditional Discrimination Test

After meeting the mastery criterion for training, in each conditional discrimination training, John was presented with a test for emerged relations without programmed consequences. The stimuli used in the test where the same set as presented in the previous conditional discrimination training. In the conditional discrimination test, John was randomly presented for both baseline (AC and BC) and untrained relations (CA, CB, AB, and BA), from the current condition, and each trial type was presented 5 times.

The test consisted of 15 AC- and 15 BC-trials (baseline), 15 CA-trials and 15-CB trials (symmetry), and 15 AB- and 15 BA-trials (transitivity/equivalence). The criterion for responding in accordance with experimenter-defined classes was defined as above 90 % correct in baseline, symmetry, and equivalence trials.

Experimental Conditions and Organization of the Stimulus Set

In the class formation sorting tests, the participant was presented with stimuli from 14 relatives. However, since Relatives 12 and 13 were twins, and logical labeling of twins was not possible to make, these stimuli were excluded from the conditional-discrimination training. The remaining 12 relatives' stimuli were separated into four sets of stimuli, each containing stimuli from three relatives (see Figure 1). An overview of the conditions is presented in Figure 2.

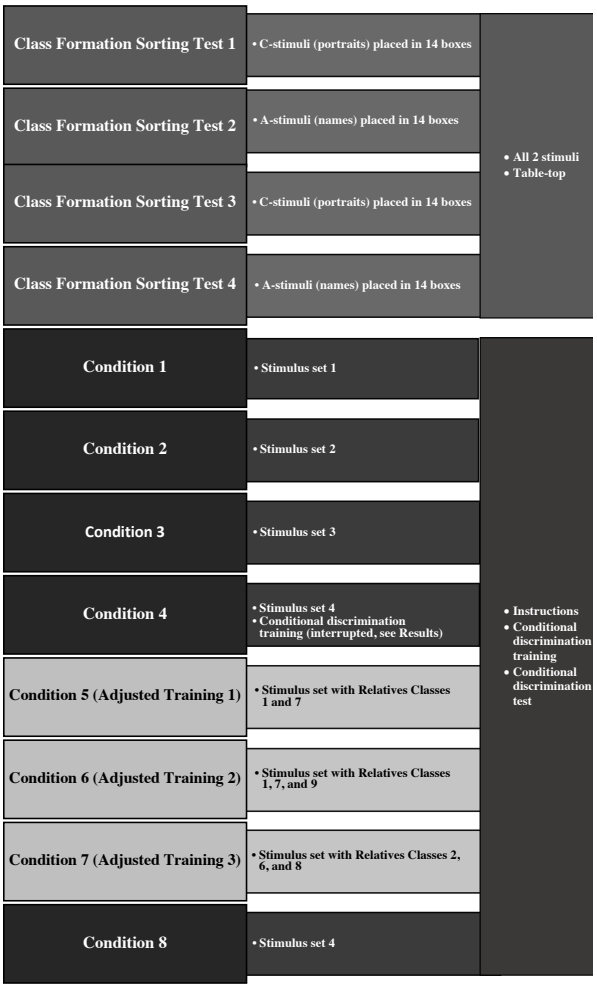

Figure 2. Overview of the Experimental Conditions. The class formation sorting tests are the middle gray squares, the ordinary conditional discrimination training and testing conditions are dark, and the conditions with the adjusted trainings and tests are light grey.

Condition 1. In Condition 1, the participant was presented with the instructions before the conditional-discrimination training and testing started with Stimulus Set 1 (see Figure 1).

Condition 2. In Condition 2, John was presented with the instructions followed by conditional-discrimination training and testing with Stimulus Set (see Figure 1).

Condition 3. In Condition 3, the participant was presented with the instructions before the conditional-discrimination training and testing with Stimulus Set 3 (see Figure 1).

Condition 4. In Condition 4, John was presented with the instructions and only conditional-discrimination training with Stimulus Set 4 (see Figure 1) because the condition was terminated due to the interruption criteria (see Results).

