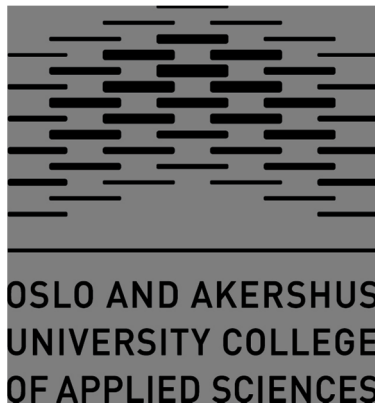


Learning and Remembering in Older Adults and Older Adults with Neurocognitive Disorders

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Abstract

Many countries face a demographic change with an aging society. Accompanying those changes are increased frequency in diseases that have their onset later in life. Among such diseases are neurocognitive disorders (NCDs) such as Alzheimer's disease. The various NCDs have in common to negatively affect the individual's social and occupational functioning with deterioration in cognitive behaviors, such as learning and remembering. Therefore, it is important to facilitate an understanding of different variables affecting these behaviors. Currently, there are, however, only few studies within the behavior analytic literature examining such complex behavior in the older population. The purpose of the current dissertation was to study variables affecting learning and remembering in older adults and NCD patients. The dissertation is based on five studies. The first two studies were with healthy older adults. Study 1 examined the effect of presenting identity matching-to-sample (MTS) before arbitrary MTS, and vice versa, on the establishment of baseline conditional discrimination and stimulus equivalence class formation, along with studying the effect of using simultaneous MTS versus 0-s delayed MTS. Study 2 examined eye-movements during establishment of baseline conditional discrimination and during testing for responding in accordance with stimulus equivalence. Studies 3–5 had participants with NCD diagnoses. Study 3 examined discrimination behavior in NCD patient using different conditional discrimination procedures. Study 4 examined the effect of using two or three comparison stimuli in conditional discrimination learning along with the use of simultaneous versus 0-s delayed MTS. Finally, Study 5 examined the effect of using different titration values in a titrating delayed MTS procedure. The five studies have extended the current literature by showing how systematic, though subtle changes in the procedures can have a great impact on participants' responses. The general conclusion is that the different conditional discrimination procedures are highly applicable to study variables affecting learning and remembering in each person. Understanding the application of the different procedures allows for identification of each individuals abilities and disabilities. The information may in turn be used in an applied setting, which may be of particular interest when working with NCD patients.

Keywords: arbitrary MTS, behavior analysis, conditional discrimination, delayed MTS, identity MTS, learning, neurocognitive disorders, older adults, remembering

Sammendrag

Flere land står foran en demografisk forandring med økende levealder. Sykdommer knyttet til økt levealder medfører denne forandringen. Forskjellige demenssykdommer, som for eksempel Alzheimers sykdommen er eksempler på dette. De forskjellige demenssykdommene har til felles at de påvirker individets sosiale- og yrkesliv med forverring av såkalte kognitive ferdigheter, som for eksempel individets evne til å lære og huske. Det er derfor særs viktig å øke forståelse av forhold eller variabler som kan påvirke disse typene av atferd. Hittil er det kun få studier innenfor atferdsanalyse der slik kompleks atferd er studert hos eldre deltakere. Formålet med denne avhandlingen var å forske på variabler som påvirker læring og husking hos eldre personer og eldre som har en demenssykdom. Avhandlingen baserer seg på fem studier. De første to studiene omfatter funksjonsfriske eldre deltakere. Studie 1 undersøkte effekten av å gjennomføre identitetsmatching før arbitrær matching, og omvendt i forhold til etablering av betinget diskriminasjon og respondering i henhold til stimulusekvivalens. Videre undersøkte studien effekten av å bruke simultan matching versus 0-s forsinket matching. Studie 2 undersøkte øyebevegelser under etablering av betinget diskriminasjon og testing for respondering i henhold til stimulusekvivalens. Studie 3–5 hadde deltakere med en demensdiagnose. Studie 3 undersøkte diskriminasjonsatferd hos en pasient med demens med bruk av forskjellige betingete diskriminasjonsprosedyrer. Studie 4 undersøkte effekten av å bruke to eller tre sammenligningsstimuli i betingete diskriminasjonsoppgaver, samt effekten av å bruke simultan og 0-s forsinket matching. Studie 5 undersøkte effekten av å bruke forskjellige titreringsverdier i forsinket matching oppgaver. Disse fem studiene har utvidet litteraturen som finnes innen atferdsanalyse med denne målgruppen med vise hvordan systematiske, og til og med små forandringer i prosedyrene, påvirker responderingen til hver enkelte. Konklusjonen er at de forskjellige betingete diskriminasjonsprosedyrene kan tilpasses hver enkelt deltaker for å påvirke læring og husking for den enkelte deltaker. Det å øke forståelsen av bruk av disse prosedyrene fører til muligheten for å lage treningsprosedyrer som kan brukes i en anvendt setting. Dette kan være av spesiell interesse i arbeid med personer med demens.

Nøkkelord: arbitrær MTS, atferdsanalyse, betinget diskriminasjon, forsinket matching, identitets matching, læring, demens, eldre, husking.

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Introduction

Older adults are currently the fastest-growing demographic group in several countries. There are a number of normal changes that occur with increased age, both physical changes (e.g., hearing, smell, sight) and changes in what can be labeled as cognitive behaviors (e.g., learning and remembering). However, there may also be abnormal changes, in both the sensory system and cognitive behaviors, with some of the latter being related to the onset of a neurocognitive disorder (NCD). These abnormal changes pose several challenges for the individual by negatively affecting his or her social and occupational functioning. Consequently, understanding variables that affect learning and remembering in older adults is appreciated.

Behavioral gerontology refers to the application of behavior analytic principles when working with older adults (Baker & LeBlanc, 2014; Burgio & Burgio, 1986). Although the behavioral gerontology literature is still rather limited compared to other areas of behavior analysis (e.g., Trahan, Kahng, Fisher, & Hausman, 2011), there seems to be an increased awareness of using behavior analytic principles when working with older adults and older adults with NCD. Most of the behavioral gerontology articles that have been published to date are within the area of applied behavior analysis, where the goal is to increase quality of life by targeting socially significant behaviors that are in need of change (e.g., Altus, Engelman, & Mathews, 2002; Baker, LeBlanc, Raetz, & Hilton, 2011; Trahan, Donaldson, McNabney, & Kahng, 2014). On the other hand, there are still few studies within the area of experimental analysis of behavior, where the goal is to understand variables affecting learning and remembering in older adults and NCD patients (e.g., Sidman, 2013; Steingrimsdottir & Arntzen, 2011b). The current dissertation targets the latter issue with the purpose of studying variables affecting learning and remembering in older adults and older adults with NCD by using different conditional discrimination procedures.

Before introducing the experimental analysis of learning and remembering, the dissertation begins by providing some information about the aging population, followed by a short introduction to various NCDs, their diagnoses, and their prevalence. This is done to briefly establish the context for this research area. Then, a methodological background for Studies 1–5 is introduced by discussing the conditional discrimination procedures that were used in the five studies: the identity, arbitrary, and delayed matching-to-sample (MTS) procedures. Thereafter, the background literature that has direct relevance for the studies will be summarized, to relate the studies to the relevant research literature. Next, a summary of the studies will be provided, followed by discussing of their results, and concluding remarks. The dissertation ends with a presentation of the five studies that form its basis.

Prevalence of Older Adults and Neurocognitive Disorders

As previously mentioned, the group of older adults is the fastest-growing population today. According to Administration on Aging (2013), there were 3.1 million Americans 65 years or older in 1900, whereas in 2012, this population surpassed 43 million. It is estimated that the older adult population in America will reach 92 million in the year 2060. Moreover, the older population is not just increasing in number; life expectancy is increasing as well. As described in the report from Administration on Aging (2013), the group of 65 to 74 year-old is 10 times larger today than it was in 1900, the group of 75 to 84 years-old are 17 times larger, and the oldest group is 48 times larger.

According to *Folkehelseinstituttet* (2014) the same development applies to the Norwegian population. For example, life expectancy has increased from approximately 50 years for women, and 47 years from men in the year 1845, to 83.6 years for women and 79.7 years for men in 2013. Older adults, which in this report are 70 years or older, currently account for approximately 10% of the total population. However, it is estimated that in 2070, older adults will account for 20% of the population. Based on these numbers, as the

population in Norway was a little over 5 million in 2015, a rough estimation of the number of older adults in Norway indicates that they are around 500.000 today. As it is estimated that the Norwegian population will grow to 7 million by the year 2063, it is predicted that older adults will account for 1.4 million of the total population.

As the group of older adults grows, owing to both demographic changes and increased life expectancy, it is assumed that the prevalence of NCDs will increase as well (e.g., Ferri et al., 2005; Snarski et al., 2011; Thies & Bleiler, 2013). For example, it was estimated that in the United States alone, around 5.2 million individuals had Alzheimer's disease (AD) in 2010, with an estimated increase to up to 13.8 million by the year 2050. Furthermore, it has been stated that AD is the sixth-leading cause of death in the United States today (Mebane-Sims, 2009; Thies & Bleiler, 2013). According to *Helsedirektoratet* (2015), there are approximately 70.000 Norwegians with NCD diagnoses today, with an estimated increase to up to 135.000 by 2040. Looking at a global scale, it was estimated that around 35.6 million individuals had NCD diagnoses in 2010, with an expected increase to 115.4 million by the year 2050 (Prince et al., 2013).

Neurocognitive Disorders

The most commonly known NCD, Alzheimer's disease (AD), was first described by Alois Alzheimer in 1906 (Weiner, 2009). The causes of the disease are related to the formation of plaques and tangles in the brain, leading to synaptic dysfunction and neural loss. The main characteristic of AD is memory impairment. However, for an AD diagnosis to be made, there has to be deterioration in other cognitive behaviors as well, such as orientation, problem solving, or language (Geldmacher, 2009). Behavioral symptoms may also occur, for example, agitation (occurs in 50–60% of AD patients) and apathy (occurs in 25–50% of AD patients) (Geldmacher, 2009). Over the course of time, the patient's social and occupational

functioning declines; the patient will gradually lose the ability to perform general activities of daily living (ADL) and eventually become totally dependent on others.

Today, it is estimated that AD accounts for between 60–90% of all NCD diagnoses (American Psychiatric Association, 2013). Other common NCDs are such as Vascular Dementia, due to reduced blood flow to the brain that leads to damage to the neurons of the brain (Szoek, Campbell, Chiu, & Ames, 2009), and NCD with Lewy Bodies (LB), where α -synuclein protein deposits form in the nerve cells in the brain, leading to abnormal neural function (Tarawneh & Galvin, 2009). Other types of NCDs include frontotemporal dementia, Huntington disease, NCD due to vitamin deficiencies, and NCD due to HIV, to name a few.

Although the common characteristic of the various NCDs is deterioration in cognitive behaviors from the previous level of functioning, different types of diseases have different etiologies (e.g., Thies & Bleiler, 2013), with a difference in how they affect the individual's functioning. This applies particularly to the early stages of the diseases (Engedal & Haugen, 2009). For example, one of the main characteristics of Alzheimer's disease is memory impairment, whereas for a patient with Vascular Dementia, the first symptoms may be a incapacitated ability to make plans and impaired judgment (Thies & Bleiler, 2013). Notably, it is important to take these differences into consideration as treatment outcome may depend upon which type of NCD the patient has.

Neurocognitive testing. For an NCD diagnosis to be made, the onset of the disease has to be later in life with the patient experiencing deterioration from the previous level of social or occupational functioning (American Psychiatric Association, 2013). Importantly, the patient's behavior cannot be able to be explained by other mental disorders, and the behavior cannot occur solely in delirium. In addition to the patient's own concerns about cognitive decline, there need to be some signs of decline on neurocognitive tests.

There are a number of neurocognitive tests that may be used when evaluating whether a patient has an NCD. The most commonly used screening test for an NCD is the Mini-Mental State Examination (MMSE) (Folstein, Folstein, & McHugh, 1975). The test has been translated to a number of languages for world-wide use (Steis & Schrauf, 2009). Its popularity is probably due to its easy administration and scoring, as the test can be administered and scored in approximately 5–10 minutes. The MMSE has 11 categories of questions (e.g., “What year is it?” “Spell the word WORLD backwards,” and “What is this?” while showing the patient a pen). If the participant answers every question correctly, he or she will get 30 points, which is the highest possible score. An incorrect answer leads to a lower MMSE score. A score from 30 to 24 indicates no cognitive impairment. An MMSE score between 23 and 21 indicates mild cognitive impairment, and a score from 20 to 10, moderate cognitive impairment. A score below 10 indicates severe cognitive impairment.

Tombaugh and McIntyre (1992) have pointed out that the test’s reliability may be questionable when it comes to differentiating between older adults without NCD and those at the early stages of an NCD. For example, studies have shown that when a patient has a higher education, a cut-off score of 26/27 may be more appropriate (e.g., O’Bryant et al., 2008; Spring et al., 2012). On the other hand, the test is said to provide fine information about the progression of the disease in patients with moderate to severe NCD. Due to the common use of the MMSE, and as it is often the only information that may be obtained from patients with NCD in Norway, this test was included in four of the studies described below (where the participants were 70 years or older and where the participants had NCD diagnoses) for an indication of a reference point for the participants’ cognitive abilities.

Another neuropsychological test is the clock drawing test (e.g., Agrell & Dehlin, 1998). In this test the patient is asked to draw a clock and to put the hands of the clock at a specific time (such as 10 after 11). The test can be done in different manners, for example,

either by presenting the patient with a blank sheet and asking him or her to draw a clock showing a specific time, or by giving the patient a sheet of paper with a circle and asking him or her to draw the numbers on the clock and set the hands at the specific time. As the test is conducted differently, the scoring varies as well. Richardson and Glass (2002) compared the results from a brief MMSE test (a shorter version of the MMSE test with a total score of 12 where cutoff point 9/10 correlates with cutoff point 23/24 in the full version) with five scoring methods of the clock drawing test. They concluded that the five methods they studied had a high correlation with the results of the brief MMSE.

The Wechsler Adult Intelligence Scale (WAIS), a general standardized intelligence test with an average normal score 100, may also be used to evaluate cognitive decline. The test is much more time consuming than the MMSE and the clock drawing test and takes about 60–90 minutes to finish. Such a long test may be very challenging for an NCD patient, and therefore shorter versions are perhaps more often used. If neurocognitive tests indicate onset of an NCD during the screening process, the patient may be sent for magnetic resonance imaging (MRI) or computed tomography (CT) for further information about what type of NCD is present and which regions of the brain are affected (e.g., Pasi, Poggesi, & Pantoni, 2011).

The neurocognitive tests introduced above are merely examples of tests that may be used for either screening or evaluation of the progression of an NCD. There are a number of other tests that may be used, but more detailed information about testing methods is out of scope for the purpose of the current dissertation. For the interested reader see, for example, Cullen, O'Neill, Evans, Coen, and Lawlor (2007).

Behavioral Gerontology

As mentioned earlier, most of the published studies to date within behavioral gerontology are on issues that are dealt with in an applied setting (e.g., Altus et al., 2002;

Baker, Hanley, & Mathews, 2006; Baker et al., 2011; Dwyer-Moore & Dixon, 2007; LeBlanc, Cherup, Feliciano, & Sidener, 2006; Trahan et al., 2014). As stated by Derenne and Baron (2002), the disparity between the traditional study of aging and the behavior analytic contribution is largest when it comes to basic research. They pointed out that one of the reasons for this disparity may be related to the fact that the age variable itself cannot be manipulated. However, they also emphasized that it does not mean that behavior analysts should avoid experimental questions where performance as a function of age is studied. On the contrary, because of the strong relation between basic research and the applied setting, behavior analysts need to find ways to deal with these research questions.

According to LeBlanc, Raetz, and Feliciano (2011), most of the studies that have been conducted within the experimental analysis of behavior with older adults as participants have been on changes in classically conditioned responses as a function of age, and age-related changes in responses to different reinforcement schedules, signal detection, and stimulus equivalence class formation. However, the authors also pointed out that the results of the studies that have been published so far are in some cases conflicting, and thus further studies are needed.

Experimental Analysis of Learning and Remembering

The behavior analytic approach to study learning and remembering emphasizes the study of functional relations between environment and behavior (e.g., Moore, 2008). Thus, it is important to begin with a clarification of what is meant by the concepts *learning* and *remembering*. Although it may be difficult to define learning per se (see Catania, 2007), *learning* is taken here as a *description* of an observed change in the probability of a response in accordance with the reinforcement contingencies set up by the experimenter. *Remembering* is also a description of behavior, but the definition is different as it involves a correct response

being emitted after a *temporal delay* from the presentation and removal of a controlling stimulus.

Studies have shown that humans change their behavior in accordance with reinforcement contingencies in the environment (Skinner, 1938, 1953). Moreover, studies on learning within neuroscience have shown that the hippocampus and basal ganglia, are among the brain areas that are involved in learning by consequences (e.g., Ortu, Skavhaug, & Vaidya, 2013). These same areas have also been shown to be negatively affected by the onset of an NCD (e.g., Deweer et al., 1995; Teipel et al., 2013). Consequently, the argument is made that learning and remembering in older adults and adults with NCD diagnoses can be studied from a behavior analytic point of view using conditional discrimination procedures. Thus, the following discussion begins by describing the conditional discrimination procedure along with a brief introduction of how it was used by Murray Sidman and colleagues to study discrimination behavior in patients with brain injuries.

Conditional discrimination. The three-term contingency is the most commonly used analytic unit within behavior analysis, where behavior is studied as a functional relation between antecedent stimuli, the behavior, and the consequences that follow (Skinner, 1938). Sidman (1986), on the other hand, proposed that the analytic unit may benefit from another antecedent stimulus being added to it, the *conditional stimulus* (Lashley, 1938). When the conditional stimulus is added to the analytic unit, the contingency is termed a *four-term contingency* (Sidman, 2000), and the procedure is called *conditional discrimination* (Cumming & Berryman, 1965).

