Social Significant Stimuli in Training of conditional discriminations in Participant with Neurocognitive Disorder

Hanna Steinunn Steingrímsdóttir, Anette Brogård-Antonsen, Silje Boye-Hansen, Heidi Grete Aasland, and Erik Arntzen
Oslo Metropolitan University

Forgetting names can be demanding for individuals diagnosed with neurocognitive disorders (NCD). The purpose of this study was to explore the effect of different lengths of inter-trial-intervals (ITIs) while employing two training protocols—the simultaneous protocol (SIM protocol) and the simple-to-complex protocol (STC protocol)—when establishing three stimulus classes in an individual with NCD. The three stimulus classes employed contained three members each: the name, family relation, and a picture of the participants significant others. In addition, to study changes in stimulus control for the emergence of equivalence classes at two time periods (T1 and T2), approximately one year apart. At T1 we applied the following four variables: (i) SIM protocol with 2,000 ms ITI, (ii) STC protocol with 2,000 ms ITI, (iii) SIM protocol with 5,000 ms ITI and (iv) STC protocol with 5,000 ms ITI. The main findings showed that correct responding was achieved when using STC protocol with 5,000 ms ITI. A 5-week follow-up test showed maintenance of the trained relations. At T2, we employed a 9-months follow-up test followed by (iii) SIM protocol with 5,000 ms ITI and (iv) STC protocol with 5,000 ms ITI. The results showed that the participant did not respond in accordance with accuracy criterion in the 9-month follow-up. Accuracy criterion was met again when exposed to STC protocol with 5,000 ms ITI. The results are discussed with suggestions for future studies.

Key words: Neurocognitive Disorder, stimulus equivalence, training protocol, inter-trial-interval, socially significant stimuli

Some older adults develop neurocognitive disorders (NCD), where the core features are deterioration in cognitive functions (American Psychiatric Association, 2013). The Alzheimer's Disease (AD) is the most known and most prevalent NCD (Geldmacher, 2009; Szoeke et al., 2009). AD is characterized by abnormal accumulation of plaques and tangles in the brain. Another type of NCD is dementia due to cerebrovascular disease, characterized by disruption of blood flow to the brain, leading to damage to the nerve cells. Although different NCD's may have a dissimilar effect on the patient's social and occupational functioning, they generally affect remembering negatively, where for example the affected individual forgets names of his significant others. As the use of names are an important component of social interaction (Hutchings et al., 2017) forgetting a name can be both emotionally and practically challenging for the individual and his or her significant others. Cavallo et al. (2016) pointed out that the efficacy of training remembering functions in indivi-

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duals with NCD has been questioned. Still, studies have shown positive outcome for participants with NCD when exposed to remembering training (Clare et al., 2002; Kanaan et al., 2014; Moore et al., 2001). Importantly, as noted by Bahar-Fuchs et al. (2013) an extension of the literature on such training is needed.

Sidman (2013) discussed remembering problems in individuals with AD, such as forgetting the name of a loved one, and addressed the complexity of the stimulus control involved in the deterioration of such behavior. He described this complexity by asking for example, if failing to say a name when asked "what is your daughter's name" (question-name) or when shown a picture of her and asked, "what is her name," (picture-name) would the individual also fail if asked to point at "Rachel" when asked to discriminate her picture from others (name-picture)? He thereby emphasized that there are different conditional discriminations within each stimulus class. Importantly, as described by Sidman, addressing remembering deterioration by assessing which relations are still intact, and which are not, provides an opportunity to re-establish the stimulus relations the participant fails to respond correctly to.

The conditional-discrimination procedure has been suggested as a valuable intervention for individuals with NCD, identifying the participants strengths and weaknesses (Brogård-Antonsen & Arntzen, 2019; Sidman, 2013; Steingrimsdottir & Arntzen, 2014a). When applying a conditional-discrimination procedure, the participant is shown a sample stimulus (e.g., a picture of one of three family members, labeled as A-stimuli: A1, A2, or A3) followed by three comparison stimuli (e.g., three written names, labeled as B-stimuli: B1, B2, B3). Choosing the correct name, in the presence of the picture of that person, is followed by consequences such as "true" or "super," whereas an incorrect response (choosing incorrect name), is followed by consequences such as "incorrect." With repeated exposures to such differential reinforcement procedure, the participant can learn which stimuli belong together.

Introducing an additional set of conditional-discriminations (for example adding the family relation of each family member, labeled as C-stimuli: C1, C2 and C3), allows testing for whether discriminative control by all the stimuli within each stimulus class has emerged. Sidman and Tailby (1982) termed those different combinations presented during testing as reflexivity, symmetry, and transitivity. When, for example, training AB and BC relations, which means that A is trained to B and B is trained to C, reflexivity is demonstrated when the stimuli stand in relation to themselves: A to A, B to B, and C to C. Symmetry is demonstrated when B is related to A and C is related to B. Transitivity is demonstrated when A is related to C, and a combined relation (equivalence) is demonstrated when C is related to A.

There are number of variables that may be changed during training of conditional discriminations that may influence equivalence class formation, such as the training structure, number of classes, types of stimuli, and number of members within each class (see Arntzen, 2012 for further elaboration on those variables). Earlier findings have for example shown that the many-to-one training structure (Arntzen et al., 2014; Arntzen & Nikolaisen, 2011; Saunders et al., 1993), and the use of familiar stimuli (Arntzen & Lian, 2010), increases the likelihood of correct responding. Other variables that may affect the likelihood of correct responding is the inter-trial interval (ITI), or the time between training trials, and the training protocol (the arrangement of training and test trials).

The effect of different lengths of the ITI has been studied in both humans (Koegel et al., 1980; Skinner et al., 1994) and non-humans (e.g., Holt & Shafer, 1973; Sherburne et al., 1998). These studies show that the length of the ITI can affect correct responding. For example, Koegel et al. (1980) noted that shorter ITI (1–3 s) lead

to higher accuracy of responding in children with autism compared to longer ITI (4 s or more). On the other hand, Skinner et al. (1994) showed equal effect when comparing no delay between trials with a 5-s ITI while studying acquisition and maintenance of sight-word learning in individuals with behavioral disorders and learning deficits.

The effect of different lengths of ITI in stimulus equivalence research in general is not yet clarified (Arntzen, 2012) and to our knowledge, the effect of different lengths of ITI on conditional discriminations in individuals with NCD is unknown.

The training protocols that have been employed in stimulus equivalence research are (1) the simple-to-complex (STC protocol), (2) complex-to-simple (CTS protocol), and (3) simultaneous protocol (SIM protocol) (e.g., Adams et al., 1993; Imam, 2006). For the current study, when using the SIM protocol, the participant is exposed to all baseline conditional discriminations in a mixed block (e.g., AB and BC) before being exposed to a test for emergent relations (BA, CB, AC, and CA). In the STC protocol, on the other hand, the participant is first exposed to the AB conditional discriminations followed by symmetry test (BA), then, the BC relations, followed again by symmetry test (CB). Thereafter, there is a mix of AB/BC relations with a mixed symmetry test (BA/CB) and finally, the participant is exposed to transitivity (AC), equivalence test (CA) and full test block with all trials including baseline conditional discriminations. Experiments with college students as participants have found a greater likelihood of formation of equivalence classes when using the STC protocol compared to the SIM protocol (Fienup et al., 2015; Imam, 2006). The STC protocol has not been used with participants with NCD to our knowledge.