Condition 5 (Adjusted Training and Testing 1). Due to systematical incorrect responding in Condition 4 (see Results), in Condition 5, John was presented with an adjusted conditional discrimination training and testing with a stimulus set consisting of Relative Number 1 (Gina) and Relative Number 7 (Amy) (see Figure 3). Because the stimulus set in Condition 5 contained only two classes of relatives, the blocks in the first two phases of the conational-discrimination training had 10 trials, while the rest of the blocks in the following phases had 20 trials (see Table 1 for comparison).

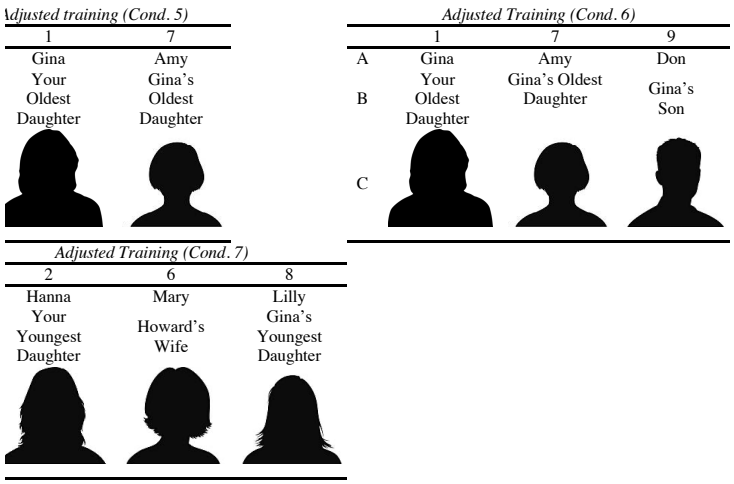

Figure 3. The Adjusted raining. *(Note*: The figure presents the stimuli used in in the adjusted training in Condition 5, 6, and 7. Pictures retrieved from Google®).

Condition 6 (Adjusted Training and Testing 2). In Condition 6, the participant was presented for conditional-discrimination training and testing with a stimulus set consisting of Relative Number 1 (Gina), Relative Number 7 (Amy), and Relative Number 9 (see Figure 3). Relative Number 9 was added to the previous stimulus sets from Condition 5. The training and test were presented as described earlier.

Condition 7 (Adjusted Training and Testing 3). In Condition 7, the participant was presented for conditional discrimination training and testing with a stimulus set containing Relatives Numbers 2, 6, and 8 (see Figure 3). The training and test were presented as described earlier.

Condition 8. In Condition 8, John was presented for conditional discrimination training and testing with Stimulus Set 4 (see Figure 1). The training and test were presented as described earlier.

Table 1. Overview of Training and Test.

.Relations	Number of trials in the block	Mastery Criterion (%)	Programmed Consequences (%)
AC	15	90	100
BC	15	90	100
AC/BC	30	90	100
AC/BC	30	90	75
AC/BC	30	90	25
AC/BC	30	90	0
Test	90	90	0

Criteria for Stopping a Session and Termination of the Experiment

The guidelines for interruption stated that the session should stop if John required so. Furthermore, if he showed any signs of discomfort, the session should be stopped, and further participation in the experiment had to be evaluated.

RESULTS

In the class formation sorting tests, John sorted the stimuli in the boxes lined up in front of him. In Test 2, he stacked some of the stimuli on the table beside the boxes. The percent of correctly sorted classes increased gradually from Tests 1 to 3: 28 %, 35.7 %, and 50 %, respectively. Hence, in Test 4, the percent of correctly sorted classes decreased to 42.6 %. The percent was calculated as the number of classes sorted correctly (all three stimuli placed in the same box without stimuli from other classes) divided by the number of classes (14). For Relatives Numbers 1, 2, 3, 5, 6, 9, 10, and 11, John had a high amount of correctly sorted stimuli (see Figure 4). Relative Number 7 had the lowest number of correctly sorted stimuli. John did not sort any of Relative Number 7's A-stimuli correctly and only half of the B- and C-stimuli. Furthermore, John