According to Sidman (1986), the stepwise increase in the size of the analytic unit allows for the study of the relation between the conditional stimulus and the discriminative stimulus, or so-called stimulus-stimulus relations (Mackay, 1991; Sidman, 1994). In that way, an approach to the study of cognitive behaviors (e.g., remembering and language) is

created, without departing from the conceptual foundations of radical behaviorism. Not only is the study of stimulus-stimulus relations during the establishment of conditional discrimination interesting. Sidman (1986) has also pointed out that “the formation of *equivalence relations* [as will be described below in the discussion of arbitrary MTS] greatly extends the relevance of the four-term unit to language and other cognitive phenomena” (p. 226).

Using conditional discrimination to study learning and remembering. In a recent article, Murray Sidman (2013) addressed the significance of doing basic experimental research with NCD patients to study their abilities and disabilities. The article is based upon his early work with individuals with brain injuries and aphasia, where he and his colleagues studied discrimination behavior using different conditional discrimination procedures (e.g., Kirshner & Sidman, 1972; Leicester, Sidman, Stoddard, & Mohr, 1969; Rosenberger, Mohr, Stoddard, & Sidman, 1968; Sidman, 1969; Sidman, Stoddard, & Mohr, 1968). The procedures they used were, for example, identity and arbitrary MTS, simultaneous MTS, and delayed MTS (with both fixed and titrating delay). They also used various stimulus materials, such as, auditory and tactile stimuli, nonsense syllables, numbers, and dots.

By using systematic variations in the procedures (e.g., simultaneous vs. delayed matching) and introducing different stimulus combinations (e.g., auditory-visual or visual-visual matching), Sidman and colleagues studied discrimination behaviors in their participants in great detail. A general summary of these studies shows that by using different conditional discrimination procedures as well as different stimulus material and stimulus combinations, Sidman and colleagues were able to provide thorough information about the participants’ behaviors, including to which type of stimulus the deficit was related (e.g., reading vs. writing), whether there was a detectable visual neglect, and information about possible memory deficits.

Despite the interesting information Sidman and colleagues retrieved about their participants' discrimination behavior, their approach to studying such complex behavior in individuals with brain injuries has mostly been left untouched within the behavior analytic literature. Also, until recently, their approach to studying these behaviors had not been tried with NCD patients (e.g., Steingrimsdottir & Arntzen, 2011b). Based upon Sidman's approach, Studies 1–5 used variations of the conditional discrimination procedures to study learning and remembering in older adults and older adults with NCD. The following text elaborates on the variations of the conditional discrimination procedures that were used in the five studies that form the basis for this dissertation.

Matching-to-Sample

The conditional discrimination procedures that were used in Studies 1–5 were presented in a matching-to-sample (MTS) format. In the MTS procedure, the participant is first presented with a sample stimulus followed by some comparison stimuli. The experimenter-defined correct response depends upon which type of procedure is used. As identity, arbitrary, and delayed MTS procedures were used in Studies 1–5, the discussion will start out by describing important issues related to the identity MTS procedure, followed by the arbitrary MTS. Thereafter, two variations of delayed MTS, fixed and titrating DMTS, will be introduced.

Identity MTS. The identity MTS procedure is perhaps the simplest variation of the conditional discrimination procedure. In the identity MTS procedure, the participant is first exposed to one stimulus, called the *sample* stimulus or *conditional* stimulus. As it is highly important to look at the sample stimulus for correct response to be emitted in the following step of the procedure, the participant may be required to respond to the sample stimulus to increase the likelihood of him/her observing it (Arntzen, Braaten, Lian, & Eilifsen, 2011). This response is called an observing response, and its function is to increase the likelihood

that the participant observes the relevant stimulus (Dinsmoor, 1985). Following an observing response to the sample stimulus, the comparison stimuli are presented.

The number of comparison stimuli that are presented may vary, with a minimum of two comparisons. It is important to note, though, that when only two comparison stimuli are used, the likelihood of the participant emitting a correct response is 0.5 and, the choice may therefore be a rejection of the incorrect stimulus instead of the selection of the correct stimulus (Carrigan & Sidman, 1992; Sidman, 1987). For this reason, it is recommended to use three or more comparison stimuli as this increases the likelihood that the participant's response to one of the comparison stimuli will be in accordance with the experimenter-defined stimulus-stimulus relation.

In the identity MTS procedure, as the name implies, the correct comparison stimulus is physically identical to the sample stimulus (e.g., Dube, McIlvane, & Green, 1992). For example, in the presence of Ψ , choose Ψ (not Φ or Σ), or in the presence of Φ , choose Φ (not Ψ or Σ). After responding to the comparison stimulus, the participant is informed of whether the response matched the experimenter-defined correct stimulus. If so, the verbal utterance "correct," or a token that can later be exchanged for other items may be presented. If the response is incorrect, it may be followed by the verbal utterance "incorrect" or no tokens. The training trial ends with an inter-trial interval (ITI), and the next trial can begin with a presentation of the next sample stimulus.

The identity MTS procedure has been suggested as a prerequisite for more-complex MTS tasks, such as arbitrary MTS, where the correct comparison is not physically identical to the sample stimulus (Sidman, 1994). The identity MTS provides information about whether the participant understands the procedure and whether the participant discriminates between the stimuli that are used (Sidman, 1994). Also, if the participant does not respond in







accordance with the experimenter-defined physically identical stimuli, questions arise as to whether the participant would do so when faced with a more complex task (Sidman, 1994).

Although the identity MTS procedure may be considered relatively simple, there are a number of issues that may be raised regarding whether the participants' behavior truly is *identity matching* or not. One theory, stimulus control topography coherence theory (SCT), describes the failure to establish conditional discrimination by stating that participants may have attended to other aspects of the stimuli than those planned by the experimenter (McIlvane, Serna, Dube, & Stromer, 2000; Stoddard & Sidman, 1971). On the other hand, when the participant starts responding in accordance with the contingencies set up by the experimenter, other irrelevant response topographies decrease in frequency (Ray, 1969; Stoddard & Sidman, 1971; Zentall & Smeets, 1996). Notably, SCT is not an explanation for the behavior; it is a description of what is observed in the setting.

The SCT theory is helpful as it emphasizes the importance of looking at other aspects of the controlling relation that may unintentionally come to control the response. For example, as shown in a study by Iversen (1997), location became a part of the controlling aspect of the stimuli, leading to the stimulus control was not based solely upon the stimuli's physical similarities. The response may also come under control of other aspects of the stimuli, such as their size, shape, or saturation. It is important for the experimenter to be aware of these issues as, if not taken into consideration, they may lead to incorrect assumptions about participants' matching behavior.

One way to determine whether participants' behavior is in based on the physical similarities of the stimuli, and not related to some other aspects of the contingency, is to do a test for generalized identity MTS (Sidman, 1994). In such a test, the participant is exposed to a new set of stimuli, and if the responses are in accordance with the physical similarities of the stimuli, one may infer that the participants' performance is *true matching* (Iversen, 1997).

Furthermore, it is worth noting here that, as stated by Sidman (1994), “since generalized identity matching is an empirical basis for the concept of sameness, we can see that sameness is a prerequisite for equivalence. Therefore [...] it is also a prerequisite for the emergence of simple meanings, vocabularies, or semantic correspondences” (p. 340).

Arbitrary MTS and stimulus equivalence. When using an arbitrary MTS procedure, each training trial is similar to what was described in the identity MTS procedure. The training trial starts with the presentation of a sample stimulus, and upon an observing response to the sample stimulus, three or more comparison stimuli are presented. As noted before, the stimuli used in an arbitrary MTS procedure are not physically identical as in the identity MTS. Instead, the stimuli may be in a distinct modality, such as an auditory sample stimulus (“*bird*”) presented with visual comparison stimuli (, , ) or may be different types of visual stimuli, such as the sample stimulus being a text stimulus (*red*) and the comparison stimuli color stimuli (, , and ).

Interestingly, following arbitrary MTS of only a few conditional discrimination relations, the experimenter may set up a test to study whether additional, so-called derived relations occur. This type of responding was described by Sidman and Tailby (1982) with a reference to mathematical set theory (Sidman, 1994). According to Sidman and Tailby (1982), if the participant responds in accordance with the experimenter-defined conditional discrimination and additionally to three defining properties of the stimulus equivalence relations during testing (reflexivity, symmetry and transitivity, as described below), the behavior is not only conditional discrimination but what they called *true matching*.

It is worth noting that before initiating arbitrary conditional discrimination training, the experimenter should ensure that the stimuli that are to be used in subsequent training are not already established in the “to be trained” stimulus equivalence classes in the participant’s repertoire. Hence, before initiating training, the participant may be asked to do pre-

categorization of the stimuli, where the stimuli are presented without providing any feedback to the categorization. If the participant categorizes the stimuli in accordance with the experimenter-defined classes, conditional discrimination training may be unnecessary as partitioning into classes already is observed. On the other hand, if the participant does not categorize the stimuli in accordance with the experimenter-defined classes, the baseline conditional discrimination training can begin.

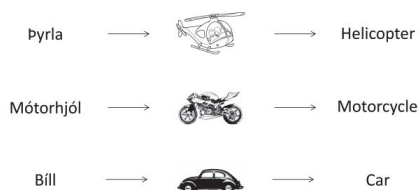



Figure 1. Graphic overview of three potential stimulus equivalence classes arranged in an LS training structure.

Figure 1 shows an example of three potential stimulus equivalence classes, each with three members. The example shows three written words in Icelandic – “*Þyrla*,” “*Mótorhjól*,” and “*Bíll*” – three pictures showing corresponding items, and finally, three text stimuli with the English words “*Helicopter*,” “*Motorcycle*,” and “*Car*.” The black arrows in the figure show the six baseline conditional discriminations set up by the experimenter that are to be trained.

At this point it is important to note the standardized terminology that is used when describing the training and testing arrangement in stimulus equivalence experiments. When using the standardized terminology, each stimulus is assigned a letter and a number (Figure 2). Numbers refer to stimulus classes and letters to each member of the class (e.g., A1 = “*Þyrla*,” B1 = , and C1 = “*Helicopter*”).

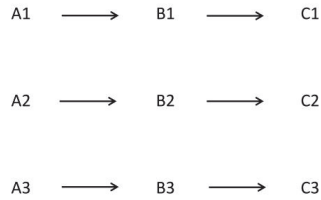


Figure 2. The figure shows the standardized terminology used in stimulus equivalence research.

The standardized terminology is important as it provides an economical account of describing training and testing arrangement for easy comparison of the procedures across studies, independent of the stimuli used. Therefore, relying on the standardized terminology, a description of the training arrangement goes as follows. During training, the participant is taught to choose B1 (and not B2 or B3) in the presence of A1 and to respond to B2 (and not B1 or B3) in the presence of the A2 (see black arrows in Figure 2). Furthermore, the participant is trained to respond to B3 (and not B1 or B2) in the presence of A3. As there are six baseline conditional discriminations, the participant is also taught to respond to C1 (and not C2 or C3) in the presence of B1, C2 (and not C1 or C3) in the presence of B2, and C3 (and not C1 or C2) in the presence of B3.

During the conditional discrimination training, each response to the comparison stimulus is followed by a consequence indicating whether the response to the comparison stimulus was correct or incorrect. Usually, the accuracy is near chance levels in the beginning of training. After repeated exposures to the baseline conditional discrimination training trials, the participant's responding may begin to change, becoming in accordance with the experimenter-defined contingency, until he or she reaches a predefined accuracy criterion. When the accuracy criterion is reached, the consequences are gradually removed across a predefined number of training trials, until no feedback is provided in the last training phase.

This is done to minimize a possible extinction effect during testing, where no consequences are presented.

In the test phase, the experimenter changes the order of the appearance of the stimuli. By doing so, the experimenter can test whether the responding is in accordance with the three defining properties of the equivalence relations (reflexivity, symmetry, and transitivity) as shown in Figure 3 (Sidman & Tailby, 1982).

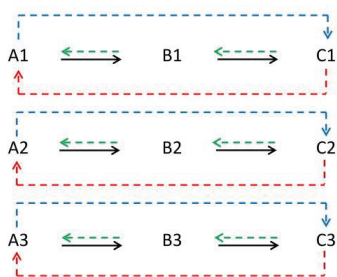


Figure 3. The figure shows the different trial types that are presented during testing. Black arrows: baseline conditional discriminations. Green arrows: symmetry trials. Blue arrows: transitivity trials. Red arrows: equivalence trials. Reflexivity is omitted from the figure for simplicity.

The first property of an equivalence relation, *reflexivity*, tests for whether following $A \rightarrow B \rightarrow C$ baseline conditional discrimination training, if presented with, for example, A1 as a sample stimulus and A1, B1, and C1 as comparison stimuli, the participant responds to A1 and not B1 and C1 (identity matching). The next property of equivalence relation is called *symmetry*. When presenting a symmetry trial, the original training trials are reversed; therefore, following $A \rightarrow B$ and $B \rightarrow C$ training, B1 may be presented as a sample stimulus with A1, A2, and A3 as comparison stimuli ($B \rightarrow A$), or C1 as a sample with B1, B2, and B3 as comparison stimuli ($C \rightarrow B$). These trial types are shown in green in Figure 3. Another property of the equivalence relation is demonstrated by presenting, for example, A1 as a sample stimulus along with C1, C2, and C3 as comparisons ($A \rightarrow C$). These trial types are called *transitivity trials* and are shown in blue in Figure 3. Finally, C1 may be presented as a

sample stimulus with A1, A2, and A3 as comparison stimuli ($C \rightarrow A$). These trials are called *equivalence trials* and are shown in red in Figure 3 (Sidman & Tailby, 1982). It is recommended that the baseline conditional discrimination (black arrows in Figure 3) be interspersed between the symmetry, transitivity, and equivalence trials to evaluate their maintenance throughout the test phase.

If the participant's responses are in accordance with all the properties of the equivalence relation, with correct responses to all the different stimulus combinations, the behavior is described as being in accordance with stimulus equivalence, with the stimuli that were trained during the baseline conditional discrimination training having become mutually interchangeable (Green & Saunders, 1998).

Stimulus equivalence as a fundamental process. According to Sidman (1994), responding in accordance with stimulus equivalence is a fundamental process that cannot be reduced to other processes: “the equivalence relation will include all of the stimulus-stimulus, stimulus-response, response-stimulus, and response-response pairs that are directly taught and all of the pairs that emerge in the tests” (p. 381). In other words, given the history of conditional discrimination where responding is in accordance with the experimenter-defined contingencies, and not due to artifacts, all of the different properties of the equivalence relations will emerge (Sidman, 1990). Therefore, “[i]f even one of the defining pairs turns out to be missing, we have to conclude (assuming the absence of procedural artifacts) that the elements [...] do not constitute an equivalence class” (Sidman, 1994, p. 381). In that view, negative results on a test for responding in accordance with stimulus equivalence can be traced to a lack of experimental control during the establishment of baseline conditional discrimination. This view is supported in the SCT theory, where negative results are suggested to be due to other unidentified variables that may have acquired stimulus control during training (Dube & McIlvane, 1996).

Notably, not all scholars agree with Sidman's view on the interdependence of the different properties of the stimulus equivalence relation. Consequently, it has been suggested that the different properties of the stimulus equivalence class relation (reflexivity, symmetry, transitivity, and equivalence) may be independent units that can be studied separately (e.g., Imam & Warner, 2014; Pilgrim & Galizio, 1996). Whether or not the emergent relations should be considered interdependent or independent units is still an unresolved issue. What is important to note in this context is that the process by which the participant's behavior changes from being near chance level in the beginning of conditional discrimination training, to reaching the accuracy criterion set by the experimenter, along with the information that may be obtained from the test of responding in accordance with stimulus equivalence, is highly relevant when studying learning, as the procedures document the possible change in the behavior of the participant in accordance with the contingencies set up by the experimenter.

Paired associate learning. At this point, it is interesting to briefly mention the *paired associate learning literature* and findings on changes in the likelihood of responding correctly on paired associate learning tasks as a function of age and NCD. The reason for bringing this up is that it has been suggested that paired association learning may be mildly impaired as a function of age (Weiler, Bellebaum, & Daum, 2008) and may even be used to identify those at the earliest stages of an NCD (e.g., Fowler, Saling, Conway, Louis, & Semple, 2002; Spaan, Raaijmakers, & Jonker, 2005). In a study by Bódi, Csibri, Myers, Gluck, and Kéri (2009), equivalence acquisition was studied in 25 Alzheimer's patients and 20 healthy older adults. The authors used a computer to train the participants to match A1 and A2 to X1, and B1 and B2 to Y1. Thereafter, A1 was trained with X2 and B1 with Y2. Figure 4 shows the six conditional discriminations presented during training (black arrows). In the test for acquired

equivalence, the experimenters tested whether the participants would match A2 to X2 and B2 to Y2 (the derived trials, shown as red dashed lines in Figure 4).

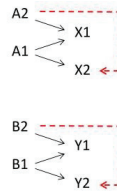


Figure 4. Trained (black) and tested (red) trials in Bódi et al. (2009).

The results showed that the participants with Alzheimer’s diagnoses made significantly more errors during the training compared to the control group. Furthermore, although both groups responded similarly when the baseline trials were presented during testing, the results showed that the Alzheimer’s patients making significantly more incorrect responses to the derived relations.

The paired associate literature has some similarities to the stimulus equivalence literature, in that the purpose of the procedure is to study responding to derived stimulus combinations based on earlier learning (such as in the example from Bódi et al. 2009). However, notably, there are crucial differences as well. Most importantly, the paired association studies incorporate the concept of *mediation* while discussing the outcome of the procedure whereas conditional discrimination studies do not refer to such a concept. According to Sidman (1994), incorporating the term “mediation” is unnecessary and may even obscure the possibility of studying the emergence of direct stimulus-stimulus relations. In other words, the conditional discrimination procedure focuses on both learning the stimulus-stimulus relations during training, and responding during testing, without referring to other processes such as mediation. To sum up, the results from the paired associate learning literature bring with it some interesting thoughts for the purpose of the current dissertation by indicating that derived relational responding may be negatively affected by the onset of an

NCD. On the other hand, using the conditional discrimination procedure allows the study of stimulus-stimulus relations without having to refer to constructs such as mediation. Thereby, the focus can be placed on variables affecting such responding.