At current date, training conditional-discriminations followed by testing of equivalence class formation has only been explored in few studies with older adults with or without known NCD (Brogård-Antonsen & Arntzen, 2020; Ducatti & Schmidt, 2016; Gallagher & Keenan, 2009; Saunders et al., 2005; Steingrimsdottir & Arntzen, 2014b, 2016; Wilson & Milan, 1995). A few of these studies have included social significant stimuli during matching-to-sample training (Brogård-Antonsen & Arntzen, 2019; Cowley et al., 1992; Ducatti & Schmidt, 2016). The main findings of these studies are that the conditional-discrimination procedure can be used to establish the necessary discriminations and test emergent relations of socially significant relations, like face-name relations of significant others. However, the literature including face-name relations is still sparse and, therefore, it is important to expand it by exploring further different variables that may increase the likelihood of re-establishment and maintenance of such stimulus classes.

The purpose of the current study was to explore the effect of using a conditional-discrimination procedure to re-establish and then maintain stimulus control of name, face, and family relations in a participant diagnosed with NCD. We asked the following four questions: (1) Will different lengths of the ITI (2,000 ms vs. 5,000 ms) have different effects on matching performance in training and testing of conditional discriminations while employing two training protocols, the SIM and the STC protocols? (2) Will the conditional discriminations be maintained in a follow-up test after five weeks without training? (3) Will the conditional discriminations be maintained nine months later? (4) Which of the two training protocols (the SIM and the STC protocols) with the 5,000 ms ITI will be most effective for re-establishment of the stimulus classes?

Method

Participant

Tor was a 73-year-old male, diagnosed with dementia due to cerebrovascular disease. At the beginning of the data collection, he lived at home with his wife and attended a

day-care service for people with NCD three days a week. He was physically active and there was no indication of visual disturbances.

Tor made some comments about having difficulties of remembering names. His Mini-Mental State Examination (MMSE) (Folstein et al., 1975) was 18 at the start of the experiment. The MMSE is a short screening test with scores ranging from 0–30. The test has been adjusted for Norwegian population (Nasjonal kompetansetjeneste for aldring og helse, 2021). Scores between 28–30 indicate no cognitive impairment, 25–27 indicate that the individual might have cognitive impairment and further testing is needed, whereas a score below 24 suggests cognitive impairment (Engedal & Haugen, 2009). According to Folstein et al. (1975) a score of 18 indicates moderate cognitive impairment.

Tor gave consent for his participation in the experiment, which was verified by his general practitioner. In addition, he was asked for his verbal consent before each training session. He was reminded that participation was voluntary before each session, and that he could withdraw from the study at any time. The experimenters running the sessions decided upon two criteria for interrupting a session; (1) if the participant showed signs of fatigue, such as closing his eyes for more than 4 seconds, or restlessness, such as asking "when will the session be over." (2) if the participant showed signs of physical discomfort such as having headache by holding his head or stating, "I have a headache." The first criterion was never applied and there was only need for the second criterion on one occasion.

Setting, Stimuli, and Apparatus

The study was conducted at the day-care service. The stimuli used during preliminary training were color stimuli: red, blue, and yellow. The participant was asked to choose the stimuli he would like to work on (pictures of family or pictures related to his hobbies) during the training and testing conditional-discriminations. As can be seen in Figure 1, Tor chose pictures of his wife and two daughters (C-stimuli) at present time, their name (A-stimuli), and their relation to him (B-stimuli). During the pre-class formation sorting condition, the stimuli were printed out on laminated cards, 12,5 x 8,5 cm in size.

A custom-made MTS computer program

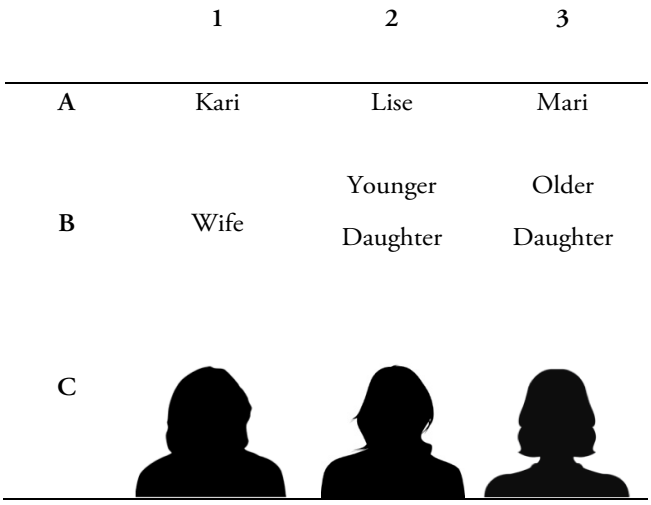

Figure 1. The Experimental Stimuli. For Anonymity, Names are Fictional, and Pictures are Silhouettes Retrieved from Google®.

was used for the presentation of the conditional discriminations. During training and testing, the stimuli were presented with the use of a Microsoft Surface Tablet running Microsoft Windows 10 pro. The participant used his finger to emit the responses on the screen.

Design

Independent and Dependent Variables

The independent variables were the different lengths of the ITI (2,000 or 5,000 ms) while using two different training protocols (SIM and STC protocol). The dependent variable was the participant's responses (correct/incorrect).

Time Period 1 (T1). The experimental sessions were conducted three times a week in a quiet room between 10:30–11:30 a.m. Training and testing took five weeks. The follow-up test was conducted five weeks after the last test session. Sessions lasted between 20–40 minutes.

Time Period 2 (T2). T2 began approximately nine months after the follow-up in T1. At this time Tor had moved into a nursing home and his MMSE score had changed from 18 to 16. Training and testing were arranged in the same manner as during T1 at the day-care service, equally often per week, at approximately the same time, with approximately same length of sessions.

Pre-class Formation Sorting

Tor sat in a chair by a table in the experimental setting. He was given a deck of laminated cards with the nine stimuli to be used during the study and asked to "please sort these." This sorting test was to find out if the participant already sorted the stimuli into the experimenter-defined stimulus classes. Tor placed the stimuli on the table. The criterion for determining whether stimuli were placed in the same stimulus class were: (a) the stimuli had to overlap one another, or (b) the stimuli had to be placed side-be-side in proximity of each other. In addition, stimuli were determined to belong to different classes if they were separated with space in-between them. Tor did not receive any programmed consequences during this part of the study. The sorting task was repeated six times to verify possible stimulus control issues. A picture of the stimuli was taken each time Tor had sorted them. Inter-observer-agreement (IOA) was calculated by two independent observers for all six sorting tasks using (agreements/agreements + disagreements) * 100 (Kazdin, 2011). IOA was 91%.

Familiarization of the Computer Program

Tor was exposed to identity matching with color stimuli (red, blue, and yellow) using the Microsoft Tablet. The goal of the preliminary training was to familiarize the participant with the apparatus, the training, and the setting. The session began with the experimenter reading the instructions out loud for Tor. Printed version of the instructions were placed next to the Microsoft tablet, available for him to read at any time during each training session. The instructions were given in Norwegian, the primary language and which the participant spoke fluently:

> "A picture or text will appear on the screen. Respond to the picture or the text by pressing the computer screen. Then, three other pictures or text will appear in the corners of the screen. Choose the picture or text you think is correct by touching it. You will receive feedback on whether your choice was correct or incorrect, although at some point the feedback will not be shown. It is important that you pay attention to the feedback provided. Good luck."