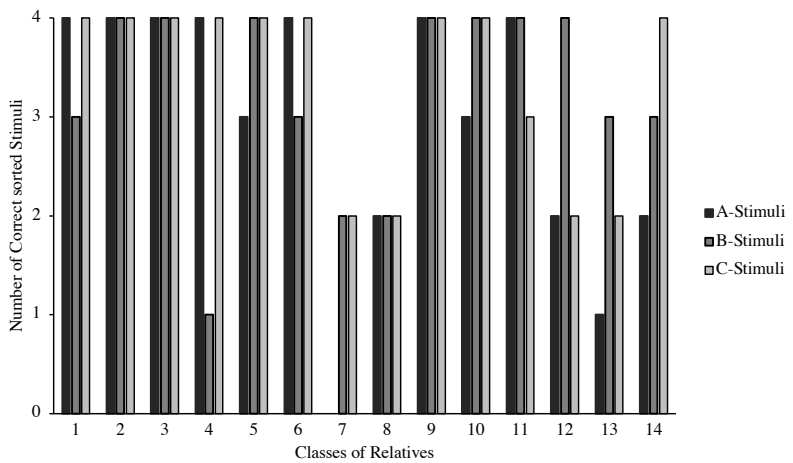

Figure 4. Number of Correct Sorted Stimuli in Class Formation Sorting Test 1-4 (The number of correct sorted stimuli in the different Classes of Relatives in Class Formation Sorting Tests 1–4 divided over the type of stimuli).

had problems when he sorted Relatives Numbers 4, 8, 12, 13, and 14. For Relative 4, all A- and C-stimuli were correctly sorted. All the B-stimuli were correctly sorted for Relative 12, and for Relative 14, all the C- stimuli were correctly sorted.

In the Conditional-Discrimination Training and Test in Conditions 1 and 2, John used a minimum number of trials to meet the mastery criterion in training. In Condition 3, he used 15 more trials (one block) than the minimum number of trials needed to meet the mastery criterion. In all the first three conditions, John responded in accordance with experimenter-defined classes in baseline, symmetry, and equivalence trials (see Table 2) in the test for stimulus equivalence.

Table 2. Overview of Number of Trials in Training and Test Untrained Relations.

Condition	Stimuli Set	AC	BC	Mix	75 %	50 %	0 %	Total	BL	SYM	EQ
1	1	15	15	30	30	30	30	150	**30**	**30**	**30**
2	2	15	15	30	30	30	30	150	**29**	**30**	**30**
3	3	30	15	30	30	30	30	165	**30**	**29**	**29**
4	4	60									
5	AdjTr 1	10	10	20	20	20	20	100	**20****	16**	**19****
6	AdjTr 2	15	15	30	30	30	30	150	**30**	**28**	**30**
7	AdjTr 3*	15	15	30	30	30	30	150	**30**	**30**	**30**
8	4	15	30	30	30	30	30	165	**30**	**30**	**30**

Notes: The numbers in bold indicate that the participant responded within the criteria of 90% in the test. Each trial type was presented 30 times in the test. AC= Number of AC-trial; BC= Number of BC-trials; Mix= Number of mixed trials; 75%= Number of trials with 75% programmed consequences: 50%= Number of trials with 50% programmed consequences; 0%= Number of trials with 0% programmed consequences; Total= Total number of trials used; BL= Baseline trials in test; SYM= Symmetry trials in test; EQ= Equivalence trials in test; AdjTr= adjusted training; ^= Condition 4 was interrupted when the participant did not show any progression in training after 60 trials; *= Due to a programmer fault was the condition first presented with 150 trials and test where stimuli A2 was presented as B2, and B2 was presented as A2; **= In Condition 5, the number of each trial type in the test were 20.

However, when John was presented with the fourth condition with Stimulus Set 4, the training was interrupted after 60 trials. He showed small signs of discomfort, like saying "All I do is wrong" and sighing. The results revealed consistently incorrect responding. When A7 ("Amy") was presented as a sample, John responded to C8 (the portrait of Lilly) 19 out of 20 times (see Figure 5). On several occasions, John said when A7 ("Amy") was presented as a sample, that there was no portrait of Amy among the comparison stimuli. Further, he pointed to C7 (the portrait of Amy) on several occasions, stating that this was Gina, which was Amy's mother. Further analysis of the results from the first blocks showed that John had all responses correct when the

		Comparison		
		 C7	 C8	 C9
Sample	Amy (A7)	1	19	
	Lilly (A8)		20	
	Don (A9)			20

Figure 5. Distribution of Responses in Condition 4. Number of responses to the different comparison stimuli when the different sample stimulus are presented. Pictures retrieved from Google®.