Variables influencing stimulus equivalence class formation. There are a number of procedural variables that may influence the likelihood of stimulus equivalence class establishment. There are, for instance, different types of *training structures* that can be used. These are (1) many-to-one (MTO), also known as comparison-as-node, (2) one-to-many (OTM), also known as sample-as-node, and (3) linear series (LS), which was used in the example in Figures 1–3 (Fields & Verhave, 1987; Saunders & Green, 1999). The first two training structures are in general more likely to lead to the formation of stimulus equivalence classes compared to the last one (e.g., Arntzen, Grondahl, & Eilifsen, 2010; Arntzen & Hansen, 2011; Arntzen & Holth, 2000a).

Another procedural variable is known as *training protocols*. There are three training protocols that may be used: simple-to-complex (STC), complex-to-simple (CTS), and simultaneous (SP) (e.g., Adams, Fields, & Verhave, 1993; Imam, 2006). In the STC protocol, the training begins with the presentation of only a few baseline conditional discriminations (e.g., AB trials) followed by a symmetry test for those (BA). Then, the next trial type is introduced (e.g., BC) and is again followed by a symmetry test (CB). Thereafter, the transitivity trials are presented (AC), and finally the equivalence trials (CA). In the CTS protocol, following the baseline conditional discrimination training (AB, BC), the participant is first exposed to equivalence testing (CA) before the presentation of the symmetry trials (BA, CB) and the transitivity test (AC). In the SP, all baseline conditional discriminations are presented during training (AB, BC) before the test phase. In the test phase, all the different trial types (symmetry, transitivity, and equivalence) are presented in random order.

The SP was used in Studies 1 and 2. Notably, there is an additional variation in the arrangement of the conditional discrimination relations in the beginning of training that may be utilized when using the SP. The basic SP describes a concurrent presentation of the stimuli from the beginning of training (Table 1). This training arrangement was used in Study 2. However, another option is to use a *serialized* or *sequential* introduction of the conditional discriminations during training (see Table 1). This training arrangement was used in Study 1.

Table 1.
Serialized and Concurrent Training Arrangement

	Concurrent	Serialized
Training	N/A	AB trials
	N/A	BC trials
	AB and BC trials	AB and BC trials

Note. The table shows the arrangement of the first training phases in a MTS procedure. Not shown is that following accuracy criterion, programmed consequences would be gradually removed before introducing the test trials.

In the serialized training arrangement, the conditional discriminations are introduced more slowly, so to speak, for the participant compared to the concurrent presentation of the training trials. For example, when training three 3-member classes, the participant is first exposed to all of the AB trial types, and when the participant has reached the accuracy criterion set by the experimenter, the BC trial types are introduced (Table 1). When the accuracy criterion is reached, the AB and the BC trials are mixed together before initiating a gradual removal of programmed consequences. On the other hand, when using the concurrent arrangement, all of the conditional discriminations that are to be trained are presented from the beginning of training (that is, the AB and BC trial types). In other words, the participant is not exposed to the first part of the serialized training (training the AB and BC trials separately); instead, the training starts immediately with a mix of all the conditional discriminations (as shown in Table 1).

Other procedural variables, such as *number of classes* and *class size* (that is, the number of members within a class), may affect the likelihood of participants responding in accordance with stimulus equivalence (Arntzen & Holth, 2000b). In general, the larger the stimulus classes, and the higher the number of classes that are used, the less likely the participant is to respond in accordance with stimulus equivalence. More specifically, Arntzen and Holth (2000b) showed that increasing the class size resulted in less stimulus equivalence class formation compared to increasing the number of classes.

In addition to the already-mentioned variations, the *stimuli* themselves may affect the likelihood of stimulus equivalence class formation. Using, for example, stimuli that are easily nameable or stimuli that are presumed to be *familiar* to the participant (also referred to as *meaningful* stimuli) can increase the likelihood of forming stimulus equivalence classes compared to using all abstract stimuli (e.g., Arntzen, 2004; Arntzen & Nikolaisen, 2011; Fields, Arntzen, Nartey, & Eilifsen, 2012; Nartey, Arntzen, & Fields, 2014).

As there are a number of different variables that may influence the likelihood of establishing the baseline conditional discriminations, and the likelihood of responding in accordance with stimulus equivalence during subsequent testing, the experimenter can choose a procedure that fits the purpose of the experiment. For example, the experimenter may opt for the LS training structure and establish three 5-member stimulus equivalence classes, while studying *other* variables that may affect the likelihood of responding in accordance with stimulus equivalence. For example, Nartey et al. (2014) used three 5-member classes and LS training structure to study the effect of using familiar stimuli, as either A stimuli or E stimuli (with the rest of the stimuli as abstract stimuli), on stimulus equivalence class formation. Their results showed that 70% of the participants formed the stimulus equivalence classes when the familiar stimulus was presented in the beginning of training (as A stimuli) whereas

only 40% formed the classes when the familiar stimulus was presented toward the end of training (as E stimuli).

Alternatively, the experimenter may choose to use a training structure that is more likely to lead to the formation of stimulus equivalence classes. For example, Cowley, Green, and Braunling-McMorrow (1992) used a table-top MTS procedure to teach name-face relations in adult participants that suffered from brain injury. Pre-categorization had shown that the participants matched neither dictated nor written names to a photo of a person, whereas they did match dictated names to written names (see Cowley et al., 1992, for a schematic representation of the training). Following conditional discrimination training with the “dictated name-face” trials, the test phase showed the emergence of three stimulus equivalence classes, with participants responding correctly to the “face-written name” trials (which, when using OTM training structure is a combined test for symmetry and equivalence).

The preceding discussion has targeted those differences that are directly related to the studies presented below. There are, nevertheless, other variables that may also be manipulated to change the likelihood of conditional discrimination establishment and stimulus equivalence responding. For further elaboration on those, see Arntzen (2012).

Delayed MTS. So far, the discussion has focused on the use of either identity or arbitrary MTS with simultaneous presentation of the stimuli on the screen. These procedures are applicable when studying learning. However, there is still another important procedure that is relevant for the study of remembering, and that is the delayed MTS (DMTS) procedure (Blough, 1959; Palmer, 1991; White, 2013). In contrast to the simultaneous MTS procedure, where the sample stimulus is presented along with the comparison stimuli, in the DMTS procedure, the sample stimulus is removed for some experimenter-defined period of time before the comparison stimuli are presented. As such, the DMTS procedure has often been

used to study what is generally known as *memory* within other areas of psychology, as the participant *has to remember* which sample stimulus was presented to respond correctly to the comparison stimuli. At this point, it is worth noting that the word “memory” is seldom used within the behavior analytic literature (Morgan & Riccio, 1998) as it brings with it some conceptual challenges for the radical behaviorist (Branch, 1977). Instead, when describing the behavior under study, terms such as “remembering” and “forgetting” are used when *describing* the functional relation between the environment and the behavior (Palmer, 1991; White, 2013).

The applicability of the DMTS procedure is particularly interesting when studying remembering behavior in NCD patients as memory impairment is one of the main characteristics of a number of NCDs (American Psychiatric Association, 2013). A person with an NCD may, for instance, forget what he is supposed to do after being asked to “go to the kitchen and get a glass.” From a behavior analytic point of view, the behavior of the person may possibly be described in terms of stimulus control (Terrace, 1966), where the conditional stimulus (the request) is presented, it disappears (it is not repeated) and after some temporal delay (walking to the kitchen), the behavior should be emitted (get the glass (S^D), and not something else). If the person fails to emit appropriate behavior, the conditional stimulus may be described as no longer having control over the behavior (Sidman, 1969), and the behavior may be termed as forgetting (White, 2013). Utilizing the DMTS procedure in an experimental setting allows for the evaluation of the effect of other variables, such as the number of comparison stimuli or the length of the delay, on the participants’ responding. Doing so provides additional information about each person’s remembering behavior (Sidman, 1969, 2013).

The DMTS procedure may be used in combination with either the identity (e.g., Sidman, 1969; Steingrimsdottir & Arntzen, 2011b) or arbitrary MTS procedure (e.g., Arntzen,

2006; Arntzen, Galaen, & Halvorsen, 2007; Arntzen & Vie, 2013). As mentioned earlier, the arbitrary MTS procedure has been described as more complex procedure than the identity MTS. Interestingly, studies have shown that using the DMTS procedure may enhance stimulus equivalence class formation compared to using simultaneous MTS (e.g., Saunders, Chaney, & Marquis, 2005). However, as shown in Study 1, these results are not conclusive with older adults as participants.

Fixed or titrating delayed MTS. Another important procedural variable that may be manipulated within the DMTS procedure is the type of delay that is used. The timing in the DMTS procedure may either be fixed (e.g., Arntzen, 2006; Blough, 1959; Sahgal, 1996) or may change as a function of participants' correct or incorrect responses, with an increase or decrease, respectively, in the temporal delay between the offset of the sample stimulus and onset of the comparison stimuli. When the length of the delay changes as a function of the participants' correct/incorrect responses, the procedure is known as *titrating* or *adjusted* DMTS (e.g., Cumming & Berryman, 1965; Eilifsen & Arntzen, 2011; Kangas, Vaidya, & Branch, 2010; Lian & Arntzen, 2011; Mackay, 1991; Nevin, Davison, Odum, & Shahan, 2007; Rosenberger et al., 1968; Scheckel, 1965; Sidman, 2013). It has been pointed out that when using fixed DMTS, floor or ceiling effects may occur. By using titrating DMTS, this threat can be avoided. However, it is important to note that there are a number of variables that are yet to be explored when using titrating DMTS. Study 5 sought to shed some light on this issue, but again, further studies are needed.

An example of a study using both fixed and titrating DMTS was by Sidman and colleagues with a 14-year-old stroke patient (Rosenberger et al., 1968). Firstly, the authors found that the participant could discriminate accurately between circles and ellipses in a simultaneous MTS procedure. During fixed DMTS, when introducing a 0-, 8-, and 16-s delay, the participant's accuracy was in accordance with the criterion set up by the

experimenters, whereas 24-, 32-, and 40-s delays led to a number of incorrect responses. The titrating DMTS procedure, on the other hand, showed that the length of the delay increased steadily to a 15- and 17-s delay when words and three-letter nonsense syllables were used whereas when trigrams were used, the participant titrated the delay only minimally.

Based on the preceding discussion on identity, arbitrary and DMTS procedures, it is suggested that knowing about the different procedures allows for adjustment in the procedures in accordance with the participants' abilities. For example, for healthy older adults, it may be more useful to use arbitrary DMTS whereas when working with patients with NCDs, the identity MTS may be more appropriate. Interestingly, as pointed out by Rosenberger et al. (1968), using identity DMTS with does not require any vocal communication and, at the same time provides information about the participants' remembering behavior. This last issue can be important when working with NCD patients as language gradually deteriorates as a function of the progression of the disease. Therefore, these procedures may be particularly useful when studying remembering in patients with severe cognitive impairment.

Analysis of the data in an MTS task. Having gathered data from conditional discrimination training and testing for responding in accordance with stimulus equivalence, there are a number of variables that may be analyzed. First of all is the *establishment of the baseline conditional discriminations* during training. The occurrence or non-occurrence of the establishment of the baseline discrimination provides important information about participants' learning. If the baseline conditional discriminations are not established, the experimenter may adjust the training to increase the likelihood of establishing the conditional discriminations by making changes in the procedure, such as using fewer classes, shaping or fading techniques, or the gradual introduction of conditional discriminations, to name a few. There is a vast literature on how to effectively establish arbitrary baseline conditional

discriminations in children or adults with developmental disability, but none of the studies published are with older adults or older adults with NCD.

Following successful establishment of the baseline conditional discriminations, the participant goes through the test condition for evaluation of *stimulus equivalence class formation*. When stimulus equivalence class formation is confirmed, the experimenter can conclude that the stimuli have become mutually interchangeable. However, if not, the experimenter may perhaps attribute the absence of equivalence class formation to the procedural variables used during training. For example, as noted earlier, participants are less likely to respond in accordance with experimenter-defined stimulus equivalence classes when the LS training structure is utilized compared to the MTO or OTM.

Another variable that may be analyzed is *reaction time* (e.g., Dymond & Rehfeldt, 2001; Whelan, 2008) or *speed* (e.g., Imam, 2006; Spencer & Chase, 1996). Reaction time data may be sensitive to variables such as the complexity of the task, the types of stimuli used, and the number of stimuli presented (Hyman, 1953). Reaction time data have shown that the response latency when presented with symmetry trials is longer compared to a baseline conditional discrimination trial, with even longer latency in transitivity and equivalence trials (e.g., Arntzen, 2004; Holth & Arntzen, 2000). Reaction time data have also been shown to be lower toward the end of testing compared to the beginning. This has led to the suggestion, among other, of the possible independency of the different properties of the stimulus equivalence class relation (e.g., Pilgrim & Galizio, 1996). Furthermore, a number of studies have shown that reaction time decreases as a function of age (e.g., Baron & Menich, 1985; Baron, Menich, & Perone, 1983). Notably, when looking at reaction time data within behavior analytic research, it is important to note that reaction time is not taken as a representation of a hypothetical construct, but as a supplemental measure that is interesting in itself (Eilifsen & Arntzen, 2009).

In addition to the variables mentioned, it has been suggested that the conditional discrimination literature may be expanded by the use of additional measures, such as *FMRI* technology (Dickins et al., 2001), *EEG recording* (Haimson, Wilkinson, Rosenquist, Ouimet, & McIlvane, 2009; Wang & Kameda, 2005), or *eye-tracking analysis* (Dube et al., 1999). By incorporating additional measures into the analysis of conditional discrimination learning and stimulus equivalence responding, a more fine-grained analysis of the results may be obtained (Palmer, 2010). Study 2 using eye-tracking equipment while studying eye-movements during conditional discrimination learning and testing for responding in accordance with stimulus equivalence in younger and older adults.

Taken together, the variables that are analyzed following MTS training provide information about when the participant responds in accordance with the experimenter-defined conditional discriminations and, if utilizing arbitrary MTS, whether stimulus equivalence class formation has occurred. When such learning does not take place, knowing about the different variables affecting learning and remembering, and the variables that may be analyzed following such training, allows the experimenter to make a number of refinements in the procedure for successful establishment of the conditional discriminations in the participant.

Stimulus Equivalence Research with Older Adults and Older Adults with NCD

Although there is great disparity between basic research and the applied settings within behavior gerontology, there are some studies on conditional discrimination learning and the likelihood of responding in accordance with stimulus equivalence in older adults and adults with NCD. Following is a review of those articles that have, to my knowledge, been published with this participant group.

In one study, Wilson and Milan (1995) compared the likelihood of responding in accordance with stimulus equivalence between younger and older participants (see Table 2).

According to the authors, their paper was the first where the goal was to study stimulus equivalence class formation as a function of age.

Table 2.

Overview of Studies with Older Adults and NCD Patients as Participants

Authors	Year	Participants	Age	MMSE	Table-top/ computerized	ID / AR	Training protocol	Training structure	Number of classes/members	SMTS / DMTS
Wilson and Milan	1995	N=20 N=20	19–22 62–81	Normal range	Comp.	AR	SP (+SER)	OTM	3x3	SMTS
Pérez-González and Moreno-Sierra	1999	N=8 N=2	Range 13–73	N/A	Table- top	AR	STC	LS	2x3	SMTS
Saunders, Chaney, and Marquis	2005	N=12 N=6	56–89 58–75	N/A	Comp.	AR	SP (+SER)	LS MTO OTM	2x3 2x4 3x3 3x4 4x3 4x4	SMTS DMTS
Gallagher and Keenan	2009	N=18 N=12 N=15	67–94 57–92 69–95	16–30 21–29 27–30	Table- top	AR	STC	LS	2x3	SMTS
Steingrimsdottir and Arntzen*	2011	N=1	84	20	Comp.	AR ID	N/A	N/A	3	SMTS DMTS
Arntzen, Steingrimsdottir, and Brogård- Antonsen	2013	N=1	84	20	Comp.	ID	N/A	N/A	3	DMTS and titrating DMTS

Note. If the study had more than one experiment or group, the number of participants for each study/group is provided along with their age and MMSE score. ID=identity matching, AR=arbitrary matching, Comp=computer, SIM=simultaneous, STC= simple-to-complex, SER=serialized, OTM=one-to-many, MTO=many-to-one, LS=linear series, SMTS=simultaneous matching-to-sample, DMTS=delayed matching-to-sample. *The study used both identity and arbitrary MTS. Arbitrary MTS was not established; therefore, information about training protocol and structure is not provided.

Wilson and Milan (1995) included 40 participants in the study, divided equally into two groups. The participants in the younger group were 19–22 years old whereas the participants in the older group were 62–81 years old. All the participants in the study scored in a normal range on the MMSE test.

The results showed that the younger participants were more likely to respond in accordance with stimulus equivalence. Furthermore, the younger participants' response latency was shorter compared to the older participants' (2.134 vs. 3.782 seconds). Based on their results, Wilson and Milan (1995) concluded that the older adults did not show any sign of deterioration in learning new material as the acquisition of the baseline trials was similar for both groups. However, they theorized that failing to respond correctly on the test may show that other private complex behavior (e.g., covert problem solving) may be negatively affected by increased age. Additionally, the authors reported that a number of participants that had not responded in accordance with the experimenter-defined stimulus equivalence classes stated in a post-experimental debriefing that they had based their response upon perceived physical similarities between the stimuli. Finally, Wilson and Milan (1995) concluded that the study documented a “general slowing in behavior with aging and that the age effect interacts with task complexity to produce disproportionately greater slowing” (pp. 216–217).