Then, the computerized training started. The sample stimulus (e.g., red square) would appear in the center of the screen. Upon touching the sample stimulus, three comparison stimuli (red, blue, and yellow squares) were presented in three corners with one corner blank. The comparison stimuli had random placement in the corners from trial to trial. When responding to one of the comparison stimuli the screen went blank

before the presentation of the next trial. No programmed consequences were provided.

Procedure

Condition 1: SIM Protocol with 2,000 ms ITI

First, Tor was exposed to the SIM protocol with serialized introduction of the training trials, which means that the AC conditional discriminations were trained to mastery criterion before the BC relations were introduced (see details in Table 1). All training trials were presented in random order in each training block. The mastery criterion was set to 90% correct for each training block. If the participant did not respond with 90% correct responses, the training block was repeated. When responding in accordance with the mastery criterion, Tor was exposed to a mixed block of AC and BC relations. Following the acquisition phase of the baseline conditional discriminations, the baseline conditional discrimination maintenance phase was introduced. During this phase, the likelihood of presentation of programmed consequences was gradually reduced. Finally, the test trials were presented in random order without programmed consequences.

When Tor finished one condition, the session was ended, and the same condition was repeated the next day. The SIM protocol with 2,000 ms ITI was repeated three more times. For the last three repetitions of the SIM protocol, the training began with the mix of the AC/BC trials (see Table 1). Apart from that, the training was identical to the first SIM protocol training and testing.

Condition 2: STC Protocol with 2,000 ms ITI

The first training block of the STC protocol consisted of nine training trials with three presentations of each of the three AC baseline conditional discriminations (see Table 2). Following mastery of minimum 90% correct, the participant was exposed to the symmetry trials (C1A1, C2A2, and C3A3 trials). If the participant did not respond in accordance with accuracy criterion (lower than 90% correct) the training and testing was repeated, whereas if 90% correct or more, the training of the BC relation was introduced.

The training of the BC relation was identical to the AC training. With a minimum of 90% correct responses, the participant was exposed to symmetry trials (C1B1, C2B2, and C3B3). If Tor had at least 90% correct on the symmetry test, he was exposed to a mixed block of the AC and BC baseline conditional discriminations in an18-trial training block, whereas if the participant did not respond in accordance with mastery criterion the BC training and testing was repeated. When responding in accordance with 90% accuracy criterion on the AC/BC mix, he was exposed to symmetry test (CA and CB relations). If the participant did not respond in accordance with the mastery criterion (lower than 90% correct) on the symmetry test, the mixed training and testing were repeated. When responding with 90% correct or more during the symmetry test, the participant was exposed to the equivalence test (AB/BA relations). The mixed test that is usually presented as the last phase of the STC protocol was omitted to avoid extended exposure to extinction condition and fatigue. This experimental condition was repeated twice more in the same way.

Conditions 3 and 4: SIM Protocol and STC Protocol with 5,000 ms ITI

An ITI of 5,000 ms was used for both protocols. The length of the test blocks was adjusted for comparison between protocols to total of 90 trials in the SIM protocol (30 baseline conditional-discrimination trials, 30 symmetry trials, 30 equivalence trials) and total of 60 trials in the STC protocol (30 symmetry and 30 equivalence). All the other parameters were as described above (see details in Tables 1 and 2).

Five Weeks Follow-Up

Five weeks after the last test, the participant was exposed to the symmetry and the equivalence test again (total 60 trials). The number of test trials and presentations of the conditional discriminations were the same as in the STC protocol test five weeks earlier.

Table 1. Simultaneous Protocol (SIM protocol).

	Baseline Training	No. Trials	% likelihood of programmed consequences	ITI**
Baseline Training	AC	15	100	
	BC	15	100	
	AC/BC	30	100	
Maintenance	AC/BC	30	75	
	AC/BC	30	25	
	AC/BC	30	0	
Test	AC/BC/ CA/CB/ AB/BA	54/90*	0	2,000/5,000

Note. The SIM protocol was used seven times during the study. In the first exposure the AC and BC training trials were presented separately before a mix of both AC and BC trials. Thereafter the training started with the mix (AC/BC training trials).

*Number of test trials was increased to 90 when ITI was increased to 5,000 ms.

**The ITI was either 2,000 or 5,000 ms depending upon condition.

Nine Months Follow-Up

Tor was exposed to the same condition as the 5-week follow-up condition in T1.

Conditions 5 and 6: SIM Protocol and STC Protocol with 5,000 ms

An ITI of 5,000 ms was used for both protocols and with all the other parameters as described above (see details in Tables 1 and 2).

Results

Pre-Class Formation Sorting

Tor's score on the six pre-class formation sorting was 1/3, 0/3, 0/3, 1/3, 1/3 and 0/3, respectively, hence he did not categorize the stimuli in accordance with the experimenter-defined categories (the corresponding name-family relation-picture for each significant other).

The Results of the Different Conditions

Time Period 1

Condition 1: SIM Protocol with 2,000 ms ITI. Tor finished the first baseline including training of conditional discriminations with only 3 incorrect responses out of a total of 150 training trials, all when stimuli from the third stimulus class, his older daughter, were presented as samples. He did not meet the 90% test criterion on any of relations in the test (see Figure 2, panel 1). Out of the 11 incorrect responses, eight where when the sample stimulus was from the third stimulus class. In six of those instances, Tor responded to stimuli related to his younger daughter.

In the second presentation of this condition, Tor made 3 incorrect responses out of 150 training trials, both during the baseline conditional discrimination maintenance phase of the training. Two of those where when the sample stimulus was from the third stimulus class. Tor did not respond in

Table 2. Simple-to-complex Training (STC protocol).

	Baseline Training	No. Trials	% likelihood of programmed consequences	ITI**
Baseline Training	AC	9	100	
Symmetry Test	CA	9	0	2,000/5,000
Baseline Training	BC	9	100	
Symmetry Test	CB	9	0	2,000/5,000
Baseline Training	AC/BC	18	100	
Symmetry Test	CA/CB	18/30*	0	2,000/5,000
Equivalence Test	AB/BA	36/30*	0	2,000/5,000

Note. The STC protocol was used six times during the study.

* Number of test trials were reduced to 30 in the STC protocol 5,000 ms ITI conditions to equalize number of test trials in the different protocols.

**The ITI was either 2,000 ms or 5,000 ms, depending upon condition.

accordance with stimulus equivalence with nine incorrect responses during the test (see Figure 2, panel 2). This time, responding was below 90% accuracy on the baseline trials, symmetry, and equivalence. Seven out of nine incorrect responses when the sample stimulus was from the third stimulus class and Tor chose comparison stimuli from the first stimulus class. The other two incorrect responses were when the stimuli from the second class served as sample stimuli, and he responded to stimuli from the third class.