A8-C8 trials and the A9-C9 trials were presented. However, for the A7-C7 trials, John had only one of five responses correct.

Based on the consistently incorrect responding in Condition 4, adjustments were made; John was presented for conditional-discrimination training with only two of the relative's classes in Condition 5, Relative Number 1 (Gina) and Relative Number 7 (Amy) (see Figure 3). The results showed that John needed a minimum number of trials to meet the mastery criterion. Further, in the test, all the baseline relations were intact, and he did respond correctly to 19 of the 20 equivalence trials. However, he had only 16 of the 20 symmetry trials correct (see Table 2).

In Condition 6, John was presented with Relatives Numbers 1 (Gina), 7 (Amy), and 9 (Don) (see Figure 3) and he needed a minimum number of trials to meet the mastery criterion. Further, he did meet the mastery criterion in all tested relations (see Table 2). In Condition 7, the stimulus set consisted of Relatives Numbers 2 (Hanna), 6 (Mary), and 8 (Lilly) (see Figure 3). Due to a programming error, the stimuli were reordered when Condition 7 was presented, B2 was presented as A2, and A2 was presented as B2. John used the minimum number of trials to meet the mastery criterion and had 89 of 90 trials correct in the test for stimulus equivalence. Hereafter, the stimuli were again presented as initially planned in Condition 7. In Condition 7, John used a minimum number of trials to meet the mastery criterion and had all responses correct in the test (see Table 2).

After the adjusted training, John was again presented with Stimulus Set 4 in Condition 8. This time, the number of correct responses was at the same level as in Condition 4 in both the A8-C8 trials and the A9-C9 trials in the first block. In addition, when comparing the A7-C7 trials in Conditions 4 and 8, the number of correct responses increased from one to four of totally five responses. In this final condition, , John met the mastery criterion in training with only one additional block. Also, in the final test for stimulus equivalence, he responded to the experimenter-defined classes (see Table 2).

DISCUSSION

The purpose of the present study was to detect intact and deteriorated relations between stimuli, such as relatives' portraits, written names, and family relationships in a man with Alzheimer's disease. Furthermore, the purpose was to study how weakened stimulus relations could be reestablished with the use of the conditional discrimination procedure, and finally, test for emerged relations to study the formation of equivalence classes. The results from the class formation tests showed intact classes of Relative Numbers 2, 3, and 9, and weakened classes of Relative Numbers 1, 4, 5, 6, 7, 8, 10, 11, 12, 13, and 14. Furthermore, the present study demonstrated how the participant responded in accordance with stimulus equivalence to all the relative's stimulus classes after adjustments of the procedure and the stimuli presented in the conditional-discrimination procedure..

Test 1 had the lowest percent of correctly sorted classes. The small number of correct sorted classes can be explained with the participant's lack of experience with this type of task. In Test 4, the percent of correct classes was again reduced, which raises questions regarding whether this was an effect of the type of stimuli placed in the boxes by the experimenter before John was asked to sort the remaining cards. In Tests 2 and 4, the A-stimuli (names) were placed in the boxes by the experimenter. Compared with Test 3, the percent correct sorted stimuli was lower in Tests 2 and 4. In Tests 1 and 3,

the C-stimuli (portraits) were placed in the boxes by the experimenter. In Tests 1 and 3, John had the opportunity to see all the portraits simultaneously, compared with Tests 2 and 4, where the names were presented in the boxes at the start of the test, and he had all the faces in the stack. The simultaneous presentation of all the portraits or all the names may have caused the differences in results in the class formation sorting tests.