In another study by Pérez-González and Moreno-Sierra (1999), the authors also studied stimulus equivalence class formation as a function of age. Their study included two experiments with participants' ages ranging from 13 to 74 years (13, 21, 44, 53, 66, 67, 70, and 74) in Experiment 1 with two additional participants, 65 and 73 years old, in Experiment 2 (see Table 2). The main conclusion from these two experiments was that participants who were younger than 64 years established the four conditional discriminations more rapidly whereas participants who were older than 64 years made more errors during the establishment

of the baseline trials. Moreover, although the authors found that the younger and older adults were just as likely to respond correctly during the test phase, the authors pointed out that the younger adults responded correctly from the very beginning of testing whereas the older adults made more errors in the beginning of the test phase before responding correctly later in the test. Finally, the authors noted that when the older adults made errors on the test trials, they also made errors on the baseline conditional discrimination trials. When the baseline conditional discriminations were re-established, the emergent relations became correct as well.

A few years later, Saunders et al. (2005) published a study in which the purpose of Experiment 1 was to study conditional discrimination establishment and stimulus equivalence class formation in older adults as a function of training structure (LS, MTO, and OTM) and as a function of 2-, 3-, and 4-choice MTS procedure. Each participant was exposed to all three training structures (LS, OTM, and MTO) with the order of the training structures counterbalanced across participants (see Saunders et al., 2005, for a schematic overview of the six training sets with the MTO training structure). Experiment 2 was a systematic replication of Experiment 1 with the use of a 0-s DMTS procedure to compare with simultaneous presentation of the stimuli (see Table 2).

The results from Experiment 1 showed that failure to respond in accordance with the experimenter-defined stimulus equivalence classes could not be traced to a breakdown in the baseline conditional discriminations. This was opposite to what Pérez-González and Moreno-Sierra (1999) had found. Additionally, the study showed that the likelihood of establishing the experimenter-defined stimulus equivalence classes was the same when using 2-, 3-, or 4-choice MTS procedures. When using a 2-choice MTS procedure, the likelihood of establishing the stimulus equivalence classes was similar across the three training structures. When using a 3-choice MTS procedure, the MTO training structure led to the greatest

likelihood of establishing the experimenter-defined classes, followed by the OTM training structure, whereas the LS training structure led to the establishment of somewhat fewer stimulus equivalence classes. For the 4-choice MTS, the MTO training structure again led to greatest likelihood of stimulus equivalence class formation, again followed by the OTM training structure, with only a few participants forming the experimenter-defined classes in the LS training structure.

The results from Experiment 2 showed that when using the 0-s DMTS procedure, the participants acquired the baseline conditional discriminations more rapidly compared to using the simultaneous MTS, both across the different training structures and across training sets. Also, when using the 0-s DMTS procedure, all participants responded in accordance with the experimenter-defined classes when the six training sets were presented in an OTM training structure, and five out of six did so when using the MTO training structure (one participant failed to establish the baseline conditional discriminations when exposed to a 2-choice MTS and did not respond in accordance with the experimenter-defined classes when exposed to a 4-choice MTS). The LS training structure was least likely to result in stimulus equivalence class establishment when the 0-s DMTS procedure was used. However, the authors called for further experiments to compare the two procedures (0-s DMTS and simultaneous MTS) to exclude the possibility that the results were due to differences in participants across experiments and not due to the 0-s DMTS procedure.

To this point, the studies that have been discussed had participants who did not have NCD diagnoses. The behavior analytic literature is unfortunately currently rather limited when it comes to studying discrimination behavior in older adults with NCD. Still, there are studies related to the subject matter that are important to mention. The first study mentioned was conducted by Gallagher and Keenan (2009), where the authors compared participants' conditional discrimination learning and likelihood of responding in accordance with stimulus

equivalence and their MMSE score. The authors presented three experiments in the paper. Experiment 1 had 18 participants, Experiment 2 had 12, and Experiment 3 had 15 (see Table 2). According to Gallagher and Keenan (2009) the results showed that there was a high correlation between the results from the stimulus equivalence training and testing and the MMSE score. Interestingly, 27 out of 30 participants with an MMSE score of 27 or higher responded in accordance with stimulus equivalence. The authors concluded that “perhaps performance in tests for equivalence is more sensitive to deficits in higher functioning than the MMSE” and further that “correlation between performances in accordance with equivalence class formation and MMSE performance suggest that testing for equivalence relations may make a useful diagnostic tool in assessing higher cognitive functioning” (p. 165).

In a study by Steingrimsdottir and Arntzen (2011b), the authors studied conditional discrimination learning in an 84-year-old woman diagnosed with Alzheimer’s disease. Her MMSE score at the time of the study was 20. The participant was exposed to nine experimental conditions: seven identity MTS conditions, ranging from simultaneous MTS to 9-s DMST, and two arbitrary MTS conditions, one with three comparison stimuli on the screen and another with two comparison stimuli. The overall results showed that the participant responded correctly when exposed to identity MTS with simultaneous presentation of the stimuli on the screen and three comparison stimuli. However, she did not respond in accordance with the experimenter-defined classes when there was an arbitrary relation between the stimuli, either when there were three comparison stimuli or when there were two.

Further analysis of her responses during the arbitrary MTS conditions showed that her responses continued to be in accordance with a participant-defined physical similarities of the stimuli. Therefore, the participant was again exposed to identity MTS. This time, the temporal delay between the offset of the sample stimulus and the onset of the comparison

stimuli was manipulated. The results showed that the number of incorrect responses increased greatly when moving from 3-s DMTS to 6-s DMTS. The difference between 6-s DMTS and 9-s DMTS was not as large. Tests for generalized identity MTS showed that she responded with 36 out of 36 correct when the delay was 3-s and 32 out of 36 when the delay was either 6- or 9-s.

In a follow-up study by Arntzen, Steingrimsdottir, and Brogård-Antonsen (2013), the participant was exposed to additional experimental conditions, with both a 12- and 10-s delay. The results showed that she did not respond in accordance with accuracy criterion when the delay was 12-s, but she did so when the delay was set to 10-s. Therefore, the next conditional discrimination procedure she was exposed to was a titrating identity MTS procedure. The titration value was set to 250 ms, and a criterion was set so that when she emitted six out of six correct responses in one training block, the delay increased, and with five out of six correct or fewer, the delay decreased. The main results showed that the titrated delay was shortest at 7.500 ms and highest at 12.250 ms in one occasion. The study led to a number of additional research questions regarding the use of titrating DMTS procedures in studies with participants with NCD diagnoses, such as whether different results might have been found with other titration values.

In sum, there are to my knowledge only a few studies that have been published on conditional discrimination learning and stimulus equivalence class formation in older adults and adults with NCD diagnoses. This is despite the fact that there seems to be an indication that these types of procedures may have great informative value about each individual's learning and remembering behavior. Also, the great variations in the procedures that have been used pose a certain challenge for comparison across studies, and therefore, further studies are warranted. For example, Wilson and Milan (1995) concluded that younger and older participants are equally likely to establish the baseline conditional discriminations,

whereas the older participants are less likely to respond in accordance with the experimenter-defined stimulus equivalence classes. By contrast, Pérez-González and Moreno-Sierra (1999) concluded that older adults need more training trials to establish the baseline conditional discriminations, but once established, they are just as likely to respond in accordance with the experimenter-defined stimulus equivalence classes. These results may come about because of the procedural differences in the experiments, such as table-top training vs. computerized training, the types of stimuli used, and the training sequence. Therefore, a systematic approach in the use of conditional discrimination procedures to study learning and remembering in older adults and NCD patients is called for. Studies 1–5 were our first steps towards studying variables affecting learning and remembering in older adults and patients with NCD.

The Five Studies Conducted for the Dissertation

Following is a discussion on ethical considerations that were related to implementation of the studies followed by a brief summary of each study.

Ethical Considerations

It is of utmost important to take careful note to ethical considerations when working with humans or animals, either in experimental or applied setting. Furthermore, as stated by Cooper, Heron, and Heward (2007) it is important to follow the professional standards that have been set for the discipline. Therefore, before starting data collection for Studies 1–5, an application was sent to the Regional Committees for Medical and Health Research Ethics for approval of conducting the studies. The application was approved with reference number 2009/2122. Following is a discussion of some of the ethical considerations that were considered of importance for the studies.

The participant. First and foremost, it is of utmost importance that the experimenter do no harm to participants (Berghmans & Meulen, 1995). The participant may not be

physically harmed in any way, mistreated, or violated. For this reason, it is very important that before participating in a study, participants sign an *informed consent* form (Cooper et al., 2007). An informed consent form provides general information about the study, what is expected of the participant during the study (e.g., type of task), whether there is any physical discomfort to be expected (and if there is, a detailed description of that discomfort), the length of the study, and information about the person(s) responsible for the study. Importantly, the informed consent form must clearly state that participation is voluntary and that the participant may withdraw from the study at any time. The participant is also informed about what data are to be gathered during the study, along with information about any other background information that the experimenter may ask for. Examples of such background information are age, gender, and MMSE score. Moreover, it is important to inform the participant that the data obtained may be used in a publication.

Informed consent is extremely important. When the participants in the study are healthy older adults, they are most likely capable of signing their own informed consent. However, when the person has an NCD diagnosis, the researcher needs to conduct an additional evaluation regarding capability of signing an informed consent form as the patient may not be able to provide informed consent. In such cases, the patients' significant others should be contacted. According to Kim, Caine, Currier, Leibovici, and Ryan (2014), even if a patient has only mild cognitive impairment, sometimes the disease can have a significant impact on the person's ability to sign the consent form.

Although it may be difficult to obtain, an objective evaluation of the capability of providing informed consent has been called for. One recommendation is that in non-therapeutic studies, where the study does not provide any direct benefit for the participant (Berghmans & Meulen, 1995), the experimenter should seek informed consent from significant others if the MMSE score is lower than 26 (Kim & Caine, 2014). Additionally,

Kim and Caine (2014) suggested that when the MMSE score is below 19, the person is unlikely to be able to provide informed consent. However, it is important to note that, although informed consent may be sought from significant others, the participants should always be asked whether they would like to participate in the study.

In Studies 1 and 2, where participants were healthy older adults, the participants themselves provided informed consent. In the studies where the participants had NCD diagnosis, each individual's capability of providing informed consent was evaluated by consulting both health care personnel that knew the patient, and their significant others. In Study 5, it was concluded that the participant was capable of providing his own consent, whereas in Studies 3 and 4, the participants' significant others were asked to sign the consent form. As mentioned above, although the informed consent was obtained from the significant others, the participants in Study 3 and 4 were also asked whether they wanted to participate in the study before the beginning of each day or each session. Hesitation or reluctance to participate was taken as withdrawal from the study.

Ethical considerations are highly important when it comes to basic experimental studies that run for a longer period of time as the study may not have a direct benefit for the participating individual. Therefore, it is important to always be aware of whether the participant is thriving in the experimental situation. For basic research, the training and testing may be integrated into the participants' daily routine. Furthermore, each session can end with an activity the participant enjoys, such as getting a cup of coffee together, going out for a walk, or listening together to music. All of these issues were taken into consideration in these studies. The participants generally expressed enjoyment of participating in the studies. Only one participant withdrew from a study after few weeks of participation (Study 4).

The experimenter. The American Psychological Association codes of conduct are guidelines for practitioners and researchers, describing how they should behave in applied or

experimental settings (American Psychological Association, 2010; Cooper et al., 2007).

There are a number of ethical considerations that are of importance when doing an experiment. Some of them will be addressed here.

According to Rowson (2006), experimenters must act with *professional integrity*. As such, it is imperative that each experimenter or practitioner learns about ethical guidelines set for his or her profession. If the experimenters experience tension between their own personal values, and the values set by their profession, they "...should consider leaving their profession" (Rowson, 2006, p. 125). This is an important issue because as a group, experimenters have different backgrounds and values. Therefore, it is imperative to follow the official codes of conduct that are provided for each scientific field. Moreover, it is important to read the codes of conducts regularly as adjustments are made over time.

Another issue regards *confidentiality*. Experimenters must, for example, keep the information they gather confidential. For instance, it is not possible to trace the data back to individual participant in Studies 1–5. The studies are anonymous; the participants are given pseudo names or random participant numbers, and any information that may directly link the data to the individual participant was excluded. By doing so, confidentiality was honored.

An experimenter must also respect the *participants' privacy*, before, during, and after the experiment. Each participant agrees to participate in a study in good faith, and that trust should not be betrayed in any way by the experimenter. The experimenter must be trusted not to use the data that are gathered for any other purpose than what is stated for the experiment in question.

Although this list is far from complete, the final ethical consideration mentioned here regards *treatment of data*. Experimenters may not, in any way, adjust, fabricate, or change the data they gather. Excluding data that do not fit properly to the result or changing data to enhance the results from the study is prohibited. This includes that, when conducting an

experiment, the researcher is obliged to account for any data gathered. Furthermore, omitting any data that may have an impact on the final result is forbidden.

The location. In the studies where the participants were healthy older adults, the participants met the experimenter at an experimental location. This is in accordance with other stimulus equivalence research. In the studies where the participants had NCD diagnoses, the experiments were conducted in a quiet room at the nursing home where the participants lived or at a day-care center they attended. Thus, the participant could be in the comfort of a known environment. Before starting the experiment, the experimenter evaluated the location in terms of possible disturbance and comfort and met the potential participant. Although they did not disturb the participants' responding, the personnel at the nursing home were nearby during the beginning of Studies 3 and 4 for participants who had an MMSE score 10 or lower. Upon being ensured of the participants' well-being, they withdrew their presence.

Potential discomfort. Study 2 required the participants to use eye-tracking glasses, and to sit relatively relaxed during the course of training and testing. During the recruitment process, the participants were informed about a potential discomfort when wearing the glasses (particularly on the nose where the glasses would sit). This was discussed again before putting the glasses on in the experimental setting. Due to potential discomfort of the glasses, the participants were encouraged to ask for breaks if they wanted.

Payment for participation. Recruitment may be challenging at times because research participants have to participate in their free time. Therefore, to possibly compensate the time loss, it was decided to create a lottery in Study 2 where each participant would get a lottery ticket after participation. When the data collection was finished, one participant won an iPad. This study was the only study where some kind of payment or reward was offered for participation.

Summary of the Studies

The previous discussion has provided a theoretical and methodological framework for the studies included in this dissertation along with discussing ethical considerations when working with older adults and NCD patients. Table 3 provides an overview of the participants and the different procedures used in Studies 1–5.

Table 3.

Overview of Studies 1–5

	Participants	Age	MMSE	Identity MTS / arbitrary MTS	Training protocol	Training structure	Number of classes/number of members	SMTS/DMTS
Study 1	N=8 N=8 N=8 N=8	70–86	28–30	Arbitrary and identity MTS	SP (+SER)	MTO	3x3	SMTS or 0-s DMTS
Study 2	N=10 N=10	20–25 60–65	N/A	Arbitrary MTS	SP	MTO	5x3	SMTS
Study 3	N=1	89	8	Arbitrary and identity MTS	SP (+SER)	MTO	3x3	0-s DMTS and SMTS
Study 4	N=1	80	10	Identity MTS	N/A	N/A	3	SMTS and 0-s DMTS
Study 5	N=1	62	23	Identity MTS	N/A	N/A	3	Titrating DMTS

Note. The table shows an overview of Studies 1–5. There were four experimental groups in Study 1, each with 8 participants, and two in Study 2, each with 10 participants. For those studies where there were only identity MTS procedures, the training protocol and structure are not provided. MMSE=Mini-Mental State Examination, MTS=matching-to-sample, SIM=simultaneous, SER=serialized, MTO=many-to-one, SMTS=simultaneous matching-to-sample, DMTS=delayed matching-to-sample.

Based upon a research question identified by Steingrimsdottir and Arntzen (2011b) and Saunders et al. (2005), Study 1, *Performance by Older Adults on Identity and Arbitrary Matching-to-Sample Tasks*, asked (1) whether starting out with identity MTS conditional discrimination training would have an effect on subsequent arbitrary MTS conditional discrimination performance and (2) whether using DMTS would lead to different results compared to SMTS (Steingrimsdottir & Arntzen, 2014b). There were 16 participants, age range from 70 – to 86 years, divided into four experimental groups depending on the order of identity and arbitrary MTS tasks and whether the procedure was a simultaneous MTS or 0-s DMTS (Table 3).

The results showed that 14 participants failed to learn the arbitrary conditional discriminations with the, highest withdrawal from the experimental condition where they started out with arbitrary simultaneous MTS. This experimental condition also resulted in the highest number of training trials to criterion. When starting out with identity MTS, the participants were more likely to establish the baseline conditional discriminations in the following arbitrary MTS task and with fewer training trials to criterion. This effect was not observed in 0-s DMTS, which had similar results as when participants started out with identity MTS before arbitrary MTS with simultaneous presentation of the stimuli on the screen.

Study 2, *Eye-Movements During Conditional Discrimination Learning*, studied conditional discrimination learning and stimulus equivalence class formation in younger (20–25 years old) and older (60–65 years old) adults with eye-tracking equipment as a supplemental measure for the study of the participants' eye-movements (Steingrimsdottir & Arntzen, submitted). The study asked five questions: (1) number of training trials to criterion during conditional discrimination training, (2–3) fixation time and rate to sample stimulus during training and testing respectively, (4) likelihood of responding in accordance with

stimulus equivalence, and (5) fixation time and rate to the comparison stimulus for each trial type during testing (the baseline conditional discrimination, symmetry, and equivalence trials). The results showed that (1) there was statistical difference between the groups in number of training trials to criterion during training with the older adults emitting more responses, than the younger adults. Further analysis of the establishment of the baseline conditional discriminations showed that the older adults received generally higher number of programmed consequences before establishing the baseline conditional discriminations compared to the younger adults. (2–3) the study did not find any difference in observation to the sample stimulus between the groups, (4) there was similar likelihood of responding in accordance with stimulus equivalence between the groups, although the older adults were little less likely to respond in accordance with stimulus equivalence. Finally, analysis of the fixation time and rate during testing showed the same pattern as previous studies have shown with reaction time data where fixation time and rate have stepwise decrease during training and then stepwise increase during testing (5). Furthermore, the fixation time and rate was generally lower during the last part of testing compared to the first part.

