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Signal Detection in Older Individuals with Neurocognitive Disorder

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SIGNAL DETECTION IN OLDER INDIVIDUALS WITH NEUROCOGNITIVE DISORDER

by

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TITLE: SIGNAL DETECTION IN OLDER INDIVIDUALS WITH NEUROCOGNITIVE DISORDER

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Abstract

Past research has been inconclusive when assessing older individuals and their responding on stimulus equivalence tasks. Therefore, the purpose of this study was to assess the ability of individuals with neurocognitive disorder (NCD) to detect the presence of a stimulus when presented along with varying amounts of distracter stimuli or “noise”. In this study, two older female participants, ages 71 and 84, with NCD, were asked to participate in a computer based task designed using a visual signal detection procedure. This procedure consisted of three parts, each presented elctronically using a computer and designed to assess their ability to percieve the presense or lack of a visual stimulus, a red circle, when also presented with several distractor stimuli. It was hypothesized that the performance of older individuals would decline when presented with increased “noise” levels.

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CHAPTER 1

INTRODUCTION

For some, one of the difficult issues related to aging is increasing deficits in an individual's memory, and when this impacts a person's ability to function day to day, a diagnosis of Major or Minor neurocognitive disorder (NCD) may be needed (American Psychiatric Association, 2013). As individuals age, the likelihood that they may develop some form of NCD increases, ranging from between 2 to 4 percent for individuals over 65 years old, and increasing to 20 percent when they reach 85 years or older (Steingrimsdottor & Arntzen, 2011a). These memory issues do not just affect the individual with the disorder, but also the friends, family, or other caregivers that may be impacted by the decline in cognitive functioning (Camp, Foss, O'Hanlon, & Stevens, 1996). As such, a great amount of research has been conducted in attempt to identify cognitive deficits as soon as possible.

Current assessments and diagnostic tools used for NCD, such as the Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975), are designed utilizing a knowledge-based approach, which require the individual to be aware of some prior knowledge in order to appropriately answer the questions presented to them. Past research has also shown that the MMSE has limitations when the individual is suspected of having only mild NCD (Gallagher & Keenan, 2009). Given these limitations, other researchers have suggested that stimulus equivalence offers a possible opportunity to assess for the same disorder or general cognitive decline, while also eliminating the additional confound of past education and knowledge (Gallagher & Keenan, 2009). Little research has been done with older individuals in regards to both stimulus equivalence and signal detection, and even less for older individuals with NCD. The following review will cover some of the changes that occur among older adults with NCD followed by research on stimulus equivalence and how it is being used to assess impairment among older adults with NCD. Finally, I will discuss how signal detection might be used to strengthen current research into stimulus equivalence as an assessment for cognitive impairment among older adults with NCD.

Neurocognitive Disorder

NCD (formerly known as Dementia) is a term used to cover a variety of symptoms related to a decline in the mental functioning of an individual which leads to difficulty in completing tasks related to daily living. As of 2014, Alzheimer's disease is the most common form, making up 60 to 80 percent of all cases (Alzheimer's Association).

The mental decline caused by NCD is not the same as the typical memory loss associated with natural aging. According to the Diagnostic and Statistical Manual of Mental Disorders (DSM-5), in order for mental decline to be considered major NCD the individual must meet the following criteria: there must be evidence of decline in cognitive function from past performance in one or more areas of cognition such as complex attention, executive functioning, language, social cognition, and learning or memory; additionally, the deficits in cognitive functioning must interfere with daily living skills and must not be caused simply due to a case of delirium (American Psychiatric Association, 2013). The DSM-5 also requires that the cognitive deficits are not reasonably explained by other mental disorders (American Psychiatric Association, 2013). Mild NCD is another possible diagnosis that can reveal an impact on an individual's cognitive function and includes all the criteria of major NCD, except that the cognitive impairment does not interfere with daily living skills (American Psychiatric Association, 2013). In addition to the possible decline in mental functioning as an individual ages, he or she could also begin to experience several deficits in sensory functioning, particularly in the areas of vision, such as tasks related to detecting changes in location, orientation, and low-salience stimuli when placed with distracters or other "visual noise" (McCarley, Yamani, Kramer, & Mounts, 2012).