Sorting tests have been used to assess stimulus class formation in stimulus equivalence studies (e.g., (Arntzen *et alia*, 2021; Dickins, 2015; Fienup & Dixon, 2006)). Several studies have shown a correlation between the outcome in the sorting test and the MTS test (e.g., Arntzen, Norbom, & Fields, 2015; Dymond & Rehfeldt, 2001). Based on these results, the sorting test has been suggested as a less time-consuming way to test stimulus classes as in Arntzen *et alia*, 2017. The results from class formation sorting tests showed that John did not sort Relative Number 7's stimuli according to the experimenter-defined classes. The Relative Number 7 class was the same class where he later, in the conditional-discrimination training, performed systematical incorrect responding. John himself noted that Relative Number 7 looked much like Relative Number 9 (mother and daughter, respectively). A question to be asked in this regard might be if the discrimination would be easier if John was presented with a portrait of Relative Number 7 at a younger age.

A sorting test can be arranged in different ways. For example, either table-top (e.g., Steingrimsdottir, Brogård-Antonsen, Boye-Hansen, Aasland, & Arntzen, 2021) or computerized (e.g., Arntzen *et alia*, 2021). Furthermore, the sorting classes of stimuli can be conducted by placing the stimuli in matrices (e.g., Dickins, 2015), stacking the stimuli on top of each other (e.g., Sigurðardóttir, Mackay, & Green, 2012), or clustering the stimuli together (e.g., Steingrimsdottir *et alia*, 2021). Another procedural aspect to take into consideration in the present class formation sorting tests is that the participant was presented with the same number of boxes as classes. Since this may affect how the participant solves the task, the number of classes could perhaps be given beforehand. Although, it seems that the number of boxes did not control the participant's sorting because he also stacked stimuli outside of the boxes in Test 2.

When John underwent the conditional discrimination training, he had few problems when presented with Conditions 1, 2, and 3. However, when he was presented for the fourth condition, his responses were consistently incorrect when the portrait of Relative Number 7 was presented. The results from the training of the conditional discriminations show the importance of identifying intact relations that following can be used to reestablish stimulus control in relations that have weakened. Training new relations between stimuli by presenting the stimuli together with establish relations in a an MTS procedure was suggested by Ducatti and Schmidt (2016) as especially suited to people with dementia. As seen in Steingrimsdottir and Arntzen (2014), through adjustments of the conditional-discrimination procedure, the participant did, in the end, also met the mastery criterion for training in Stimulus Set 4.

In the tests for stimulus equivalence, John responded in accordance with the experimenter-defined classes in all conditions, except for symmetry in Condition 5. Condition 5 was the first adjusted training condition in which he was presented with Relative Numbers 1 and 7 (his daughter and granddaughter), based on the assumption that he had problems discriminating between those two relatives' photographs. The participant met the mastery criterion for training with the lowest number of trials in training in Condition 5. Although, when he was presented for the equivalence test, he did not respond in accordance with symmetry. The incorrect responding in the symmetry trials may be

because, in training, he always had the opportunity to discriminate between the portraits as they were always presented simultaneously as comparisons. However, when he was presented with symmetry trials, the portraits were presented as the sample stimulus, John had to successively discriminate between the portraits. Successive discrimination has been shown as a more complex task than simultaneous discrimination (Huziwara, Silva, Perez, & Tomanari, 2015; Lipsitt, 1961; Mundy, Honey, & Dwyer, 2007).

Sidman (2013) questioned what should constitute the successful recognition of a person. Considering the present experiment, we could discuss if we could say that the participant recognizes the person only if all relations are intact, or could some of the relations be intact and others not? Sidman discusses if it is possible to use the MTS procedure to detect if one direction of the relation between the stimuli is intact and another is not. As an example, in Condition 5, the participant responded correctly when portraits were presented as comparison stimuli, but in the symmetry test, where portraits were presented as sample stimuli, the participant did not respond to the mastery criterion. Although, after repetitive training and testing, the participant responded in accordance with symmetry in the following conditions.

In the present study, the participant was not tested with larger stimulus sets or for maintenance of stimulus control over time as done in Brogård-Antonsen and Arntzen (2019). In future studies, it would be of interest to see how the training can be generalized to other pictures of the relatives or to include tests for how the skills were used in a natural setting by presenting the relatives in vivo.

In sum, the results revealed, through class formation sorting tests and conditional-discrimination training, intact relations in the different relative's stimulus classes. In addition, the result detected consistently incorrect responding to some of the stimuli. However, after adjustments to the conditional-discrimination training, the participant responded in accordance with the experimenter-defined classes.

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