Study 3, *Discrimination Learning in Adults with Neurocognitive Disorders* focused on discrimination behavior in NCD patients (Steingrimsdottir & Arntzen, 2014a). Some previous studies have shown difficulties in establishing arbitrary conditional discrimination relations in NCD patients (e.g., Steingrimsdottir & Arntzen, 2011b). As other studies have shown that using familiar stimuli might enhance conditional discrimination learning (Arntzen & Lian, 2010), the purpose of the study was (1) to learn about the effect of using what were assumed to be familiar stimuli in an arbitrary MTS procedure and (2) to study variables that would affect stimulus control in a patient with a severe NCD (Table 3). The study consisted of 12 experimental conditions, with each experimental condition simplified from the previous (apart from the last condition). For example, in the first condition a 0-s DMST procedure was

used while presenting pictures of clothes, hand wash and cutlery, whereas Condition 6 was an identity MTS condition with two color stimuli (see Study 3 for more-detailed information about the procedure).

The results showed that conditional discrimination was not established in the first three conditions where the familiar stimuli were used during arbitrary MTS format. Therefore, the pictures of cutlery were trained separately in an identity MTS format. Despite the change to the identity MTS with cutlery, the participant's responding was still random. Therefore, color stimuli were introduced in Condition 6. Throughout small changes in the procedure in Conditions 7–10, the participant's responding finally came under control of the conditional discriminations set up by the experimenter in Condition 10. Condition 10 was followed up by Conditions 11 and 12 with the participant responding in accordance with the accuracy criterion set up by the experimenter.

Study 4, *Identity Matching in a Patient With Alzheimer's Disease*, asked about the effect of using simultaneous and 0-s DMTS on the participant's responding along with asking about the effect of different numbers of comparison stimuli to select from (Steingrimsdottir & Arntzen, 2011a). The participant MMSE score was 10 at the time of the experiment, which is at the boarder of moderate to severe NCD (Table 3). The results showed that when using simultaneous MTS with three comparison stimuli, the participant's responding was around 52% correct. The next condition included a prompt showing the participant the correct response. The participant responded accurately enough to get through the training phases, but in the last phase, where the prompt was removed, his responding went below the accuracy criterion. The next experimental condition was simplified from the previous by using only two comparison stimuli. This time, the participant's responding was almost without error. However, the last part of training showed that accuracy declined as the density of programmed consequences decreased. When adding 0-s DMTS, the participant's accuracy

was lower compared to the simultaneous matching. Again, his accuracy was higher when the density of programmed was high, but declined as the density decreased.

Based upon earlier studies (Arntzen et al., 2013; Steingrimsdottir & Arntzen, 2011a, 2011b), Study 5, *On the Use of Variations in a Delayed Matching-to-Sample Procedure in a Patient with Neurocognitive Disorder*, asked about the effect of using different titrating values in the titrating DMTS procedure (Arntzen & Steingrimsdottir, 2014). The participant was a 62-year-old patient diagnosed with mild cognitive impairment (Table 3). The results showed that using 500 ms titrating values led to greater variation in the titrated delay compared to using 100 ms titrating values. The study replicated earlier findings and thereby supports the conclusion that lower titrating values lead to a smoother response pattern compared to larger titrating values.

Discussion

The general purpose of the dissertation was to study variables affecting learning and remembering in older adults and NCD patients using conditional discrimination procedures. The results from Study 1 showed that for healthy older adults, being exposed to identity MTS before arbitrary MTS did not hinder arbitrary conditional discrimination establishment as was seen in an NCD patient (Steingrimsdottir & Arntzen, 2011b). Moreover, in contrast to what Saunders et al. (2005) concluded with, Study 1 did not find differences between using 0-s DMTS or simultaneous MTS. Study 2 showed that conditional discrimination establishment occurred more slowly in the older adults compared to the younger adults, their fixation time to sample stimulus did not differ from the younger participants' whereas their fixation duration and rate to the comparison stimuli were generally longer than in the younger participants. Also, the older adults were slightly less likely to respond in accordance with stimulus equivalence, but the difference was minimal.

For the participants with moderate to severe NCD diagnoses (Study 3 and 4), general conclusion is that adjusting the reinforcement contingency in accordance with the participant's responding allows for identification of the participant's abilities and disabilities and a possible starting point for conditional discrimination training. By means of subtle changes in the procedure, contingency control was established in the participant in Study 3, whereas for the participant in Study 4, contingency control was identified as a function of the number of comparison stimuli presented, 0-s DMTS, and density of programmed consequences. Study 5 showed the difference in the responding of a patient with mild NCD as a function of titration values used in a titrating DMTS procedure, with greater variability in titrating delays when using 500 ms values compared to 100 ms. The result from each individual study has identified variables affecting learning and remembering in older adults and older adults with NCD. Following is a general discussion across the five studies. Taken together, the studies have led to a number of additional research questions, with some of them being addressed in the sections below.

Establishment of Conditional Discrimination

Study 1 and 2 showed that for healthy older adults, the likelihood of establishing arbitrary conditional discriminations is generally high. Nevertheless, Study 2 showed that it took the older participants longer to establish the different baseline conditional discriminations compared to the younger adults. In a study by Tripp and Alsop (1999) the authors argued that older adults were less sensitive to reinforcement than younger participants. In their study, they used a signal detection task to study the effect of reinforcement frequency. Their results on "response bias data suggest that the sensitivity of behavior to the relative frequency of reward declines progressively with age" (p. 34). However, Study 2 showed that *not all* conditional discriminations were established with great difference in number of presentations of positive programmed consequences between the two

groups. On the contrary, some conditional discriminations were established slowly and others more quickly. It is therefore possible that other variables that have not been accounted for are in effect. For example, Wilson and Milan (1995) noted in a post-experimental debriefing that the older participants had looked for similarities between the stimuli during training. Study 2 included an additional measure for furthering our understanding of the role of eye-movements during conditional discrimination training and testing for responding in accordance with stimulus equivalence. Previous studies had shown that increased accuracy during conditional discrimination training is correlated with higher fixation duration to sample stimulus during training (e.g., Dube et al., 2006). The eye-movement data from Study 2 did not show any such difference between younger and older adults regarding observing the sample stimulus. Therefore, it may be that the difference in number of training trials found in Study 2 may be related somewhat to the stimuli themselves which may have affected the establishment of the different relations (as suggested by Wilson & Milan, 1995). The data also showed that the older adults' fixation duration and fixation rate towards the comparison stimulus was higher for the older adults during training. In other words, the older adults looked at each comparison stimulus for longer period of time and looked more often back and forth between the different comparison stimuli. These results lead to the question of whether the higher fixation rate and duration to the comparison stimuli may have been interrupting for the conditional discrimination establishment in the participants. Therefore, future studies may, for example, study the effect of increase the fixation duration to the sample stimulus, or to use for example gradual introduction in number of comparison stimuli for evaluation of whether, for example, fixation rate may decrease for evaluation of whether more rapid establishment of the conditional discriminations may be achieved.

Although most of the participants in Study 1 and 2 established the conditional discriminations after some training trials, 14 participants did not establish the arbitrary

conditional discrimination in Study 1, and two in Study 2. Other unpublished studies from the Experimental Studies of Complex Human Behavior Laboratory at Oslo and Akershus University College have also found some difficulties in establishing arbitrary conditional discrimination relations in healthy older adults (70 years or older). Although the reason is still unclear some suggestions may be made. Previous scholars have, for example, suggested that establishment of conditional discriminations and likelihood of responding in accordance with stimulus equivalence may change as a function of increased age (Pérez-González & Moreno-Sierra, 1999; Wilson & Milan, 1995). Studies 1 and 2 may indicate agreement with these suggestions, that is, as much higher number of participants did not establish the conditional discriminations in Study 1 (with 70 years or older participants), compared to Study 2, where the participants were 60–65 years-old.

Other suggestions may be related to procedural variables. For example, in Studies 1 and 2, the response was a mouse click. Although one of the criteria for participating in our studies was to be able to operate a computer mouse, and we insured that the participants could use the computer mouse, there may be a confounding variable as currently, the length of experience operating a computer mouse decreases with participants age. For example, it is most likely that the oldest participants in our studies (80 years or older) had less experience using computer mouse than younger adults. When the participant does not have long experience operating a computer mouse, the experimenter may be studying some kind of “computer behavior” (Smith, Sharit, & Czaja, 1999) instead of conditional discrimination learning. For this reason, a suggestion is made to a study that compares responding with a computer mouse vs. using a touch screen. The participants might begin, for example, by using a computer mouse. Those participants who do not establish the conditional discrimination within some pre-defined number of training trials might switch to a touch screen. The results from such a study might show whether it may be more appropriate to use

a touch screen (as was done in Studies 3 and 4) during the arbitrary conditional discrimination training when working with older adults, even if they have some experience using a computer mouse. Notably, the significance of this issue may change in the next few decades as younger generations are more likely to have greater experience using computers compared to the current older generation.

Another alternative cannot be excluded, and that is that the older adults who did not establish the conditional discriminations simply gave up before getting in contact with the experimenter-defined reinforcement contingency. Therefore, future experiments may study the effect of using a different type of stimuli, such as incorporating a meaningful stimuli into the training (e.g., Fields et al., 2012), with the goal of increasing the likelihood of arbitrary conditional discrimination establishment. Another suggestion is to begin with a pre-training phase (for example, using identity MTS as was done in Study 1) so participants get acquainted with the training procedure before the arbitrary conditional discrimination training begins.

Stimulus Equivalence as a Fundamental Process

The establishment of arbitrary conditional discrimination is imperative to be able to expose the participant to a test for responding in accordance with stimulus equivalence. As previously mentioned, Sidman (1994) stated that given the formation of arbitrary conditional discrimination, and assuming absence of artifacts in the stimulus control establishment, other properties of the stimulus equivalence relation would necessarily occur. Interestingly, previous studies have pointed out that older adults are less likely than younger adults to respond in accordance with stimulus equivalence, with the suggestion being made that the change in the likelihood may be related to deterioration in so-called cognitive behaviors (Gallagher & Keenan, 2009; Wilson & Milan, 1995). The results from Study 1 showed that approximately five out of eight participants responded in accordance with stimulus

equivalence ($\approx 63\%$). The data from Study 2 showed that seven out of 10 older adults respond in accordance with stimulus equivalence (70%) compared to nine out of 10 in the younger group (90%). These data therefore indicate slight differences in the likelihood of responding in accordance with stimulus equivalence as a function of age.

As mentioned in the introduction, the suggestion that derived relational responding may be negatively affected at an onset of an NCD may be supported with referenced to the paired associate learning literature. Although the interpretation of the data within the paired associate learning tradition is somewhat different from what behavior analysts are used to, results from the paired associate learning literature indicate that derived relational responding is negatively affected by the onset of an NCD (e.g., Bódi et al., 2009; Fowler et al., 2002).

It is imperative to note at this point that Studies 1 and 2 do not say, and cannot say, whether those participants who failed to establish the arbitrary conditional discrimination or failed to respond in accordance with stimulus equivalence were possibly at early stages of an NCD. For that reason, it is essential to look at other variables that may affect establishment of arbitrary conditional discrimination in older adults and the likelihood of responding in accordance with stimulus equivalence (see Arntzen, 2012). Furthermore, apart from few participants in Gallagher and Keenan (2009) there are, to my knowledge, no studies within the behavior analytic literature where variables affecting responding in arbitrary DMTS procedures in patients with mild cognitive impairment is studied. Such a study would fill a gap in the literature. Future research may also want to study the likelihood of responding in accordance with stimulus equivalence with comparison, for example, to results from electroencephalography (EEG) as a biomarker for an early NCD diagnosis (e.g., Rosen, 1997; Snaedal et al., 2012). Such study might provide insight into whether there is a change in the likelihood of responding in accordance with stimulus equivalence as a function of age (without an onset of NCD), or whether failure to respond correctly on such a test is more

likely to be related to abnormal changes in the brain instead of the age variable by itself. If the correlation between the results from the EEG recordings and the test for responding in accordance with stimulus equivalence is high, it may expand our understanding of the conditional discrimination and responding in accordance with stimulus equivalence as a basic fundamental process.

Going from Identity to Arbitrary MTS in NCD Patients

In an experiment with an NCD patient, Steingrimsdottir and Arntzen (2011b) found that the participant responded correctly when exposed to identity MTS with simultaneous presentation of the stimuli on the screen and with a delay to up to 9-s. On the other hand, attempts to establish arbitrary conditional discrimination relations had failed. Also, Study 3 showed that even when what were assumed to be familiar stimuli were used, establishing the arbitrary conditional discriminations failed. Therefore, the results from our studies show difficulty in establishing arbitrary conditional discrimination in NCD patients. However, further studies are needed to identify variables that may affect such responding.

Although identity matching is described as a prerequisite for more-complex MTS tasks, and it may seem to be important to begin training with what is assumed to be an easier task, it has also been pointed out that for some people, learning identity MTS before being exposed to arbitrary MTS may hinder arbitrary MTS learning as the person continues to look for similarities between the stimuli instead of responding in accordance with the new experimenter-defined contingency. Therefore, one of the purposes of Study 1 was to examine whether exposure to identity MTS before arbitrary MTS with healthy older adults would also lead to similar results. In contrast to what had happened in Steingrimsdottir and Arntzen (2011b), the results from this study showed that using identity MTS before arbitrary MTS with simultaneous presentation of the stimuli on the screen led to quicker establishment of the arbitrary conditional discriminations than starting out with arbitrary MTS followed by identity

MTS. Consequently, it is suggested that future studies explore the exchange between the identity and arbitrary MTS by using, for example, stimulus fading procedures where the matching procedure is progressively changed from identity MTS to arbitrary MTS with gradual changes in the stimuli that are used (Sidman, 1994). In one such study, Zygmunt, Lazar, Dube, and McIlvane (1992) used what they called a stimulus-control shaping procedure to establish arbitrary MTS in their participants. The participants in the study were able to do identity MTS but did not demonstrate arbitrary MTS. However, with small changes in the sample stimulus, the authors successfully changed from identity to arbitrary MTS. It is worth pointing out, though, that although Zygmunt et al. (1992) successfully established arbitrary MTS in their participants by using stimulus-control shaping procedure, one can easily run into difficulties in the process (for further elaboration on procedural difficulties, see, e.g., Brino et al., 2011; Brino, Galvão, Barros, Goulart, & McIlvane, 2012). Performing such a study with NCD patients would increase our understanding of the exchange between the two procedures.

To sum up the preceding discussion on the establishment of conditional discriminations, the likelihood of responding in accordance with stimulus equivalence, and the exchange between identity and arbitrary MTS, when looking across the studies that form the basis of this dissertation, it seems to be possible to study conditional discrimination behavior as a function of age and/or an NCD. This is in accordance with Sidman's early studies, where he and his colleagues found a correlation between responding to (1) simple and (2) conditional discrimination and (3) testing for responding in accordance with stimulus equivalence, and (4) stepwise increase in class size, with the patient's recovery process.

In other words, taking into consideration the previous research literature, in both paired associate learning and behavior analysis, including the five studies presented here, the suggestion is made that it may be possible to find a correlation between responding to the

different conditional discrimination procedures and the likelihood of stimulus equivalence class formation (1) as a function of age, or, perhaps more importantly, (2) as a function of NCD. Figure 5 summarizes this idea.

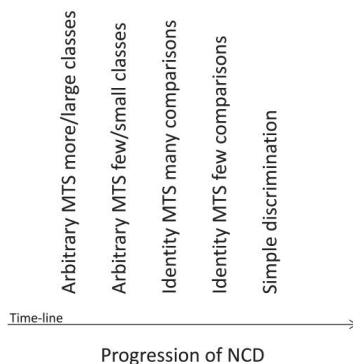


Figure 5. A suggested correlation between participants' responding on different conditional discrimination tasks with the progression of an NCD. The arrow indicates a time-line. Additionally, the DMTS procedure may be incorporated at any stage of the conditional discrimination training.

As the figure shows, procedures such as arbitrary MTS with simultaneous or DMTS, with a higher number of classes and larger classes may be used to study learning and remembering in healthy older adults. If the participant does not respond in accordance with the experimenter- defined criterion, the procedure may be simplified by decreasing the number of classes or class size. As our studies have shown difficulties for those who have NCD diagnoses in responding to arbitrarily related conditional discriminations, the procedure may be changed to identity MTS, with or without delay, and so forth. It is worth noting, though, as mentioned before, further studies on the exchange between arbitrary and identity MTS procedures are needed to draw firmer conclusions about the subject matter.

Conditional Discrimination Training in NCD Patients

Currently, the biggest challenge regarding conditional discrimination training with NCD patients is that patients and trainers are most often competing with progressive and generally irreversible diseases. Hopefully, the near future brings with it medications that can

hinder the progression of the disease, and then procedures for effective rehabilitation will be needed. Until then, understanding variables affecting conditional discrimination learning and responding in accordance with stimulus equivalence will prepare future practitioners for identifying effective interventions.



Figure 6. The figure shows how rehabilitation may be designed. In addition to those procedures mentioned in the figure, the DMTS procedure may be incorporated at any stage of the conditional discrimination training.

The benefit of using conditional discrimination training is that owing to the large body of research literature that already exists, a general guideline may be identified (as roughly suggested in Figure 6). Such an approach has been called for (Boccardi & Frisoni, 2006). However, replications of these procedures with older adults and NCD patients are greatly needed. Designing conditional discrimination training allows for tailoring the training to each and every person, targeting those variables that are of most interest for each individual patient (e.g., Cowley et al., 1992; Guercio, Podolska-Schroeder, & Rehfeldt, 2004; Leirer, Morrow, Sheikh, & Pariante, 1990). Studies 1–5 have expanded the current literature by identifying variables affecting learning and remembering in older adults and older adults with NCD diagnoses and demonstrated the use of some of these variables. Again, replications are needed for understanding variables that may enhance conditional discrimination learning.