NCD is currently assessed using tools such as the MMSE. There are benefits to using the MMSE, two of these benefits are the speed and ease at which it can be administered (Steingrimsdottor & Arntzen, 2011b). However, these tools have been criticized in the past. The MMSE specifically has been reported as not being sensitive enough to detect mild cases of dementia, and that the questions presented are not balanced when assessing for NCD (Gallagher & Keenan, 2009). Due to this limitation, the need to utilize other diagnostic tools along with the MMSE has been recommended (Steingrimsdottor & Arntzen, 2011a).

Stimulus Equivalence

Given the limitations of the current assessments for NCD, researchers have started to look for alternative methods that could lead to more reliable assessment tool, and one such method is stimulus equivalence (Gallagher & Keenan, 2009). Past studies have looked at the ability of older individuals with NCD to achieve the various components of stimulus equivalence including: reflexivity, symmetry, and transitivity. This is often done through the use of tests designed utilizing various types of match-to-sample procedures. Stimulus equivalence occurs when the function of one stimulus is transferred to a second stimulus, which now elicits a similar response from the individual (Saunders, Chaney, & Marquis, 2005). Stimulus equivalence is said to emerge if an individual is trained using a series of match-to-sample presentations, which use conditional discrimination tasks, so that if stimulus A is related to stimulus B and if stimulus B is related to stimulus C, then stimulus A must be related to stimulus C, despite the fact this final relationship is not directly trained (Saunders et al., 2005). This training can occur at varying degrees of delay, often depending on the use of memory as a variable under study. Although a great number of studies have focused on stimulus equivalence, relatively few have included older adults as participants. Those studies have generally focused on either the effects of the delay between stimulus presentation and the opportunity to respond, or on the number of stimuli used.

Wilson and Milan (1995) were among the first to study stimulus equivalence among older adults. They completed a study using 40 participants, with ages ranging from 19 to 22 and 62 to 81, all with scores in the normal range on the MMSE. The authors presented a series of visual stimuli, in the form of Greek letters, training the A to B and A to C relations (Wilson & Milan, 1995). Older participants were found to perform at levels below that of young participants in their ability to form equivalences classes and their response latency (Wilson & Milan, 1995). Given the differences in performance between older adults and other age groups, other researchers began to study older adult performance.

In their first experiment, Perez-Gonzalez and Moreno-Sierra (1999) found that older participants, above the age of 65, were able to achieve stimulus equivalence; however they made more errors across training and testing phases when compared to younger participants, age 64 and younger. In this experiment, participants were trained using A to B and B to C relations, using visual stimuli consisting of six different shapes including circles, triangles, squares, crosses, stars, and swirls (Perez-Gonzalez & Moreno-Sierra, 1999). In a second experiment, two older participants, one 73 and the other 65, were exposed to similar procedures to experiment one, except for the sample stimulus presented. This second experiment was designed to attempt to reduce the number of errors achieved in the first experiment, however, the participants made a similar number of errors as those in the first experiment (Perez-Gonzalez & Moreno-Sierra, 1999).

Saunders et al. (2005) used several types of match-to-sample configurations to test class establishment in 12 older participants, between the ages of 56 and 89, including 2 item, 3 item and 4 item choice match-to-sample procedures. This procedure was used to test predictions made by Sidman (as cited in Saunders et al., 2005), and to assess the use of multiple structures of match-to-sample procedure including one-to-many and many-to-one (Saunders et al., 2005). The authors found that the 3 and 4 item choice methods were no better at class formation when compared with the 2 item version, and the researchers were only able to achieve class formation once with the 2 item choice (Saunders et al., 2005). This study provides support that presenting more stimuli as comparisons do not aid in the formation of stimulus classes among older adults.