The third presentation of the SIM protocol 2,000 ms ITI condition resulted in overall fewer errors during training and testing compared to the previous training and testing, with only one incorrect response during the baseline conditional discrimination maintenance phase of training (when sample was from the third stimulus class). The third presentation of the SIM protocol with 2,000 ms ITI condition resulted in overall fewer errors during training and testing compared to the previous condition. However, Tor responded below accuracy criterion on both symmetry and equivalence trials (Figure 2, panel 3). The distribution of incorrect responses was more even across the

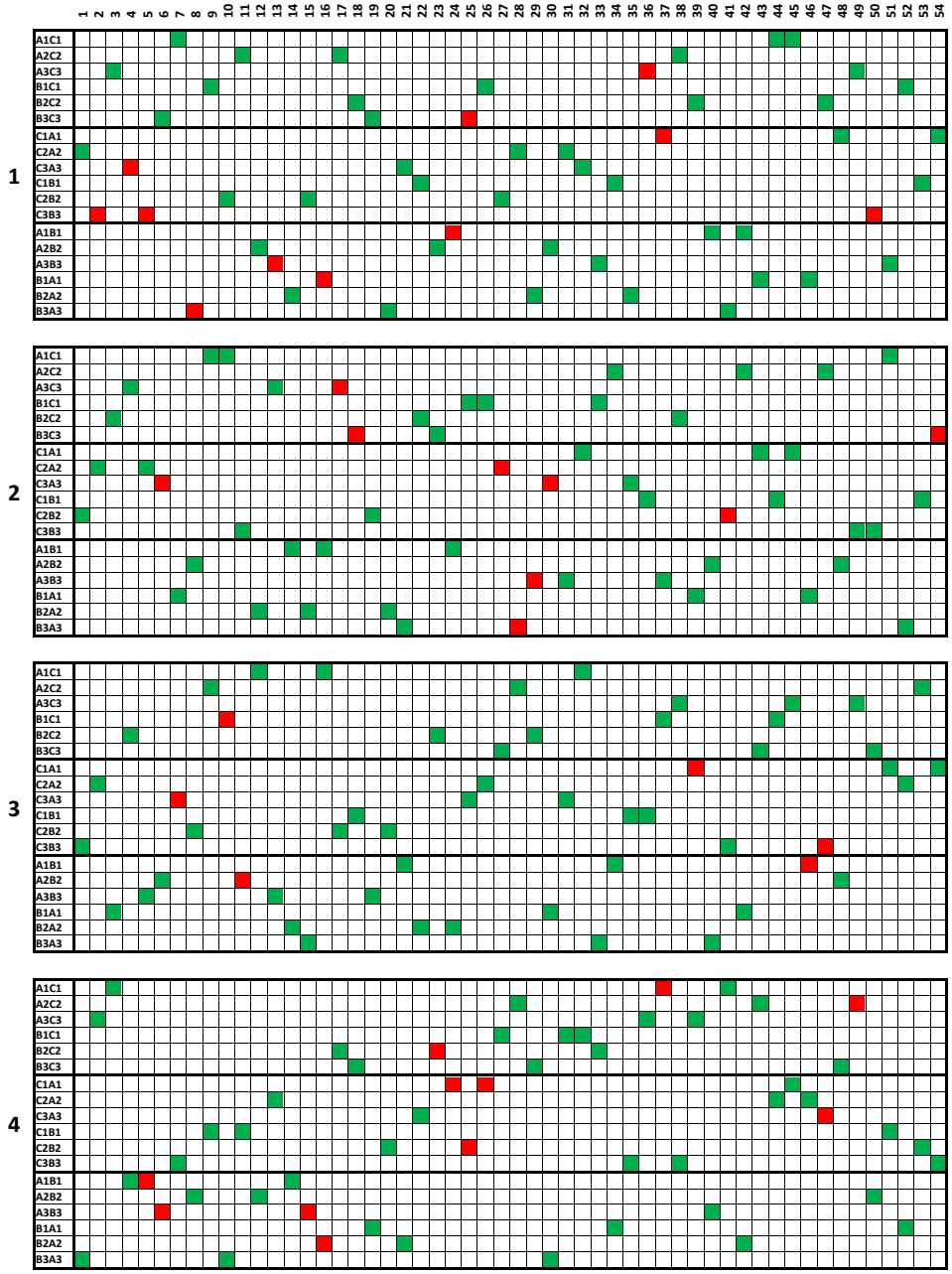

Figure 2. Correct and Incorrect Responses when Exposed to Condition 1.

Note. The figure shows the participant's correct (green) and incorrect (red) responses when exposed to the test trials during the SIM protocol conditions with 2,000 ms ITI. When white, the stimulus was not presented or not responded to.

three stimulus classes compared to before with two out of six incorrect responses when the sample was from the third stimulus class.

In the last presentation of this condition, Tor made five incorrect responses during training. Four of the incorrect responses were

when A3 was the sample, and one when B2 was the sample. Tor emitted 11 incorrect responses during test (Figure 2, panel 4), responding below 90% accuracy criterion on baseline, symmetry, and equivalence trials. The incorrect responses were distributed across all classes instead of being mainly when stimuli from the third stimulus class was presented as sample. However, there was some pattern in his responding where Tor responded to comparison stimuli from the third stimulus class when exposed to sample stimulus from the second stimulus class (mixing younger and older daughter).

Condition 2: STC Protocol with 2,000 ms ITI. Tor's incorrect responses were like the previous conditions. He made 11 incorrect responses when exposed to the baseline conditional discriminations, eight when the sample was from the third stimulus class and three when the stimuli were from the second stimulus class. Tor responded above 90% accuracy criterion on the symmetry trials, but below 90% accuracy criterion on the equivalence trials (see Figure 3, panel 1). Six out of seven incorrect responses on the equivalence trials were related to the stimuli from the classes of younger and older daughter where Tor mixed the two stimulus classes on five occasions.

In the second presentation of this condition, Tor made seven incorrect responses during the baseline of conditional discriminations, four when the sample was from the third stimulus class and three when the sample was from the second stimulus class. He made only one incorrect response in the symmetry test (see Figure 3, panel 2). During the equivalence test, Tor made nine incorrect responses (see Figure 3, panel 2). This time he made five incorrect responses when stimuli from the first stimulus class served as samples, two when stimuli from the second stimulus class served as samples, and two when stimuli from the third stimulus class served as samples.

In the last presentation of the STC protocol 2,000 ms ITI condition, Tor made six incorrect responses during training, four when the sample was from the second stimulus class and two when the sample was from the third. When exposed to the test, Tor responded again with one error on the symmetry trials (above 90% accuracy criterion). However, he made 15 incorrect responses on the test for equivalence (see Figure 3, panel 6), four in the presence of stimuli from the second class and 10 when stimuli from the third class served as sample.

Conditions 3 and 4: SIM Protocol and STC Protocol with 5,000 ms ITI. When first exposed to the SIM protocol with 5,000 ms ITI Tor made five incorrect responses during training. Now, the responses changed from being mainly in the presence of stimuli from class two and three to four incorrect responses when stimuli from the first class were presented as sample and one when stimulus from the second class served as the sample. During testing, Tor made 15 incorrect responses (see Figure 4, panel 1). He responded below 90% accuracy criterion on all test relations (baseline, symmetry, and equivalence). Tor made most incorrect responses when stimuli from either the second (six) or third stimulus class (seven) were presented as the sample, choosing the stimuli from the first stimulus class (his wife) in nine out of 13 occasions.

The STC protocol 5,000 ms ITI was used in the second presentation of training and testing. Tor made total of four incorrect responses on the baseline conditional discriminations, with relatively even distribution across classes. He responded in accordance with symmetry and in accordance with equivalence for the first time during the study in this condition. There were two incorrect responses, both when exposed to stimuli from the third stimulus class (see Figure 4, panel 2).

The SIM protocol 5,000 ms ITI was reintroduced. Tor made only one incorrect response during training when sample stimulus was from the third stimulus class.