Familiar stimuli and color stimuli. Previous studies have shown the positive effect of using familiar stimuli when establishing arbitrary conditional discriminations (Arntzen &

Lian, 2010; Fields et al., 2012) and therefore, Study 3 used what were assumed to be familiar stimuli (pictures of clothes, pictures related to hand wash and pictures of eating utensils) to study their effect on arbitrary conditional discrimination establishment in an NCD patient. It was noted that the participant, who had severe NCD, was unable to name a number of things in her environment, such as her bed and the curtains. However, it was not known whether naming an object is the same as categorizing it in a group of similar items. Despite using what were assumed to be familiar stimuli, the participant did not respond in accordance with the arbitrary relations. Therefore, the procedure was gradually simplified to find at what point conditional discrimination might be established. First, the eating utensils were used for identity MTS but still without an increase in accuracy in the participant's responding. Therefore, the procedure was simplified to color matching.

Color stimuli have been used in number of experiments where conditional discrimination is studied (e.g., Santi, 1978; Urcuioli & Zentall, 1986; Urcuioli, Zentall, Jackson-Smith, & Steirn, 1989). The reason for using color stimuli in an MTS task is that these types of stimuli have been described as being easily discriminated by the participant, which is an important component of conditional discrimination. However, it turned out that the color stimuli alone were not sufficient for establishing conditional discrimination within the time frame we gave. Thus, the participant received specific instructions when using the color stimuli. These combinations led to conditional discrimination establishment. Most interestingly, after successful establishment of the color matching, the participant responded in accordance with accuracy criterion both when exposed to additional color matching task and when the stimuli were changed to cutlery again.

The results from Study 3 bring with them some promising results regarding the possibility of training conditional discrimination in NCD patients. It is not known whether the more-complex conditional discrimination procedures negatively affected subsequent

responding in our study. Still, it is suggested that future studies including patients with severe NCD should begin with simpler discrimination training before moving to more-complex matching. Based on the results from Study 3, it is suggested beginning with color matching with three color stimuli when working with a patient with severe dementia and, when accuracy criterion is reached, doing an a test for generalized identity matching. If the participant fails to respond in accordance with the identity of the stimuli, the number of comparison stimuli might be reduced to two in a new training session with new color stimuli, followed by another test for generalized identity MTS. On the other hand, if the participant responds accurately on the test for generalized identity matching, the next step would be to increase the number of comparison stimuli to four, or to change to a more complex, or less discriminable, set of stimuli (Figure 5). It would also be interesting to study the effect of using (1) familiar stimuli and (2) color matching in a patient with a slightly higher MMSE score. Involving participants with a higher MMSE score is likely to lead to different results from what was found in Study 3.

Delayed MTS

The DMTS procedure has been used in other areas of psychology with some interesting results. For example, it has been suggested that the DMTS procedure, which is one of the subtests of the Cambridge Neuropsychological Test Automated Battery (CANTAB), may differentiate between those at the early stages of an NCD from healthy older adults (Fowler, Saling, Conway, Semple, & et al., 1997; Fowler, Saling, Conway, Semple, & Louis, 1995). For the behavior analyst, the procedure is interesting as it can provide information about remembering behavior in each individual participant.

Earlier studies had shown that when using 0-s DMTS procedure, the likelihood of responding in accordance with stimulus equivalence is increased (e.g., Arntzen, 2006; Saunders et al., 2005). Study 1, on the contrary did not find such difference. However, the

study did show that using 0-s DMTS procedure, led to similar results as when using identity MTS before simultaneous arbitrary MTS with fewer training trials to criterion during establishment of arbitrary conditional discriminations. Taken together, it is interesting to see the possible positive effect the use of 0-s DMTS procedure may have in experiments with healthy older adults. This is particularly thought-provoking because using the 0-s DMTS identity MTS can lead to higher number of incorrect responses in NCD patient compared to when using simultaneous matching (e.g., Study 3).

The studies with those participants who had NCD diagnoses utilized both the identity and arbitrary MTS procedures. However, as it proved to be difficult to use the arbitrary MTS procedure (e.g., Study 3), the discussion focuses on the use of variables affecting responding on identity DMTS (Study 4 and 5). Study 4 asked about the effect of the number of comparison stimuli presented in an identity MTS task in a patient at the border of moderate to severe dementia. Furthermore, the study asked about the effect of using 0-s DMTS. The results showed that responding was considerably more accurate when using two comparison stimuli compared to three. Therefore, two comparison stimuli were used during the introduction of the 0-s DMTS procedure. The introduction of the 0-s DMTS procedure had a considerable effect on the participant's responding, with many more incorrect responses compared to the simultaneous procedure. Unfortunately, the participant withdrew from the study before we were able to finish the experimental condition. However, the results that were obtained indicated the possibility of using the 0-s DMTS procedure with participants with such a low MMSE score.

Replication of the study is highly needed. As previously mentioned, it is important to use three comparison stimuli to increase the likelihood of responding being in accordance with the identity of the stimuli, and not being a form of rejection of the incorrect stimulus. Therefore, it is suggested that future studies start with identity MTS with three comparison

stimuli. If responding is in accordance with the experimenter-defined criterion, the 0-s DMTS procedure is introduced. If not, the number of comparisons should be reduced to two before the introduction of the 0-s DMTS procedure. The results from the 0-s DMTS procedure would show whether it would be possible to then make a step-wise increase in the length of the delay to study the participant's remembering behavior.

As mentioned in the introduction, when increasing the length of the delay, it may either be fixed throughout the training or it may change as a function of the participants' correct or incorrect responses (titrating DMTS). When using the titrating DMTS procedure, the possible floor and ceiling effect of the fixed DMTS procedure can be avoided and remembering behavior be studied without the experimenter intervening during the increase or decrease of the delay. The titrating DMTS was used in Study 5, which asked about the effect of using different titration values in a titrating DMTS procedure. Our study showed that using 100 ms titration values led to smoother response pattern compared to using 500 ms titration values. The study is an important contribution to the study of remembering as it documents the effect of procedural variables on the participants' responding and offers suggestions for future studies. For example, the participant began with a pre-categorization of the stimuli that were used in the experiment, which showed that he matched the stimuli based on their similarities. Future studies, however, might also use simultaneous identity matching on the computer before starting the DMTS procedure. Doing so makes it more probable that incorrect responses are related to the delay itself, not to other issues such as failure to understand the procedure or failure to discriminate between the stimuli that are used.

In our study the length of the delay increased when the participant made six out of six correct responses, whereas it decreased with five (or fewer) out of six correct responses. Future studies might vary the criterion for changing the length of the delay. Also, depending upon the research question, it may be possible to titrate the delay solely upward to identify the

greatest possible length of the delay. Such a study could replicate each experimental condition, for example, three times for evaluation of whether the same length of delay would be reached each time. On the other hand, allowing the titration values to both increase and decrease, as was done in Study 5, allows for the identification of an asymptotic level, showing the longest stable titration values in each condition. The current study showed different asymptotic levels across the experimental conditions, with an increase from the A conditions to the B conditions. The different asymptotic levels identified show that it is important to learn more about the procedure to be able to describe participants' remembering behavior. For example, when identifying the asymptotic level, how many up/down patterns should be used to claim that the asymptotic level was identified, and how long should the stability criterion be?

In sum, further studies are needed in general to clarify stimulus control as a function of different procedural variables. For example, future studies need to clarify the effect of different procedural variables in the titrating DMTS procedure, such as the titration value, criterion for increasing/decreasing the delay, and variables related to identifying an asymptotic level of responding. Understanding the procedures is important because when DMTS with abstract stimuli is used, whether it is identity or arbitrary MTS, the procedure provides information about the participants' remembering behavior without having to rely on language (Fray & Robbins, 1996). This is particularly helpful when working with patients with severe NCD when language deficiencies have become prominent. Additionally, DMTS is free from cultural bias, which makes the procedure applicable across different languages and cultures. The independency of the DMTS procedure from language and culture excludes the need to adjust the test to each culture/language, as is needed for most neuropsychological tests (e.g., the MMSE).

Instructions, Prompt, and Gradual Increase in Number of Comparisons

In addition to the preceding discussion, there are some other issues that were raised in the five studies presented below. For example, the five studies forming the basis of the dissertation used a standardized set of instructions. In general, the instructions had minimal description of the procedure (see each study for a description of instructions), thereby increasing the likelihood of the behavior being under control of the experimental contingencies set up for the experiment, instead of being influenced by, for example, a rule (see, for example, Arntzen, Vaidya, & Halstadro, 2008, for elaboration on the role of instructions on participants' responding). On the other hand, there may be times when instructions are considered necessary. Study 3 showed how instructions could affect participants' responding. First, the participant was presented with both arbitrary and identity MTS tasks, without the participant's responding changing in accordance with the tasks. Therefore, instructions were incorporated. At first, the participant's responding did not change upon the presentation of the first set of instructions, whereas with systematic, though small, changes in the instructions, the behavior changed and responding became in accordance with identity MTS.

The reason for highlighting this issue is that when working with older adults with severe NCD, language deficiencies become apparent. Therefore, it is suggested that future research using conditional discrimination procedures to study learning and remembering in either healthy older adults or adults with NCD, should keep instructions to a minimum so that discrimination behavior can be studied without having to rely on the participants' language abilities. Doing so also makes comparison across studies easier.

Another issue relates to the issue of using procedures such as errorless learning (Clare, Wilson, Breen, & Hodges, 1999) and spaced retrieval (Camp, Foss, O'Hanlon, & Stevens, 1996) when training remembering in NCD patients. Although a different procedure from the

errorless learning and spaced retrieval, Study 4 examined the effect of using a prompt on identity MTS establishment. The procedure did not prove to facilitate correct responding as used in the study. Additionally, Study 3 examined the use of gradual introduction of the number of comparison stimuli on arbitrary MTS establishment. During the first phase, when there was only one comparison stimulus, the participant necessarily emitted a sufficient number of correct responses for the second comparison stimulus to be introduced. However, the procedure did not facilitate arbitrary MTS establishment when number of comparison stimuli was increased to two. In sum, these two studies did not document the positive effect of using a prompt and gradual introduction of comparison stimuli. Again, it is imperative to replicate these studies. The participants in these studies had an MMSE score of eight (Study 3) and 10 (Study 4). Future studies may try these procedures with participants with a higher MMSE score who do not respond in accordance with the experimenter-defined contingencies to evaluate their effect on responding.

Experimental Control and Generality of the Findings

Experimental control is a central feature of all experiments (e.g., Kazdin, 2011; Shadish, Cook, & Campbell, 2002). This applies for the behavior analyst as well, whether he is working within an applied (Baer, Wolf, & Risley, 1968) or experimental setting (Sidman, 1960). There are, however, some differences in what type of experimental control is established. For example, the applied behavior analyst may use functional analysis to learn about which consequences maintain a problem behavior (Iwata, Dorsey, Slifer, Bauman, & Richman, 1994; Iwata & Dozier, 2008). Also, when designing an intervention, the applied behavior analyst may use different types of single-subject designs (N=1) to study whether the behavior changes reliably as a function of the introduction of the independent variable, thereby excluding other reasons for the behavior change (Steingrimsdottir & Arntzen, accepted). As pointed out by Imam and Warner (2014), the behavior analyst may also study

contingency control, where if the behavior changes in accordance with the experimenter-defined contingencies, experimental control is demonstrated.

Contingency control is often used within conditional discrimination research, where variables affecting the stimulus control are studied. According to Sidman (1994), stimulus equivalence research is “an outgrowth of contingency analysis that had given rise to basic relational concepts like stimulus, response, reinforcement, discrimination, conditioned and generalized reinforcement, and conditional discrimination” (pp. 324–325). All of the studies in this dissertation are based upon the establishment of contingency control. Overall, the studies have shown that there are a number of variables that may influence participants’ responding, such as the use of fixed DMTS vs. titrating DMTS, the use of different lengths of delay, along with the types of stimuli that are used, and the number of comparison stimuli presented. However, as noted before, replications of these studies are needed for an evaluation of the generality of the findings (Sidman, 1960).

Concluding Remarks

As pointed out in the beginning of the dissertation, there are number of demographic changes occurring worldwide with an intense increase in the number of older adults in number of countries, and increased life expectancy for each individual. These changes are accompanied by an increased frequency of NCD diagnoses. When a person gets an NCD, the disease affects his or her behavior in number of ways, such as with deterioration in learning and remembering. Currently, there are few published studies examining conditional discrimination behavior in older adults or NCD patients within the behavior analytic literature. The experimental behavior gerontology literature has been expanded and strengthened by the five studies conducted for this dissertation. The five studies have shown conditional discrimination learning in both healthy older adults and NCD patients, ranging from arbitrary to identity MTS, with or without delayed presentation of the comparison

stimuli, with suggestion of how the procedures can be adapted to each individuals level of functioning. Importantly, learning about the use of these procedures and the prerequisites needed for more-complex matching to be done may have important value for the applied setting. The data that can be obtained from each individual can provide important information, both about his or her discrimination behavior and by identifying an appropriate starting point for conditional discrimination training. In this way, the conditional discrimination may be established in individuals that do not respond in accordance with such relations. As stated by Sidman (1994) “a true appreciation of the prerequisites for the emergence of equivalence relations will require a thorough grounding in the principles of stimulus control” (p. 77). Therefore, replications of the five studies are called for. By understanding the procedures and variables affecting learning and remembering in these participant groups, effective training programs may be created, for example, to teach name-face relations and to maintain object identification in NCD patients to name a few.

References

- Adams, B. J., Fields, L., & Verhave, T. (1993). Effects of test order on intersubject variability during equivalence class formation. *The Psychological Record, 43*, 133–152. Retrieved from <http://thepsychologicalrecord.siuc.edu/index.html>
- Administration on Aging. (2013). *A Profile of Older Americans: 2013*. Retrieved from http://www.aoa.acl.gov/Aging_Statistics/Profile/2013/docs/2013_Profile.pdf
- Agrell, B., & Dehlin, O. (1998). The clock-drawing test. *Age and Ageing, 27*, 399–403. doi: 10.1093/ageing/27.3.399
- Altus, D. E., Engelman, K. K., & Mathews, R. M. (2002). Using family-style meals to increase participation and communication in persons with dementia. *Journal of Gerontological Nursing, 28*, 47–53. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/12240521>.
- American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Arlington, VA: American Psychiatric Publishing.
- American Psychological Association (Producer). (2010). Ethical principles of psychologists and code of conduct. Retrieved from <http://www.apa.org/ethics/code/principles.pdf>
- Arntzen, E. (2004). Probability of equivalence formation: Familiar stimuli and training sequence. *The Psychological Record, 54*, 275–291. Retrieved from <http://thepsychologicalrecord.siu.edu/index.html>.
- Arntzen, E. (2006). Delayed matching to sample: Probability of responding in accord with equivalence as a function of different delays. *The Psychological Record, 56*, 135–167. Retrieved from <http://thepsychologicalrecord.siuc.edu/index.html>
- Arntzen, E. (2012). Training and testing parameters in formation of stimulus equivalence: Methodological issues. *European Journal of Behavior Analysis, 13*, 123–135. Retrieved from <http://www.ejoba.org/>
- Arntzen, E., Braaten, L. F., Lian, T., & Eilifsen, C. (2011). Response-to-sample requirements in conditional discrimination procedures. *European Journal of Behavior Analysis, 12*, 505–522. Retrieved from <http://www.ejoba.org/>.
- Arntzen, E., Galaen, T., & Halvorsen, L. R. (2007). Different retention intervals in delayed matching-to-sample: Effects of responding in accord with equivalence. *European Journal of Behavior Analysis, 8*, 177–191. Retrieved from <http://www.ejoba.org/>.
- Arntzen, E., Grondahl, T., & Eilifsen, C. (2010). The effects of different training structures in the establishment of conditional discriminations and subsequent performance on tests

- for stimulus equivalence. *The Psychological Record*, 60, 437–462. Retrieved from <http://thepsychologicalrecord.siu.edu/index.html>.
- Arntzen, E., & Hansen, S. (2011). Training Structures and the Formation of Equivalence Classes. *European Journal of Behavior Analysis*, 12, 483–503. Retrieved from <http://www.ejoba.org/>.
- Arntzen, E., & Holth, P. (2000a). Equivalence outcome in single subjects as a function of training structure. *The Psychological Record*, 50, 603–628. Retrieved from <http://thepsychologicalrecord.siu.edu/index.html>.
- Arntzen, E., & Holth, P. (2000b). Probability of stimulus equivalence as a function of class size vs. number of classes. *The Psychological Record*, 50, 79–104. Retrieved from <http://thepsychologicalrecord.siu.edu/index.html>.
- Arntzen, E., & Lian, T. (2010). Trained and derived relations with pictures versus abstract stimuli as nodes. *The Psychological Record*, 60, 659–677. Retrieved from <http://thepsychologicalrecord.siu.edu/index.html>.
- Arntzen, E., & Nikolaisen, S. L. (2011). Establishing equivalence classes in children using familiar and abstract stimuli and many-to-one and one-to-many training structures. *European Journal of Behavior Analysis*, 12, 105–120. Retrieved from <http://www.ejoba.org/>.
- Arntzen, E., & Steingrimsdottir, H. S. (2014). On the Use of Variations in a Delayed Matching-to-Sample Procedure in a Patient with Neurocognitive Disorder *Mental Disorders*. (pp. 123–137): iConcept Press Ltd.
- Arntzen, E., Steingrimsdottir, H. S., & Brogård-Antonsen, A. (2013). Behavioral Studies of Dementia: Effects of Different Types of Matching-to-Sample Procedures. *The Norwegian Journal of Behavior Analysis*, 40, 17–29. Retrieved from <http://www.nta.atferd.no/>.
- Arntzen, E., Vaidya, M., & Halstadro, L. B. (2008). On the role of instruction in conditional discrimination training. *Experimental Analysis of Human Behavior Bulletin*, 29, 17–24. Retrieved from <http://www.eahb.org/NewSitePages/BulletinHomepage.htm>.
- Arntzen, E., & Vie, A. (2013). The expression of equivalence classes influenced by distractors during DMTS test trials. *European Journal of Behavior Analysis*, 14, 151–161. Retrieved from <http://www.ejoba.org/>.
- Baer, D. M., Wolf, M. M., & Risley, T. R. (1968). Some current dimensions of applied behavior analysis. *Journal of Applied Behavior Analysis*, 1, 91–97. doi: 10.1901/jaba.1968.1-91