A study conducted by Gallagher and Keenan (2009) consisted of 18 participants, between the ages of 67 and 94, that were exposed to a series of arbitrary symbols and nonsense syllables which were paired in A to B, B to C, and A to C combinations. The authors found that individuals who scored 27 or higher on the MMSE were capable of displaying stimulus equivalence, while only one participant with an MMSE score below 27, a score of 26, was able to display equivalence (Gallagher & Keenan, 2009). Six participants, with MMSE scores ranging from 23 to 27, were unable to achieve symmetry (Gallagher & Keenan, 2009).

Steingrimsdottor and Arntzen (2011a) conducted a study with a single male participant, age 80 with a diagnosis of Alzheimer's Disease, and the authors utilized a computerized match-to-sample procedure that was designed to assess the efficacy of increasing numbers of comparison stimuli in identity match-to-sample tasks. This study consisted of four conditions with each condition including novel stimuli for the target stimulus and the comparison stimuli, which changed throughout. The first two conditions included three possible comparison stimuli and the second two conditions decreased the number of stimuli to two (Steingrimsdottor & Arntzen, 2011a). Steingrimsdottor and Arntzen (2011a) found that by increasing the amount of comparison stimuli from two to three resulted in more incorrect responses on identity match-to-sample procedures for an individual with NCD, and correct responses did not surpass chance levels, even with a 0-second prompt delay.

In a second study, Steingrimsdottor and Arntzen (2011b) presented an 84 year old woman with a diagnosis of Alzheimer's Disease, a series of arbitrary and identity match-to-sample procedures, as well as varied the delay from 0 seconds up to 9 seconds. This study consisted of three phases. In phase one, an arbitrary match-to-sample task involved A to B relation training, followed by B to C relations, and lastly, a series of A to C relations with program consequences set at 100%. Phase two was a similar procedure; however, the percentage of programmed consequences was set to 0%. The third phase was an identity match-to-sample procedure training A to A, B to B, and C to C relations, followed by the same adjustments made to the programmed consequences as phases one and two (Steingrimsdottor & Arntzen, 2011b). Four experimental conditions were included in this study with conditions one and two setting the number of comparison stimuli at two, during condition three the number was set to three, and condition four consisted of three comparison stimuli and an increasing time delay, starting at 0 seconds, then increasing to 3 seconds, 6 seconds, and 9 seconds (Steingrimsdottor &Arntzen, 2011b). The authors found that while the participant could respond accurately to an identity match-to-sample procedure, when the images are exactly the same, the participant was unable to respond accurately when presented with an arbitrary match to-sample procedure.

The studies completed by Steingrimsdottor and Arntzen (2011a and 2011b) included individuals with NCD, while the study done by Saunders et al., (2005) included individuals over the age of 55 but excluded individuals who took medications, or had medical conditions that could affect memory or learning. The inconsistent results of past research that should be considered in future research include the effects of reinforcement on responding, the effect of the number of comparison stimuli, and the effects of delay on response accuracy. These are limitations that a procedure based on signal detection theory can help address.

Signal Detection

Signal detection theory is an analysis of the discrimination of various wavelengths, visual or auditory, and the effects that immediate feedback, in the form of either reinforcement or punishment, has on correct and incorrect responding (Nevin, 1969). In a signal detection preparation, there are four dependent variables, classified as a *Hit*, *Miss*, *Correct Rejection*, and *False Alarm*. A *Hit* occurs when the participant indicates that he or she saw the stimulus when it was in fact on the screen. *False Alarm* occurs when the participant indicates that he or she saw the stimulus when it was in fact not visible on the screen. *Correct Rejection* occurs when the participant indicates that he or she did not see the stimulus when it was in fact not on the screen. A *Miss* occurs when the participant indicates that he or she did not see the stimulus when it was in fact visible on the screen. While most studies related to signal detection theory focus on auditory stimuli, past research has found deficits in older individuals related to areas such as pure-tone hearing thresholds, temporal gap detection, and the processing of speech (DeLoss et al., 2013). Past research has also shown a decline in several areas related to vision, including visual acuity, discrimination of texture, and discrimination of stimulus orientation (DeLoss et al., 2013). As noted earlier in the section on NCD, as people age, interference or “noise” often causes more *False Alarms* and *Misses* on selective visual attention tasks when compared to younger counterparts (Guerreiro et al., 2010). White (1999) found that responding in a choice situation is contingent on the ability to discriminate the stimuli that are present, and through this ability to discriminate, a history of reinforcement can develop. Aging related changes in vision and visual perception have been found to be exacerbated among those with NCD (Archibald, Clarke, Mosimann, & Burn, 2011). As such, signal detection protocols that focus on visual stimuli are a relatively simple, yet effective way to ensure that visual changes are not a factor in the differential scores found by Gallagher and Keenan (2009) and others who have studied stimulus equivalence among older adults with NCD.