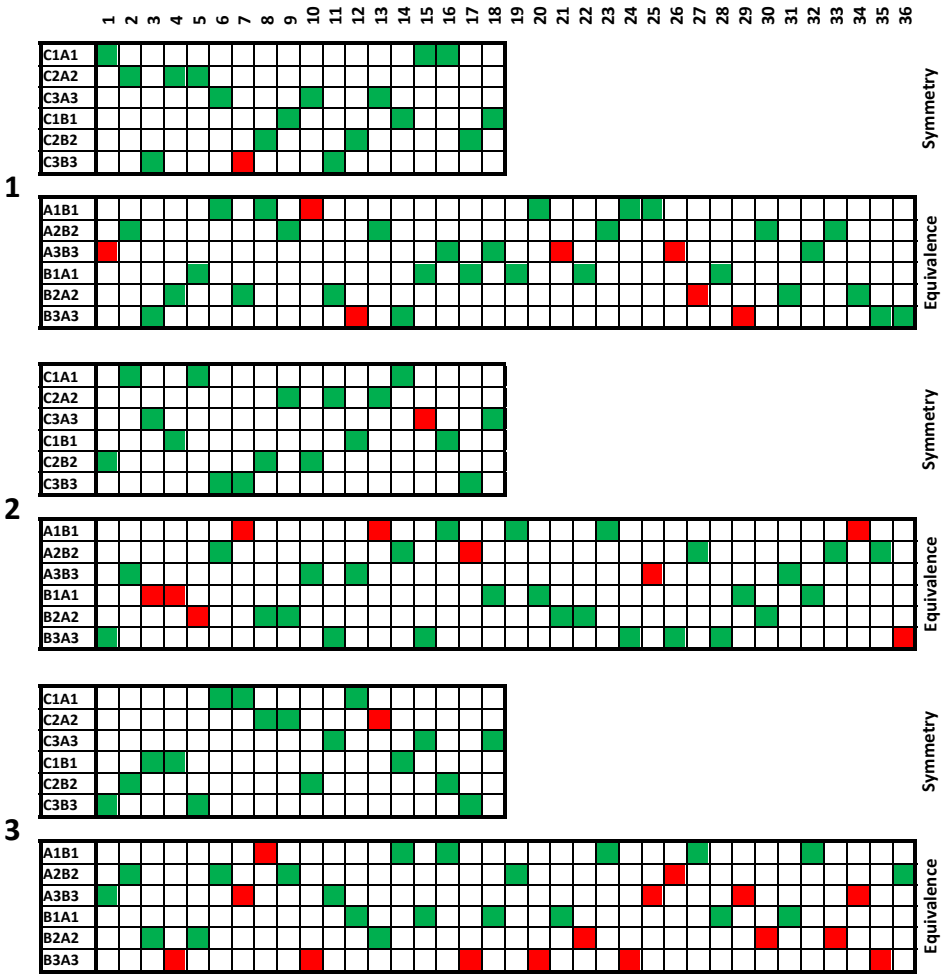

Figure 3. Correct and Incorrect Responses when Exposed to the Test Trials in Condition 2.

Note. The figure shows the participant's responses (green= correct, red= incorrect) when exposed to the test trials of the STC protocol condition with 2,000 ms ITI. Numbers refer to the repeated presentations to the condition. When white, the stimulus was not presented or not responded to.

He responded above 90% accuracy criterion on baseline and equivalence trials, but below accuracy criterion on the symmetry trials. There were eight incorrect responses during testing (see Figure 5, panel 1). Five of the incorrect responses when stimuli from the third class (older daughter) were presented as the sample, where Tor chose either stimuli from the first or second class. The other two were when stimuli from the second class were presented as the sample, where Tor chose stimuli from the third class.

When the STC protocol with 5,000 ms ITI was repeated, Tor made no errors during training and had only two incorrect responses during testing, one on the symmetry trial (see Figure 5, panel 2) and one on equivalence trial. Both were when the sample was from the third stimulus class.

Five Weeks Follow-Up Test. Tor responded in accordance with equivalence (100% correct responses on both symmetry trial and equivalence trials, see Figure 6).

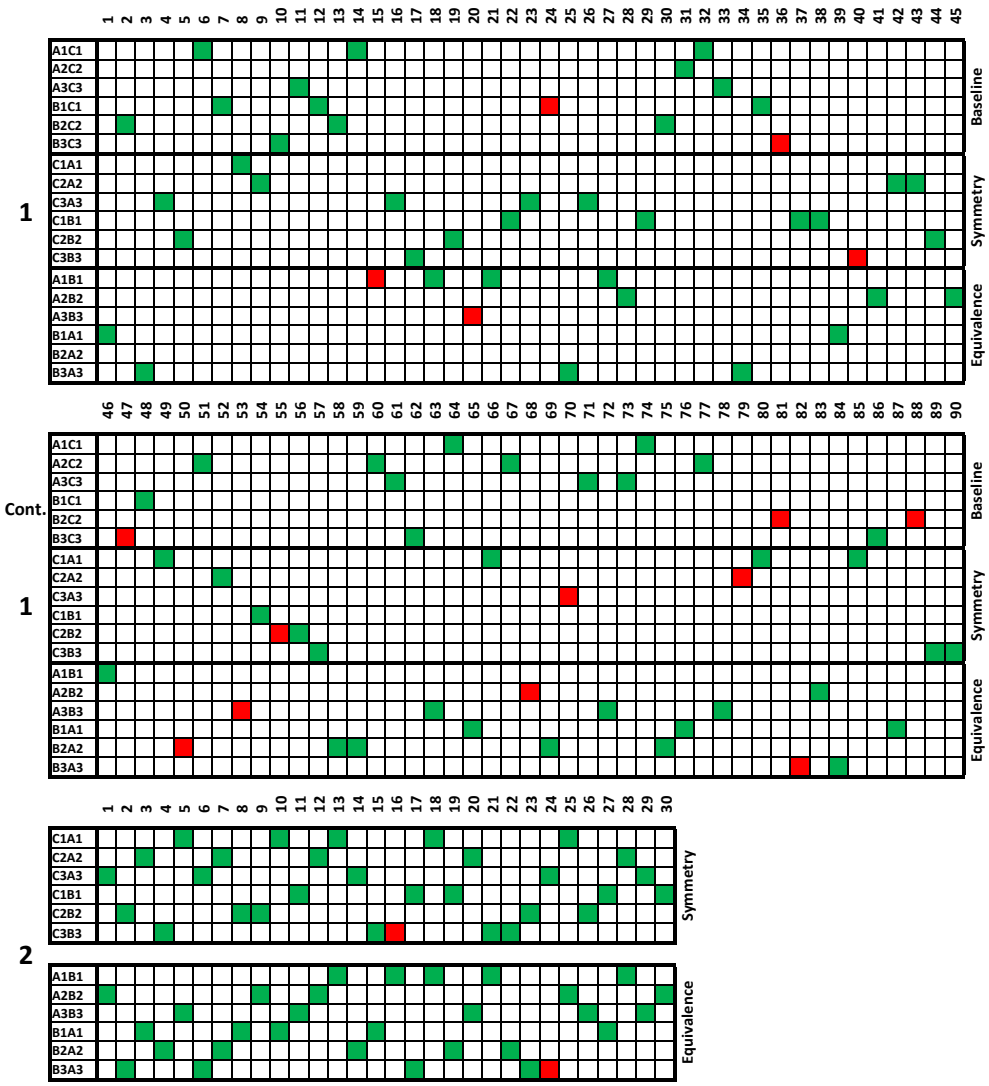

Figure 4. Correct and Incorrect Responses when Exposed to Conditions 3 and 4 - First Two Presentations.

Note. Participant's responses (green= correct, red= incorrect) during test trials of SIM protocol 5,000 ms ITI (panel 1) and the STC protocol 5,000 ms ITI (panel 2). When white, the stimulus was not presented or not responded to.