- Baker, J. C., Hanley, G. P., & Mathews, R. M. (2006). Staff-administered functional analysis and treatment of aggression by an elder with dementia. *Journal of Applied Behavior Analysis, 39*, 469–474. doi: 10.1901/jaba.2006.80-05
- Baker, J. C., & LeBlanc, L. A. (2014). Aging *The Wiley Blackwell Handbook of Operant and Classical Conditioning* (pp. 695–713): John Wiley & Sons, Ltd.
- Baker, J. C., LeBlanc, L. A., Raetz, P. B., & Hilton, L. C. (2011). Assessment and treatment of hoarding in an individual with dementia. *Behavior Therapy, 42*, 135–142. doi: 10.1016/j.beth.2010.02.006
- Baron, A., & Menich, S. R. (1985). Reaction times of younger and older men: effects of compound samples and a prechoice signal on delayed matching-to-sample performances. *Journal of the Experimental Analysis of Behavior, 44*, 1–14. doi: 10.1901/jeab.1985.44-1
- Baron, A., Menich, S. R., & Perone, M. (1983). Reaction times of younger and older men and temporal contingencies of reinforcement. *Journal of the Experimental Analysis of Behavior, 40*, 275–287. doi: 10.1901/jeab.1983.40-275
- Berghmans, R. L. P., & Meulen, R. H. J. T. (1995). Ethical issues in research with dementia patients. *International Journal of Geriatric Psychiatry, 10*, 647–651. doi: 10.1002/gps.930100803
- Blough, D. S. (1959). Delayed matching in the pigeon. *Journal of the Experimental Analysis of Behavior, 2*, 151–160. doi: 10.1901/jeab.1959.2-151
- Boccardi, M., & Frisoni, G. B. (2006). Cognitive rehabilitation for severe dementia: Critical observations for better use of existing knowledge. *Mechanisms of Ageing and Development, 127*, 166–172. doi: 10.1016/j.mad.2005.09.027
- Bódi, N., Csibri, É., Myers, C. E., Gluck, M. A., & Kéri, S. (2009). Associative learning, acquired equivalence, and flexible generalization of knowledge in mild Alzheimer disease. *Cognitive and Behavioral Neurology, 22*, 89–94. doi: 10.1097/WNN.0b013e318192ccf0
- Branch, M. N. (1977). On the Role of "Memory" in the Analysis of Behavior. *Journal of the Experimental Analysis of Behavior, 28*, 171–179. doi: 10.1901/jeab.1977.28-171
- Brino, A. L., Barros, R. S., Galvao, O. F., Garotti, M., da Cruz, I. R., Santos, J. R. et al. (2011). Sample stimulus control shaping and restricted stimulus control in capuchin monkeys: a methodological note. *Journal of the Experimental Analysis of Behavior, 95*, 387–398. doi: 10.1901/jeab.2011.95-387

- Brino, A. L., Galvão, O. F., Barros, R. S., Goulart, P. R. K., & McIlvane, W. J. (2012). Restricted stimulus control in stimulus control shaping with a capuchin monkey. *Psychology & Neuroscience*, *5*, 83–89. doi: 10.3922/j.psns.2012.1.11
- Burgio, L. D., & Burgio, K. L. (1986). Behavioral gerontology: application of behavioral methods to the problems of older adults. *Journal of Applied Behavior Analysis*, *19*, 321–328. doi: 10.1901/jaba.1986.19-321
- Camp, C. J., Foss, J. W., O'Hanlon, A. M., & Stevens, A. B. (1996). Memory Interventions for Persons with Dementia. *Applied Cognitive Psychology*, *10*, 193-210. doi: 10.1002/(SICI)1099-0720(199606)10:3<193::AID-ACP374>3.0.CO;2-4
- Carrigan, P. F., & Sidman, M. (1992). Conditional discrimination and equivalence relations: A theoretical analysis of control by negative stimuli. *Journal of the Experimental Analysis of Behavior*, *58*, 183–204. doi: 10.1901/jeab.1992.58-183
- Catania, A. C. (2007). *Learning* (Interim edition, 4th ed.). New York: Sloan Publishing.
- Clare, L., Wilson, B. A., Breen, K., & Hodges, J. R. (1999). Errorless learning of face-name associations in early Alzheimer's disease. *Neurocase*, *5*, 37–46. doi: 10.1080/13554799908404063
- Cooper, J. O., Heron, T. E., & Heward, W. L. (2007). *Applied behavior analysis* (2nd ed.). Upper Saddle River, N.J.: Pearson/Merrill Prentice Hall.
- Cowley, B. J., Green, G., & Braunling-McMorrow, D. (1992). Using stimulus equivalence procedures to teach name-face matching to adults with brain injuries. *Journal of Applied Behavior Analysis*, *25*, 461–475. doi: 10.1901/jaba.1992.25-461
- Cullen, B., O'Neill, B., Evans, J. J., Coen, R. F., & Lawlor, B. A. (2007). A review of screening tests for cognitive impairment. *Journal of Neurology, Neurosurgery & Psychiatry*, *78*, 790-799. doi: 10.1136/jnnp.2006.095414
- Cumming, W. W., & Berryman, R. (1965). The complex discriminated operant: studies of matching-to-sample and related problems. In D. I. Mostofsky (Ed.), *Stimulus Generalization* (pp. 284–330). Stanford, California: Stanford University Press.
- Derenne, A., & Baron, A. (2002). Behavior analysis and the study of human aging. *Behavior Analyst*, *25*, 151–160. Retrieved from <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2731606/>.
- Deweer, B., Lehericy, S., Pillon, B., Baulac, M., Chiras, J., Marsault, C. et al. (1995). Memory disorders in probable Alzheimer's disease: the role of hippocampal atrophy as shown with MRI. *Journal of Neurology, Neurosurgery, and Psychiatry*, *58*, 590–597. Retrieved from <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1073492/>.

- Dickins, D. W., Singh, K. D., Roberts, N., Burns, P., Downes, J. J., Jimmieson, P. et al. (2001). An fMRI study of stimulus equivalence. *Neuroreport*, *12*, 405–411. doi: 10.1097/00001756-200102120-00043
- Dinsmoor, J. A. (1985). The role of observing and attention in establishing stimulus control. *Journal of the Experimental Analysis of Behavior*, *43*, 365–381. doi: 10.1901/jeab.1985.43-365
- Dube, W. V., Balsamo, L. M., Fowler, T. R., Dickson, C. A., Lombard, K. M., & Tomanari, G. Y. (2006). Observing behavior topography in delayed matching to multiple samples. *The Psychological Record*, *56*, 6. Retrieved from <http://thepsychologicalrecord.siu.edu/index.html>.
- Dube, W. V., Lombard, K. M., Farren, K. M., Flusser, D. S., Balsamo, L. M., & Fowler, T. R. (1999). Eye tracking assessment of stimulus overselectivity in individuals with mental retardation. *Experimental Analysis of Human Behavior Bulletin*, *17*, 267–271. Retrieved from <http://www.eahb.org/1/wp-content/uploads/2014/03/eahb-vol-17-Dube-et-al.pdf>.
- Dube, W. V., & McIlvane, W. J. (1996). Some implications of a stimulus control topography analysis for emergent behavior and stimulus classes. In T. R. Zentall & P. M. Smeets (Eds.), *Stimulus Class Formation in Humans and Animals* (pp. 197–218). Amsterdam, Netherlands: Elsevier Science.
- Dube, W. V., McIlvane, W. J., & Green, G. (1992). An analysis of generalized identity matching-to-sample test procedures. *The Psychological Record*, *42*, 17–28. Retrieved from <http://thepsychologicalrecord.siu.edu/>.
- Dwyer-Moore, K. J., & Dixon, M. R. (2007). Functional Analysis and Treatment of Problem Behavior of Elderly Adults in Long-Term Care. *Journal of Applied Behavior Analysis*, *40*, 679–683. doi: 10.1901/jaba.2007.679-683
- Dymond, S., & Rehfeldt, R. A. (2001). Supplemental measures of derived stimulus relations. *Experimental Analysis of Human Behavior Bulletin*, *19*, 8–12. Retrieved from <http://www.eahb.org/NewSitePages/BulletinHomepage.htm>.
- Eilifsen, C., & Arntzen, E. (2009). On the role of trial types in tests for stimulus equivalence. *European Journal of Behavior Analysis*, *10*, 187–202. Retrieved from <http://www.ejoba.org/>.
- Eilifsen, C., & Arntzen, E. (2011). Single-subject withdrawal designs in delayed matching-to-sample procedures. *European Journal of Behavior Analysis*, *12*, 152–172. Retrieved from <http://www.ejoba.org/>.

- Engedal, K., & Haugen, P. K. (2009). *Lærebok demens. Fakta og utfordringer*. Tønsberg: Forlaget Aldring og Helse.
- Ferri, C. P., Prince, M., Brayne, C., Brodaty, H., Fratiglioni, L., Ganguli, M. et al. (2005). Global prevalence of dementia: a Delphi consensus study. *The Lancet*, *366*, 2112–2117. doi: 10.1016/s0140-6736(05)67889-0
- Fields, L., Arntzen, E., Nartey, R. K., & Eilifsen, C. (2012). Effects of a meaningful, a discriminative, and a meaningless stimulus on equivalence class formation. *Journal of the Experimental Analysis of Behavior*, *97*, 163–181. doi: 10.1901/jeab.2012.97-163
- Fields, L., & Verhave, T. (1987). The structure of equivalence classes. *Journal of the Experimental Analysis of Behavior*, *48*, 317–332. doi: 10.1901/jeab.1987.48-317
- Folkehelseinstituttet. (2014). Folkehelse rapporten 2014 Retrieved 04.02, 2015, from <http://www.fhi.no/artikler/?id=110865>
- Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research*, *12*, 189–198. doi: 0022-3956(75)90026-6 [pii]
- Fowler, K. S., Saling, M. M., Conway, E. L., Louis, W. J., & Semple, J. M. (2002). Paired associate performance in the early detection of DAT. *Journal of the International Neuropsychological Society*, *8*, 58–71. doi: 10.1017/S1355617702811067
- Fowler, K. S., Saling, M. M., Conway, E. L., Semple, J. M., & et al. (1997). Computerized neuropsychological tests in the early detection of dementia: Prospective findings. *Journal of the International Neuropsychological Society*, *3*, 139–146.
- Fowler, K. S., Saling, M. M., Conway, E. L., Semple, J. M., & Louis, W. J. (1995). Computerized delayed matching to sample and paired associate performance in the early detection of dementia. *Applied Neuropsychology*, *2*, 72–78. doi: 10.1207/s15324826an0202_4
- Fray, P. J., & Robbins, T. W. (1996). CANTAB battery: Proposed utility in neurotoxicology. *Neurotoxicology and Teratology*, *18*, 499–504. doi: 10.1016/0892-0362(96)00027-X
- Gallagher, S. M., & Keenan, M. (2009). Stimulus equivalence and the Mini Mental Status Examination in the elderly. *European Journal of Behavior Analysis*, *10*, 159–165. Retrieved from <http://www.ejoba.org/>
- Geldmacher, D. S. (2009). Alzheimer Disease. In M. F. Weiner & A. M. Lipton (Eds.), *Textbook of Alzheimer Disease and Other Dementias* (pp. 155–172). Washington, DC: American Psychiatric Publishing, Inc.

- Green, G., & Saunders, R. R. (1998). Stimulus Equivalence. In K. A. Lattal & M. Perone (Eds.), *Handbook of Research Methods in Human Operant Behavior* (pp. 229–262). New York: Springer.
- Guercio, J. M., Podolska-Schroeder, H., & Rehfeldt, R. A. (2004). Using stimulus equivalence technology to teach emotion recognition to adults with acquired brain injury. *Brain Injury, 18*, 593–601. doi: 10.1080/02699050310001646116
- Haimson, B., Wilkinson, K. M., Rosenquist, C., Ouimet, C., & McIlvane, W. J. (2009). Electrophysiological correlates of stimulus equivalence processes. *Journal of the Experimental Analysis of Behavior, 92*, 245–256. doi: 10.1901/jeab.2009.92-245
- Helsedirektoratet. (2015). Demens Retrieved 04.02, 2015, from <http://helsedirektoratet.no/helse-og-omsorgstjenester/omsorgstjenester/demens/Sider/default.aspx>
- Holth, P., & Arntzen, E. (2000). Reaction times and the emergence of class consistent responding: A case for precurrent responding. *The Psychological Record, 50*, 305–337. Retrieved from <http://thepsychologicalrecord.siu.edu/index.html>.
- Hyman, R. (1953). Stimulus information as a determinant of reaction time. *Journal of Experimental Psychology, 45*, 188–196. doi: 10.1037/h0056940
- Imam, A. A. (2006). Experimental control of nodality via equal presentations of conditional discriminations in different equivalence protocols under speed and no-speed conditions. *Journal of the Experimental Analysis of Behavior, 85*, 107–124. doi: 10.1901/jeab.2006.58-04
- Imam, A. A., & Warner, T. A. (2014). Test order effects in simultaneous protocols. *Learning & Behavior, 42*, 93–103. doi: 10.3758/s13420-013-0128-4
- Iversen, I. (1997). Matching-to-sample performance in rats: A case of mistaken identity? *Journal of the Experimental Analysis of Behavior, 68*, 27–45. doi: 10.1901/jeab.1997.68-27
- Iwata, B. A., Dorsey, M. F., Slifer, K. J., Bauman, K. E., & Richman, G. S. (1994). Toward a functional analysis of self-injury. *Journal of Applied Behavior Analysis, 27*, 197–209. doi: 10.1901/jaba.1994.27-197
- Iwata, B. A., & Dozier, C. L. (2008). Clinical Application of Functional Analysis Methodology. *Behavior Analysis in Practice, 1*, 3–9. Retrieved from <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2846577/>.

- Kangas, B. D., Vaidya, M., & Branch, M. N. (2010). Titrating-delay matching-to-sample in the pigeon. *Journal of the Experimental Analysis of Behavior, 94*, 69–81. doi: 10.1901/jeab.2010.94-69
- Kazdin, A. E. (2011). *Single-case research designs: Methods for clinical and applied settings*. New York: Oxford University Press.
- Kim, S. Y. H., & Caine, E. D. (2014). Utility and limits of the mini mental state examination in evaluating consent capacity in Alzheimer's disease. *Psychiatric Services, 53*, 1322–1324. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/12364686#>.
- Kim, S. Y. H., Caine, E. D., Currier, G. W., Leibovici, A., & Ryan, J. M. (2014). Assessing the competence of persons with Alzheimer's disease in providing informed consent for participation in research. *The American Journal of Psychiatry, 158*, 712–717. doi: 10.1176/appi.ajp.158.5.712
- Kirshner, H., & Sidman, M. (1972). Scanning patterns in aphasic patients during matching-to-sample tests. *Neuropsychologia, 10*, 179–184. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/5055223>.
- Lashley, K. S. (1938). Conditional reactions in the rat. *The Journal of Psychology, 6*, 311–324. doi: 10.1080/00223980.1938.9917609
- LeBlanc, L. A., Cherup, S. M., Feliciano, L., & Sidener, T. M. (2006). Using Choice-Making Opportunities to Increase Activity Engagement in Individuals With Dementia. *American Journal of Alzheimer's Disease & other Dementias, 21*, 318–325. doi: 10.1177/1533317506292183
- LeBlanc, L. A., Raetz, P. B., & Feliciano, L. (2011). Behavioral Gerontology. In W. W. Fisher, C. C. Piazza & H. S. Roane (Eds.), *Handbook of Applied Behavior Analysis* (pp. 472–486). New York, NY: The Guilford Press.
- Leicester, J., Sidman, M., Stoddard, L. T., & Mohr, J. P. (1969). Some determinants of visual neglect. *Journal of Neurology, Neurosurgery, and Psychiatry, 32*, 580–587. Retrieved from <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC496593/>.
- Leirer, V. O., Morrow, D. G., Sheikh, J. I., & Pariante, G. M. (1990). Memory skills elders want to improve. *Experimental Aging Research, 16*, 155–158. doi: 10.1080/07340669008251544
- Lian, T., & Arntzen, E. (2011). Training conditional discriminations with fixed and titrated delayed matching-to-sample in children. *European Journal of Behavior Analysis, 12*, 173–193. Retrieved from <http://www.ejoba.org/>.

- Mackay, H. A. (1991). Conditional stimulus control. In I. H. Iversen & K. A. Lattal (Eds.), *Experimental analysis of behavior, part 1* (pp. 301–350). Amsterdam, The Netherlands: Elsevier.
- McIlvane, W. J., Serna, R. W., Dube, W. V., & Stromer, R. (2000). Stimulus control topography coherence and stimulus equivalence: Reconciling test outcomes with theory. In J. C. Leslie & D. E. Blackman (Eds.), *Experimental and applied analysis of human behavior* (pp. 85–110). Reno, NV: Context Press.
- Mebane-Sims, I. (2009). 2009 Alzheimer's disease facts and figures. *Alzheimer's & Dementia*, 5, 234–270. doi: 10.1016/j.jalz.2009.03.001
- Moore, J. (2008). *Conceptual foundations of radical behaviorism*. Cornwall-on-Hudson: Sloan Pub.
- Morgan, R. E., & Riccio, D. C. (1998). Memory retrieval processes. In W. O'Donohue (Ed.), *Learning and Behavior Therapy* (pp. 464–482). Needham Heights, MA: Allyn and Bacon.
- Nartey, R., Arntzen, E., & Fields, L. (2014). Two discriminative functions of meaningful stimuli that enhance equivalence class formation. *The Psychological Record*, 64, 777–789. doi: 10.1007/s40732-014-0072-5
- Nevin, J. A., Davison, M., Odum, A. L., & Shahan, T. A. (2007). A theory of attending, remembering, and reinforcement in delayed matching to sample. *Journal of the Experimental Analysis of Behavior*, 88, 285–317. doi: 10.1901/jeab.2007.88-285
- O'Bryant, S. E., Humphreys, J. D., Smith, G. E., Ivnik, R. J., Graff-Radford, N. R., Petersen, R. C. et al. (2008). Detecting dementia with the mini-mental state examination in highly educated individuals. *Archives of Neurology*, 65, 963–967. doi: 10.1001/archneur.65.7.963
- Ortu, D., Skavhaug, I. M., & Vaidya, M. (2013). Timescales of learning in the basal ganglia and the hippocampus. *Frontiers in Behavioral Neuroscience*, 7, 98. doi: 10.3389/fnbeh.2013.00098
- Palmer, D. (1991). A behavioral interpretation of memory In L. J. Hayes & P. N. Chase (Eds.), *Dialogues on verbal behavior: The first international institute on verbal relations* (pp. 261–279). Reno, NV: Context Press.
- Palmer, D. (2010). Behavior under the microscope: Increasing the resolution of our experimental procedures. *The Behavior Analyst*, 33, 37–45. Retrieved from <http://www.ncbi.nlm.nih.gov/pmc/journals/557/>.