As noted above, most signal detection research focuses on auditory stimuli, but a few studies have included visual stimuli and provide a methodological basis for studying visual stimuli among older adults. In a study conducted by Alsop and Rowley (1996), the authors utilized three illuminated lights which used red and green lights as well as lines presented at varying orientations. The researchers found that increases in the ratio of reinforcement did not necessarily lead to increases in stimulus discrimination (Alsop & Rowley, 1996). Furthermore, past research has found that as the number of possible stimulus presentations increases, the likelihood of a false alarm increases (Critchfield, 1994). Tripp and Alsop (1999) completed a study with 94 participants, 32 children, between the ages of 8 and 9, 31 young adults, ages 18 to 26, and 31 older adults, ages 66 to 89. In this study, the researchers presented two types of visual stimuli; easy, which consisted of colored circles or squares, and hard, which adjusted the ratio of the shapes presented (Tripp & Alsop, 1999). The authors found that older individuals did not display a response bias towards reinforcement like the younger participants, and this decrease in response bias increased as the age of the participants increased, with younger participants showing a greater level of bias; furthermore, reaction times for participants also decreased as the age levels increased (Tripp & Alsop, 1999).

Other research with older individuals has shown that a denser rate of reinforcement could lead elderly participants to respond more rapidly, and more frequently, to a specific condition (Plaud, Gillund, & Ferraro, 2000). Plaud et al. (2000) completed a study with seven older individuals, between the ages of 62 and 74, none of which were diagnosed with NCD. Each participant was asked to press one key when they saw a white circle appear on a computer screen and another key when they saw a red letter, and a blackout procedure was included as well that would extend if the participant pressed a key during the intertrial intervals (Plaud et al., 2000). Plaud et al. found that the use of a signal detection procedure greatly reduced the number of false alarms, and that approximately two thirds of the participants responded more frequently on the schedule with the greater density of reinforcement. Although bias is important and can play a role in responding, when the contingencies are held fairly constant, researchers can evaluate signal detection in its own right. For the present study, this review will focus on signal discrimination rather than bias.

Purpose

It is important to return to the assessment of prerequisite skills when faced with the inconsistent results of previous research. This is even more relevant with an aging population who experience age related sensory changes, particularly vision, that would impact signal detection and could play a very important role in the inconsistent results in past stimulus equivalence studies. To date, no studies on stimulus equivalence have addressed a participant's vision as a possible factor in their performance on the task or described the level of visual capabilities of their participants. Therefore, the current study will include a basic assessment of each participant's visual capabilities. This can increase the potential effectiveness of stimulus equivalence as an assessment tool be reducing the impact of a possible confound. The purpose of this study is to assess the ability of an individual with NCD to detect the presence of a stimulus when presented along with several distracter stimuli, and to assess if increasing the number comparison stimuli act as a hindrance for older participants on visual tasks.

CHAPTER 2
METHODS

Participants and Setting

Two older adult females, with NCD, ages 71 and 84, were recruited from local area assisted living facilities and supported living facilities. All sessions were conducted on site, in either a conference room or any private room. In order to be included in the study, the participant had to meet certain visual requirements. Specifically, the individual had to capable of viewing the computer screen at a distance of approximately two feet, with or without corrective lenses. The participant was also able capable of physically interacting with the touch screen with at least one hand.