Time Period 2

Nine Months Follow-Up Test. Tor made nine incorrect responses in the 9-month follow-up, three and six on the symmetry and equivalence trials, respectively (see Figure 7). Most of the errors were related to stimuli from the third stimulus class. Tor would often respond to stimuli from the third class when exposed to a sample from the first and second class, and to stimuli from first and second stimulus class when exposed to sample stimulus from the third stimulus class.

Conditions 5 and 6: SIM Protocol and STC Protocol with 5,000 ms ITI. When exposed to the baseline of conditional discriminations with the SIM protocol, Tor made

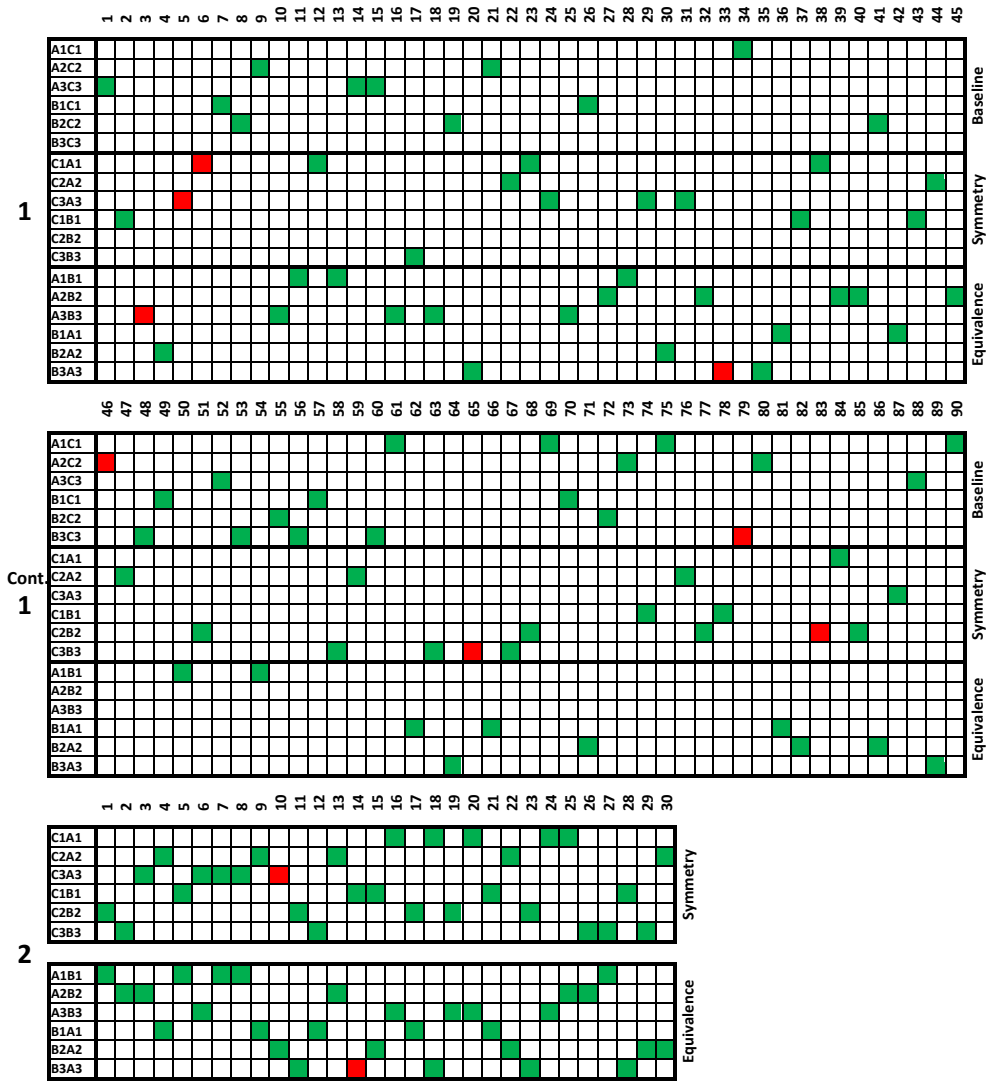

Figure 5. Correct and Incorrect Responses in Conditions 3 and 4 - Second Presentation.
Note. Participant's responses (green= correct, red= incorrect) during test trials of SIM protocol 5,000 ms ITI (panel 1) and the STC protocol 5,000 ms ITI (panel 2). When white, the stimulus was not presented or not responded to.

more incorrect responses than he did when he was first exposed to this condition nearly a year earlier (10 out of 150 training trials, compared for example with three out of 150 in the first presentation of the SIM protocol in Condition 1). As for the 9-months follow-up test, the incorrect responses were mainly related to the third stimulus class. During test for equivalence class formation, he made 10 incorrect responses (Figure 8, panel 1). He responded above 90% accuracy criterion during the baseline trials, while he did not meet the test criterion for symmetry and equivalence trials. The errors were mostly related to stimuli from the third stimulus class (responding to stimuli from the third class in the presence of sample stimulus from the first or second stimulus

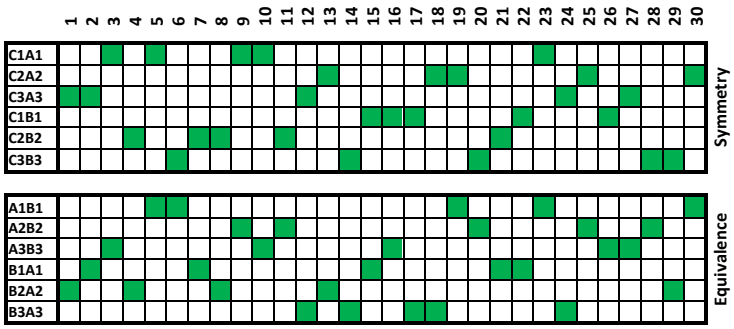

Figure 6. Correct and Incorrect Responses when Exposed to the 5-weeks Follow-Up Test.
Note. Tor's responses in a 5-week follow-up. Green= correct. White= stimuli not presented or not responded to.

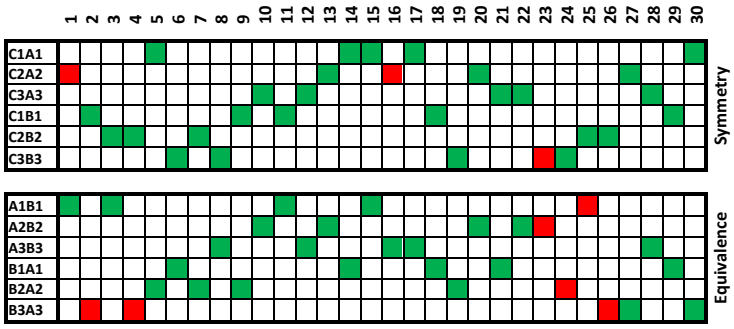

Figure 7. Correct and Incorrect Responses when Exposed to 9-Months Follow-Up Test.
Note. Tor's responses when expose to the follow-up test again nine months later. Green= correct. White= stimuli not presented or not responded to.

class and responding to stimuli from the first and second stimulus class when exposed to sample stimulus from the third stimulus class).

During the last presentation of the training and testing of conditional discriminations (STC protocol with 5,000 ms ITI), Tor made fewer incorrect responses than before (see Figure 8, panel 2). Due to programming error, he was exposed to the symmetry test twice. The errors Tor made were still mostly related to the third stimulus class. Although there were few errors, Tor responded above 90% accuracy during testing, repeating the results from the same condition in T1.