- Pasi, M., Poggesi, A., & Pantoni, L. (2011). The use of CT in dementia. *International Psychogeriatrics*, *23*, 6–12. doi: 10.1017/S1041610211000950
- Pérez-González, L. A., & Moreno-Sierra, V. (1999). Equivalence class formation in elderly persons. *Psicothema*, *11*, 325–336. Retrieved from <http://www.redalyc.org/articulo.oa?id=72711208>.
- Pilgrim, C., & Galizio, M. (1996). Stimulus equivalence: A class of correlations, or a correlation of classes? In T. R. Zentall & P. Smeets (Eds.), *Stimulus class formation in humans and animals* (pp. 173–195). New York, NY: Elsevier Science.
- Prince, M., Bryce, R., Albanese, E., Wimo, A., Ribeiro, W., & Ferri, C. P. (2013). The global prevalence of dementia: A systematic review and metaanalysis. *Alzheimer's & Dementia*, *9*, 63–75.e62. doi: 10.1016/j.jalz.2012.11.007
- Ray, B. A. (1969). Selective attention: the effects of combining stimuli which control incompatible behavior1. *Journal of the Experimental Analysis of Behavior*, *12*, 539–550. doi: 10.1901/jeab.1969.12-539
- Richardson, H. E., & Glass, J. N. (2002). A Comparison of scoring protocols on the clock drawing test in relation to ease of use, diagnostic group, and correlations with Mini-Mental State examination. *Journal of the American Geriatrics Society*, *50*, 169–173. doi: 10.1046/j.1532-5415.2002.50024.x
- Rosen, I. (1997). Electroencephalography as a diagnostic tool in dementia. *Dementia and Geriatric Cognitive Disorders*, *8*, 110–116. doi: 10.1159/000106615
- Rosenberger, P. B., Mohr, J. P., Stoddard, L. T., & Sidman, M. (1968). Inter- and intramodality matching deficits in a syphasic youth. *Archives of Neurology*, *18*, 549–562. doi: 10.1001/archneur.1968.00470350107010
- Rowson, R. (2006). *Working ethics: How to be fair in a culturally complex world*. London, UK: Jessica Kingsley Publishers.
- Sahgal, A. (1996). The neuroanatomical basis of cognitive deficits in Lewy body dementia. In R. Perry, I. McKeith & E. Perry (Eds.), *Dementia with Lewy Bodies: Clinical, Pathological, and Treatment Issues* (pp. 114–144). New York, NY: Cambridge University Press.
- Santi, A. (1978). The role of physical identity of the sample and correct comparison stimulus in matching-to-sample paradigms. *Journal of the Experimental Analysis of Behavior*, *29*, 511–516. doi: 10.1901/jeab.1978.29-511

- Saunders, R. R., Chaney, L., & Marquis, J. G. (2005). Equivalence class establishment with two-, three-, and four-choice matching to sample by senior citizens. *The Psychological Record, 55*, 539–559. Retrieved from <http://opensiuc.lib.siu.edu/tpr/vol55/iss4/3>.
- Saunders, R. R., & Green, G. (1999). A discrimination analysis of training-structure effects on stimulus equivalence outcomes. *Journal of the Experimental Analysis of Behavior, 72*, 117–137. doi: 10.1901/jeab.1999.72-117
- Scheckel, C. L. (1965). Self-adjustment of the interval in delayed matching: Limit of delay for the Rhesus monkey. *Journal of Comparative and Physiological Psychology, 59*, 415–418. doi: 10.1037/h0022058
- Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). *Experimental and quasi-experimental designs for generalized causal inference*. Boston, New York: Houghton Mifflin Company.
- Sidman, M. (1960). *Tactics of scientific research: Evaluating experimental data in psychology*: Basic Books New York.
- Sidman, M. (1969). Generalization gradients and stimulus control in delayed matching-to-sample. *Journal of the Experimental Analysis of Behavior, 12*, 745–757. doi: 10.1901/jeab.1969.12-745
- Sidman, M. (1986). Functional analysis of emergent verbal classes. In T. Thompson & M. D. Zeiler (Eds.), *Analysis and Integration of Behavioral Units* (pp. 213–145). Hillsdale, New Jersey: Lawrence Erlbaum.
- Sidman, M. (1987). Two choices are not enough. *Behavior Analysis, 22*, 11–18.
- Sidman, M. (1990). Equivalence relations: Where do they come from? In D. E. Blackman & H. Lejeune (Eds.), *Behaviour analysis in theory and practice: Contributions and controversies* (pp. 93–114). Hillsdale, NJ, England: Lawrence Erlbaum Associates, Inc.
- Sidman, M. (1994). *Equivalence relations and behavior: A research story*. Boston: Authors Cooperative.
- Sidman, M. (2000). Equivalence relations and the reinforcement contingency. *Journal of the Experimental Analysis of Behavior, 74*, 127–146. doi: 10.1901/jeab.2000.74-127
- Sidman, M. (2013). Techniques for describing and measuring behavioral changes in Alzheimer's patients. *European Journal of Behavior Analysis, 14*, 141–149. Retrieved from <http://ejoba.org/>

- Sidman, M., Stoddard, L. T., & Mohr, J. P. (1968). Some additional quantitative observations of immediate memory in a patient with bilateral hippocampal lesions. *Neuropsychologia*, *6*, 245–254. doi: 10.1016/0028-3932(68)90023-7
- Sidman, M., & Tailby, W. (1982). Conditional discrimination vs. matching to sample: an expansion of the testing paradigm. *Journal of the Experimental Analysis of Behavior*, *37*, 5–22. doi: 10.1901/jeab.1982.37-5
- Skinner, B. F. (1938). *The Behavior of Organisms*. Acton, MA: Copley Publishing Group.
- Skinner, B. F. (1953). *Science and Human Behavior*. Upper Saddle River, New Jersey: Pearson Education, Inc.
- Smith, M. W., Sharit, J., & Czaja, S. J. (1999). Aging, motor control, and the performance of computer mouse tasks. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *41*, 389–396. doi: 10.1518/001872099779611102
- Snaedal, J., Johannesson, G. H., Gudmundsson, T. E., Blin, N. P., Emilsdottir, A. L., Einarsson, B. et al. (2012). Diagnostic accuracy of statistical pattern recognition of electroencephalogram registration in evaluation of cognitive impairment and dementia. *Dementia and Geriatric Cognitive Disorders*, *34*, 51–60. doi: 10.1159/000339996
- Snarski, M., Scogin, F., DiNapoli, E., Presnell, A., McAlpine, J., & Marcinak, J. (2011). The Effects of Behavioral Activation Therapy With Inpatient Geriatric Psychiatry Patients. *Behavior Therapy*, *42*, 100–108. doi: 10.1016/j.beth.2010.05.001
- Spain, P. E. J., Raaijmakers, J. G. W., & Jonker, C. (2005). Early Assessment of Dementia: The Contribution of Different Memory Components. *Neuropsychology*, *19*, 629–640. doi: 10.1037/0894-4105.19.5.629
- Spencer, T. J., & Chase, P. N. (1996). Speed analyses of stimulus equivalence. *Journal of the Experimental Analysis of Behavior*, *65*, 643–659. doi: 10.1901/jeab.1996.65-643
- Spering, C. C., Hobson, V., Lucas, J. A., Menon, C. V., Hall, J. R., & O'Bryant, S. E. (2012). Diagnostic accuracy of the MMSE in detecting probable and possible Alzheimer's disease in ethnically diverse highly educated individuals: an analysis of the NACC database. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, *67*, 890–896. doi: 10.1093/gerona/gls006
- Steingrimsdottir, H. S., & Arntzen, E. (2011a). Identity matching in a patient with Alzheimer's disease. *American Journal of Alzheimer's Disease and Other Dementias*, *26*, 247–253. doi: 10.1177/1533317511402816

- Steingrimsdottir, H. S., & Arntzen, E. (2011b). Using conditional discrimination procedures to study remembering in an Alzheimer's patient. *Behavioral Interventions*, *26*, 179–192. doi: 10.1002/bin.334
- Steingrimsdottir, H. S., & Arntzen, E. (2014a). Discrimination learning in adults with neurocognitive disorders. *Behavioral Interventions*, 241–252. doi: 10.1002/bin.1389
- Steingrimsdottir, H. S., & Arntzen, E. (2014b). Performance by older adults on identity and arbitrary matching-to-sample tasks. *The Psychological Record*, 1–13. doi: 10.1007/s40732-014-0053-8
- Steingrimsdottir, H. S., & Arntzen, E. (accepted). On the Utility of Within-Participant Research Design when Working with Patients with Neurocognitive Disorders. *Journal of Clinical Interventions in Aging*.
- Steingrimsdottir, H. S., & Arntzen, E. (submitted). Eye-Movements During Conditional Discrimination Learning.
- Steis, M. R., & Schrauf, R. W. (2009). A review of translations and adaptations of the minimal state examination in languages other than English and Spanish. *Research in Gerontological Nursing*, *2*, 214–224. doi: 10.3928/19404921-20090421-06
- Stoddard, L. T., & Sidman, M. (1971). The removal and restoration of stimulus control. *Journal of the Experimental Analysis of Behavior*, *16*, 143–154. doi: 10.1901/jeab.1971.16-143
- Szoeke, C. E. I., Campbell, S., Chiu, E., & Ames, D. (2009). Vascular Cognitive Disorder. In M. F. Weiner & A. M. Lipton (Eds.), *Textbook of Alzheimer Disease and Other Dementias* (pp. 181–194). Washington, DC: American Psychiatric Publishing, Inc.
- Tarawneh, R., & Galvin, J. E. (2009). Dementia with Lewy Bodies and other synucleinopathies. In M. F. Weiner & A. M. Lipton (Eds.), *Textbook of Alzheimer Disease and Other Dementias* (pp. 195–218). Washington, DC: American Psychiatric Publishing, Inc.
- Teipel, S. J., Grothe, M., Lista, S., Toschi, N., Garaci, F. G., & Hampel, H. (2013). Relevance of magnetic resonance imaging for early detection and diagnosis of Alzheimer disease. *The Medical Clinics of North America*, *97*, 399–424. doi: 10.1016/j.mcna.2012.12.013
- Terrace, H. S. (1966). Stimulus control. In W. K. Honig (Ed.), *Operant Behavior: Areas of Research and Application* (pp. 271–344). New York: Appleton-Century-Crofts.
- Thies, W., & Bleiler, L. (2013). 2013 Alzheimer's disease facts and figures. *Alzheimer's & Dementia: The Journal of the Alzheimer's Association*, *9*, 208–245. doi: 10.1016/j.jalz.2013.02.003

- Tombaugh, T. N., & McIntyre, N. J. (1992). The mini-mental state examination: a comprehensive review. *Journal of American Geriatrics Society*, *40*, 922–935. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/1512391>
- Trahan, M. A., Donaldson, J. M., McNabney, M. K., & Kahng, S. (2014). Training and maintenance of a picture-based communication response in older adults with dementia. *Journal of Applied Behavior Analysis*, *40*, 404–409. doi: 10.1002/jaba.111
- Trahan, M. A., Kahng, S. W., Fisher, A. B., & Hausman, N. L. (2011). Behavior-analytic research on dementia in older adults. *Journal of Applied Behavior Analysis*, *44*, 687–691. doi: 10.1901/jaba.2011.44-687
- Tripp, G., & Alsop, B. (1999). Age-related changes in sensitivity to relative reward frequency. *New Zealand Journal of Psychology*, *28*, 30–36. Retrieved from <https://www.questia.com/library/journal/1G1-55805876/age-related-changes-in-sensitivity-to-relative-reward>.
- Urcuioli, P. J., & Zentall, T. R. (1986). Retrospective coding in pigeons' delayed matching-to-sample. *Journal of Experimental Psychology: Animal Behavior Processes; Journal of Experimental Psychology: Animal Behavior Processes*, *12*, 69–77. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/3701260>.
- Urcuioli, P. J., Zentall, T. R., Jackson-Smith, P., & Steirn, J. N. (1989). Evidence for common coding in many-to-one matching: Retention, intertrial interference, and transfer. *Journal of Experimental Psychology: Animal Behavior Processes*, *15*, 264–273. Retrieved from <http://psycnet.apa.org/index.cfm?fa=buy.optionToBuy&id=1989-35478-001>.
- Wang, G., & Kameda, S. (2005). Event-related potential component associated with the recognition of three-dimensional objects. *Neuroreport*, *16*, 767–771. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/15858422>.
- Weiler, J. A., Bellebaum, C., & Daum, I. (2008). Aging affects acquisition and reversal of reward-based associative learning. *Learning & Memory*, *15*, 190–197. doi: 10.1101/lm.890408
- Weiner, M. F. (2009). Dementia and Alzheimer Disease. In M. F. Weiner & A. M. Lipton (Eds.), *Textbook of Alzheimer Disease and Other Dementias* (pp. 3–16). Washington, DC: American Psychiatric Publishing, Inc.
- Whelan, R. (2008). Effective analysis of reaction time data. *The Psychological Record*, *58*, 475–482. Retrieved from <http://opensiuc.lib.siu.edu/tpr/vol58/iss3/9>.

- White, K. G. (2013). Remembering and Forgetting. In G. J. Madden, W. V. Dube, T. D. Hackenberg, G. P. Hanley & K. A. Lattal (Eds.), *APA handbook of behavior analysis, Vol. 1: Methods and principles* (pp. 411–437). Washington, DC, US: American Psychological Association.
- Wilson, K. M., & Milan, M. A. (1995). Age differences in the formation of equivalence classes. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, *50*, 212–218. doi: 10.1093/geronb/50B.4.P212
- Zentall, T. R., & Smeets, P. M. (Eds.). (1996). *Stimulus Class Formulation in Humans and Animals*. Amsterdam, N.: Elsevier.
- Zygmunt, D. M., Lazar, R. M., Dube, W. V., & McIlvane, W. J. (1992). Teaching arbitrary matching via sample stimulus-control shaping to young children and mentally retarded individuals: a methodological note. *Journal of the Experimental Analysis of Behavior*, *57*, 109–117. doi: 10.1901/jeab.1992.57-109

Errata

Page 5, line 20

On the other hand, there are still few studies within the area of...

Is changed to:

On the other hand, there are still only few studies within the area of...

Page 8, line 15-16

...the first symptoms may be a incapacitated ability...

Is changed to:

...the first symptoms may be an incapacitated ability

Page 9, line 23

Another neuropsychological test is the clock drawing test...

Is changed to:

Another neuropsychological test is the clock-drawing test...

Page 10, line 7

...methods of the clock drawing test.

Is changed to:

...methods of the clock-drawing test.

Page 10, line 11

...test is much more time consuming than the MMSE and the clock drawing test and takes about...

Is changed to:

...test is much more time consuming than the MMSE and the clock-drawing test and takes about...

Page 17, line 11

...presented with visual comparison stimuli ...

Is changed to:

...presented with visual comparison stimuli ...

Page 24, line 15

...simultaneous (SP)...

Is changed to:

...simultaneous protocol (SP)...

Page 24, line 22

...(BA, CB) and the transitivity test (AC).

Is changed to:

...(BA, CB) and the transitivity trials (AC).

Page 34, line 7

...(2.134 vs. 3.782 seconds)...

Is changed to:

...(2.134 vs. 3.782 seconds)...

Page 39, line 24

First and foremost, it is of outmost importance that the experimenter...

Is changed to:

First and foremost, it is of outmost importance that the experimenters...

Page 47, line 11

...followed up by Conditions 11 and 12...

Is changed to:

...followed by Conditions 11 and 12...

Page 100, line 10

...be studied as any other operant behavior and are both important aspect of what is ...

Is changed to:

...be studied as any other operant behavior and is important aspect of what is ...

Page 101, line 5

...shorter fixation time towards ample stimulus during conditional discrimination training...

Is changed to:

...shorter fixation time towards sample stimulus during conditional discrimination training ...

Page 101, line 10

... (2010) have also showed that by training observing behavior...

Is changed to:

... (2010) also showed that by training observing behavior...

Page 103, line 23

... trial. Fixation times equal...

Is changed to:

... trial). Fixation times equal...

Page 104, line 10

Experimenter started by showing the participant the room where the two computers....

Is changed to:

Experimenter. Experimenter started by showing the participant the room where the two computers....

Page 108, line 22

...during testing.

Is changed to:

...during testing (Figure 6).

Page 108, line 23

...with a stepwise decrease in both behaviors during testing...

Is changed to:

...with a stepwise decrease in both behaviors during training...

Page 109, line 21

...fewer positive reinforcer presented for each baseline conditional discrimination trial...

Is changed to:

...fewer positive programmed consequences for each baseline conditional discrimination trial...

Page 112, line 19

...number of reinforcer presented before...

Is changed to:

...number of reinforcers presented before...

Page 113, line 19

...discrimination behavior in these populations (and that would be of great applied value).

Is changed to:

...discrimination behavior in these populations.