Materials

Mini Mental Status Exam (MMSE). The MMSE was developed by Folstein et al. (1975), and is used to assess a variety of cognitive impairments. The MMSE is rated on a scale from 0 – 30, and is divided into sections that each assess different areas of cognitive skills. Cognitive impairment is indicated by a score below 24. The score reflects the degree of cognitive impairment, thus a lower score is indicative of a higher degree of impairment. It has been suggested that this score may adjusted based upon age and level of academic completion.

The researcher used the MMSE to assess for any cognitive impairment that may be present. Scores on this assessment will range based upon the severity of cognitive impairment, and participants will not be excluded based upon their score on this assessment. This score was adjusted to compensate for age of the participant and highest level of education completed. The MMSE was not administered to the participants of the pilot study due to the assessment being done as part of the larger study. The data from the larger study were utilized for the current study, Participant 1 had an MMSE score of 10 and Participant 2 had a score of 15.

Paired stimulus preference assessment. Similar to the MMSE, the researcher used preference assessment data from a larger study. In the larger study, the researcher conducted a pictorial paired stimulus preference assessment (DeLeon & Iwata, 1996), utilizing the responses generated during the PES-AD. The stimuli used for the participants were pictures of horses for Participant 1 and pictures of men for Participant 2.

Signal Detection Software. The Signal Detection software was designed by this author, and consists of a series of six presentation series of the target stimulus with varying amounts of distracter stimuli. This program was designed using Microsoft Visual Express® 2012.

Dependent Variables

Response latency. Response latency was recorded by the signal detection software for each button press. Latency was defined as the time from the start of a stimulus presentation until the participant responds with a button press. The overall duration of each session was restricted to 5 minutes. These times were compared to times on version 2 and version 3 of the program. Response latency was compared across series and noise level, as well as across the various versions of the signal detection software that participant is exposed to.

Response accuracy. For accuracy, participants were able to respond in one of four ways, *Hit*, *Miss*, *Correct Rejection*, and *False Alarm*. A *Hit* occurred when the participant indicated that she saw the stimulus when it was in fact on the screen. *False Alarm* occurred when the participant indicated that she saw the stimulus when it was in fact not visible on the screen. *Correct Rejection* occurred when the participant indicates that she did not see the stimulus when it was in fact not on the screen. A *Miss* occurred when the participant indicated that she did not see the stimulus when it was in fact visible on the screen. Participants only received reinforcement for responses marked as *Hit* and *Correct Rejection*. Each participant's overall accuracy was calculated across all four categories of responses, and this score was compared with their score on other versions of the program.

Procedure

The study occurred over the course of two sessions. These two sessions occurred over the course of a single week. Session one consisted of the administration of the first two versions of the signal detection software. The software was presented to the individual to detect a participant's ability to recognize the presentation or lack of a presentation of a target stimulus. Session two was used to administer version 3 of the signal detection software.

Version 1 of the signal detection software (*Figure 1*) consisted of a set of six series of stimulus presentations in which a single target stimulus is displayed along with a varying number of distracter stimuli. The location of the target stimulus was randomized. Once a participant has responded with ten correct responses, or five minutes had elapsed, the program automatically advanced to the next series. A 5 minute break was provided to participants as needed. During this break, the researcher engaged the participant in a preferred activity. The study continued until such a time as the program was completed or the participant withdrew assent. Upon completion of version 1, participants moved into version 2 on a different day.