In sum of all conditions during T1 and T2, Tor responded for the first time in accordance with the experimenter-defined criterion of stimulus equivalence when exposed for the first time to the STC protocol with 5,000 ms ITI (see Figure 9, black triangle). Accuracy was maintained in the 5-week follow-up (marked with X). However, in the 9-month follow-up accuracy was below the mastery criterion of 90% correct response (marked with ✳). As before, mastery was reached again with the use of STC protocol and 5,000 ms ITI (black diamond).

Discussion

The purpose of this study was fourfold. We asked about (1) the effect of different lengths of ITI in combination with different training protocols on stimulus class formation. Then (2) about the maintenance of

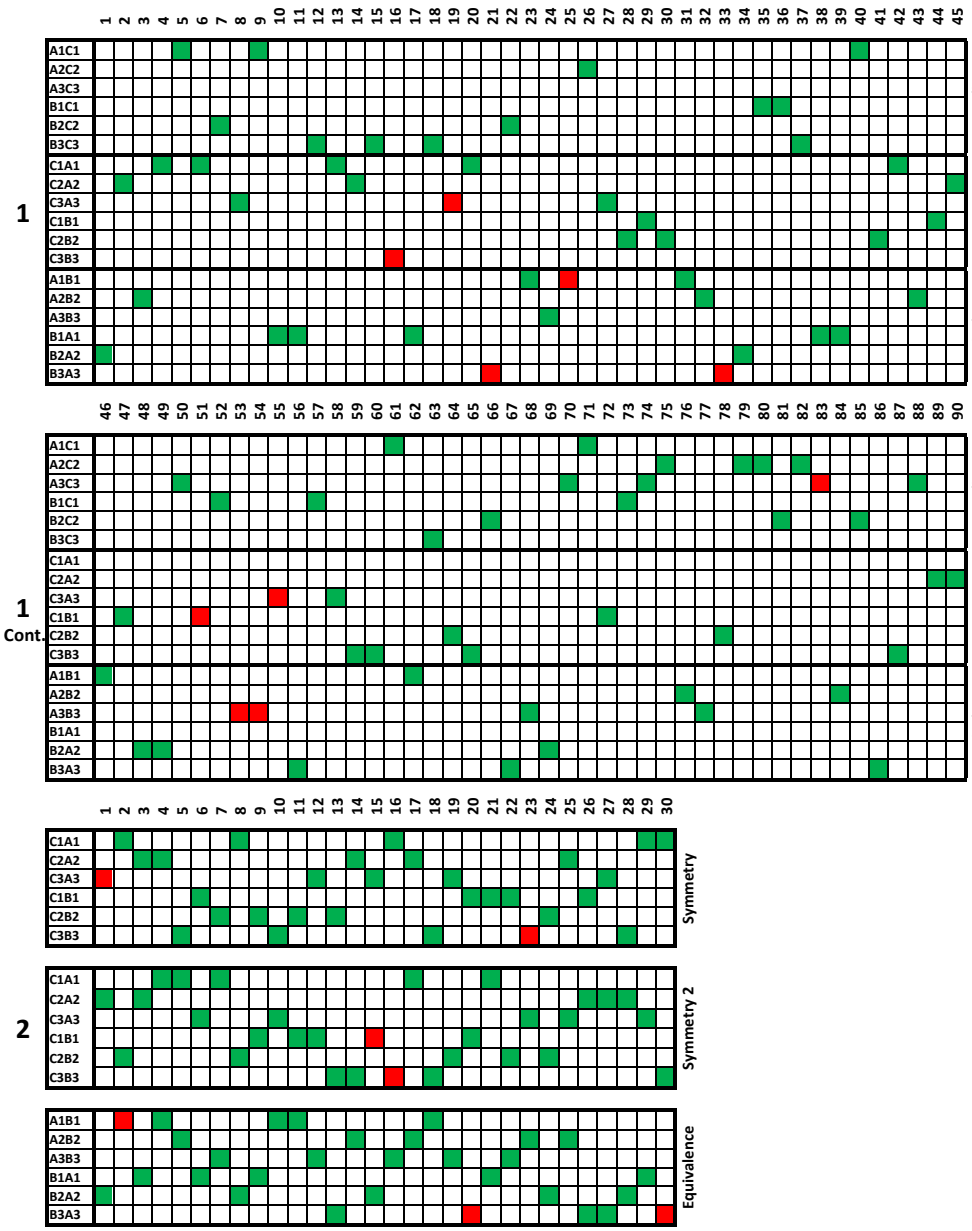

Figure 8. Correct and Incorrect Responses when Exposed to Conditions 5 and 6.

Note. The figure shows the participant's responses (green= correct, red= incorrect) when exposed to the test trials of the SIM protocol and STC protocol condition with 5,000 ms ITI. When white, the stimulus was not presented or not responded to.

the conditional discriminations in a 5-week follow-up, and again in (3) a 9-month follow-up. Finally, (4) whether the same results for re-establishment of the stimulus classes would be obtained for the SIM and SCT protocols with 5,000 ms ITI.

The main results were that the STC protocol with the 5,000 ms ITI was most

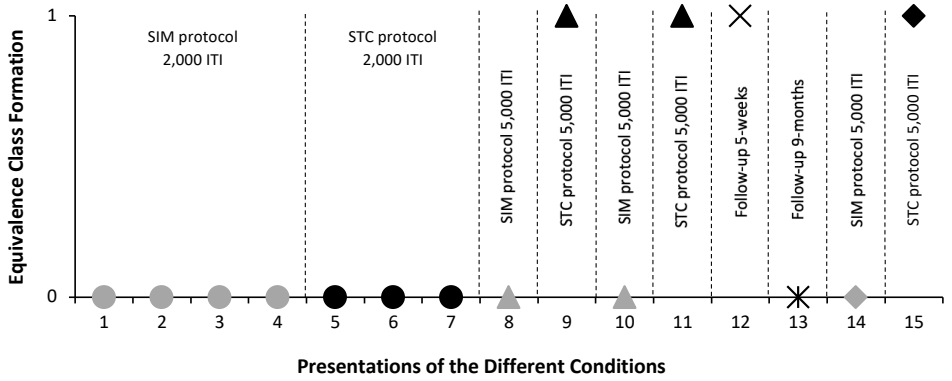

Figure 9. Equivalence Class Formation Across the Different Conditions.

effective for the re-establishment of the conditional discriminations. Furthermore, the 5-week follow-up showed that the participant continued to respond correctly to the different conditional discriminations despite no training for five weeks. Repeated presentation of this last condition nine months later showed an increase in incorrect responding from the last follow-up. Repetition of the two conditions (the SIM protocol and the STC protocol) with 5,000 ms ITI confirmed previous finding, re-establishment of the conditional discriminations when exposed to the latter.

Training and Test Arrangements

Studies have shown that increasing the length of the ITI may lead to more accurate responding during delayed matching-to-sample tasks (Roberts & Kraemer, 1982; Williams et al., 2006). The current study expands the literature by showing how matching performance was influenced by different lengths of ITI during simultaneous matching-to-sample. Specifically, increasing the length of the ITI seems to have enhanced the distinction between two training trials. In other words, it seemed to be easier for Tor to differentiate between the ending of one training trial and the beginning of the next when the ITI was longer, thereby minimizing the likelihood that previously presented training trial interfered with responding on the next training trial. The downside of increasing the length of the ITI on the other hand is that the sessions last longer. Notably, the current study includes only one participant, therefore, further studies of the effect of different lengths of ITI is warranted.

Furthermore, previous literature has shown the benefits of using the STC protocol for the emergence of equivalence classes (Fields et al., 1991). The results from the current study expands the literature by demonstrating how a variation of the STC protocol with 5,000 ms leads to greater likelihood of formation of stimulus equivalence classes in a participant with NCD.

Social Significant Behavior

The current study is seen as an example of translational research (Mace & Critchfield, 2010; McIlvane, 2009), where socially significant behavior for the participant is targeted while studying variables enhancing equivalence class formation. Previous studies have discussed the possibility that conditional discriminations, may be affected at very early stages of the NCDs (Arntzen & Steingrimsdottir, 2017). Also, studies have shown that conditional-discrimination procedures may be used to gain information about behavior changes in this population (Bódi et al., 2009; Brogård-Antonsen & Arntzen, 2019; Ducatti & Schmidt, 2016; Gallagher & Keenan, 2009). Furthermore, as suggested by Sidman (2013), the application of conditional-discrimination

procedures may provide information about the participant's strengths and weaknesses. The results of the present study support these suggestions by identifying important variables for training and maintenance of the conditional discriminations. The results showed that Tor often made incorrect in relation to the stimuli from the third stimulus class, his older daughter. When comparing the pictures of his significant others, one could see that his older daughter looked more alike her mother compared to the younger daughter. At the same time, although Tor's two daughters were unique in many ways (hair color and age, to name some) they also resembled each other in number of ways. As such, the results provided important information about stimulus control issues related to recognition of his family members. Importantly, knowing which stimulus-stimulus relations are more difficult for a participant (where the participant makes most incorrect responses) allows practitioners to work on those stimulus-stimulus relations for the maintenance of face-name conditional-discrimination relations.

The results also show some positive aspect of Tor's behavior. Tor seldom made an incorrect response when presented with a sample stimulus from the first stimulus class (wife), or in other words, stimulus control was preserved. It is important to note that when working with individuals with NCD, the training is competing with the development of the disorder. As described in a meta-analysis by Hu et al. (2019), computerized cognitive training is most effective when training begins at early stages of the disease with data showing significant improvements in remembering. Furthermore, the authors noted that the effect of computerized training is greater when the training is individually tailored and targets specific strengths or weaknesses of the individual's behavioral repertoire, in comparison with non-specific computerized training (such as doing a puzzle or crosswords). The current study takes both aspects into an account. Training was implemented before extensive deterioration was documented and training was tailored in accordance with Tor's correct/incorrect responses. This may increase the likelihood of successful re-establishment of possibly newly deteriorated stimulus control and increase the likelihood of maintaining stimulus control over time.

Throughout the course of the study, Tor formed equivalence classes, with a documented maintenance of the stimulus-stimulus relations in the follow-up five weeks later. Although he made more errors nine months later, the repeated presentation of training of conditional discriminations led to the re-establishment of the classes. Equivalence based instructions has proven to be useful for establishment and evaluation of maintenance of conditional discriminations over a longer period in other populations (Arntzen et al., 2014; Arntzen et al., 2010). Focusing on the re-establishment and maintenance of conditional-discrimination relations and testing for responding in accordance with stimulus equivalence is the strength of the current study as it provides a well-defined continuum from the training to the learning outcomes (Hampstead et al., 2013). For future studies, we suggest that additional follow-up testes after 10, 15 and 20 weeks are incorporated for continuous documentation of the stability of the trained stimulus-stimulus relations over time. Monitoring the stimulus-stimulus relations within socially significant stimulus classes is particularly important since the stimuli hold such a great value for the participant. Notably, data from such tests will give practitioners the opportunity to tailor additional training if necessary.

Difference Between the SIM and STC Protocols

There is the difference in thinning of programmed consequences in the protocols; the thinning of programmed consequences was used during the SIM protocol conditions and not the STC protocol conditions.

Overall, the results of the first presentations of the SIM protocol showed that Tor mainly emitted correct responses during baseline training and then incorrect response during testing. There was a minimal increase of incorrect responses when the density of programmed consequences was decreased. However, the number of incorrect responses never resulted in the repetition of the training block. In other words, the baseline conditional discriminations were minimally affected by the reduced likelihood of programmed consequences. Since Tor made consequently correct responses throughout the training blocks when density of programmed consequences was decreased, we agreed on using 100% accuracy criterion, which left no room for incorrect responses on the baseline conditional discriminations and exclude thinning of programmed consequences in the STC protocol conditions. By doing so, we hoped to minimize the threat of fatigue during the training and test session. However, future studies should compare the use of thinning of programmed consequences within each training protocol to learn more about the effect of that variable on participants responding.

Limitations and Future Research

The first limitation is connected to use of the same stimulus set (name, face, and family relation) throughout the experiment. The participant was asked which stimuli should be used during the discrimination training (he chose from range of stimuli such as pictures of family members and pictures related to his hobbies). This ensured user involvement and social validity of the experiment. However, the downside was that the experimental control is threatened due to carry over affect across conditions. Also, as the study lasted for some weeks, seeing his significant others outside the experimental setting may also be a threat to the internal validity of the experiment. The experimenters in the current study did not make any adjustments to reduce or limit discussion or access to the participants significant others as that was evaluated as unethical. Although the experimental conditions were introduced alternately, which may strengthen the validity of the study, it is important to replicate the study to address this limitation. Future studies may therefore either use different stimulus sets while exploring the effect of the independent variables, or use matched group design while employing the same stimulus set throughout the study to document the effect of the different variables.

A second limitation is that the STC protocol did not include a mixed test block with all trial types. The reason for not including such test a block was to avoid a lengthy exposure to extinction conditions and to avoid fatigue. However, follow up studies might study the effect of using the mix as well.

A third limitation is related to the difference between responding above or below test criterion throughout the study. It is important to note that although those differences were sometimes small, they were of social significance for the participant. Furthermore, it is important to emphasize that forming of equivalence classes is defined as scoring above a certain value on a categorical scale. Therefore, instances which are closed to the experimenter-defined criterion are not possible to avoid.

The fourth limitation is also related to these instances with the scorings below the experimenter-defined criterion and to threats toward the experimental control in the design. We considered it as unethical to wait for further deterioration of stimulus control in participants. Therefore, we suggest replications of this study with different participants at different stages of the disease to further understanding of the effect of those variables on stimulus class formation in individuals with NCD. Such studies might for example reverse the use of ITI and training protocol while employing different sets of stimuli, allowing counterbalancing of conditions across participants.

Finally, it should be included how the functional relations that are trained in an experimental setting are transferred from the training setting to real life setting. When doing so, the trainer may use the STC protocol with longer ITI to train the conditional discriminations and test for emergent relations, and then test for generalization to other stimuli that should also be part of the stimulus class.

Conclusion

The results of this study showed that conditional discriminations were re-established when using the STC protocol with 5,000 ms ITI. Accuracy was maintained in the 5-week follow-up. In the nine-month follow-up, responding was below 90% mastery criterion. However, the classes were established again when exposed to the STC protocol with 5,000 ms ITI. The study expands the current literature on the use of the conditional-discrimination procedure with individuals with NCD and provides important suggestions for future research, namely, to attend to the length of the ITI and the type of training protocols employed. Importantly, the results showed the necessity to study further different variables that may affect establishing conditional discriminations and equivalence class formation in participants with NCD. Understanding the effect of different experimental variables will assist experimenters and practitioners to identify optimal training conditions for this population.

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