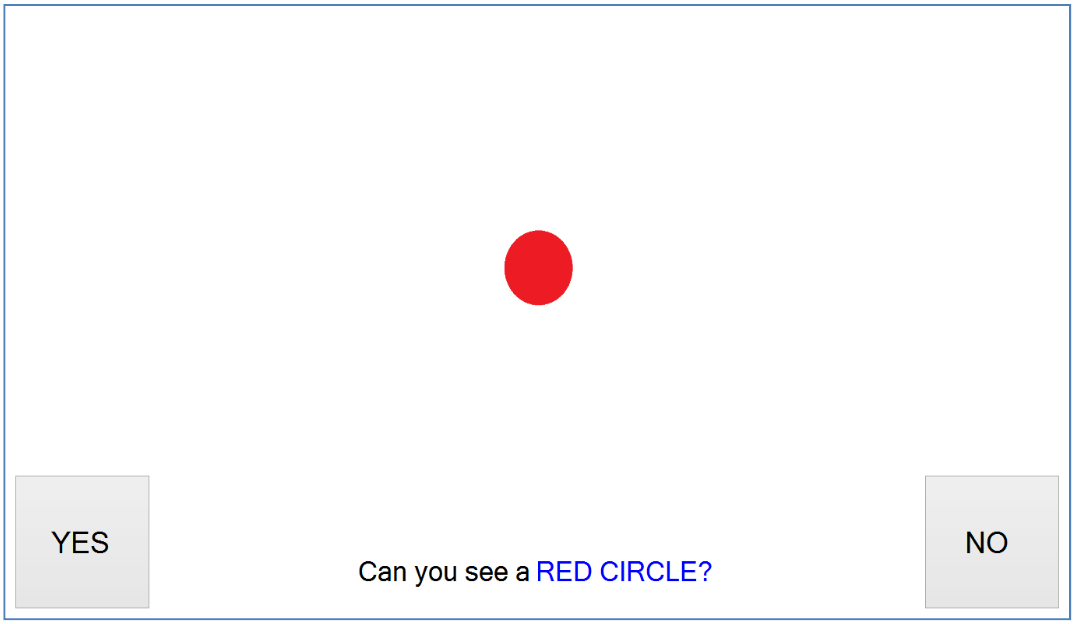

Figure 1: Series 1 for version 1 of the signal detection software.

Version 2 (*Figure 2*) was given to all individuals without regards to their performance when completing of version 1 of the program. Version 2 operated identically to version 1; however, stimuli on the screen differed. Specifically, an increased level of "noise" was added in the form of additional distracter stimuli. The five minute timer remained in place for this version.

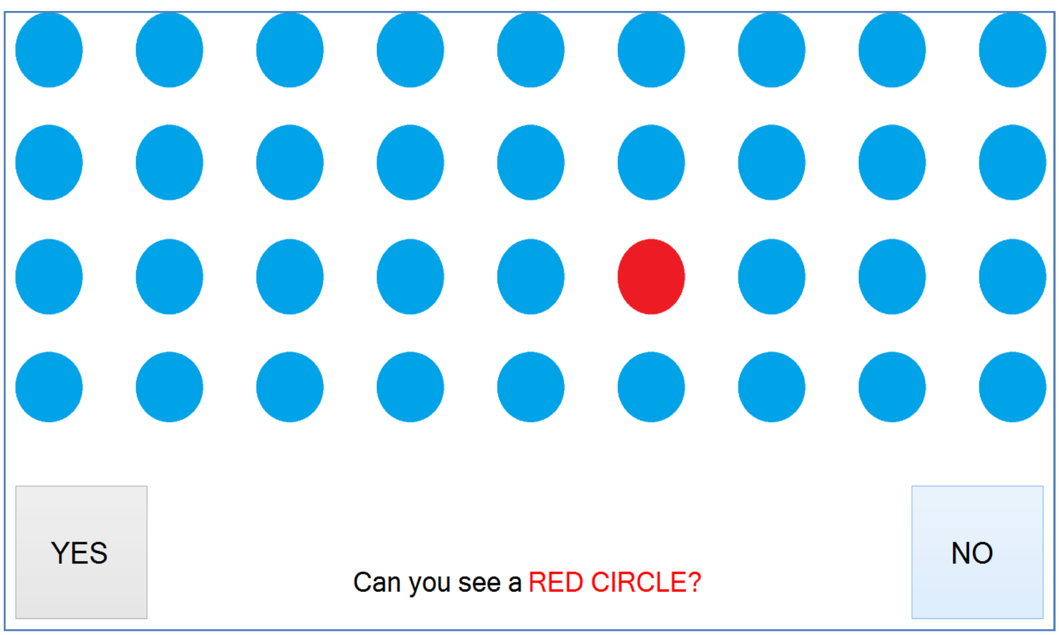

Figure 2: Series 1 for version 2 of the signal detection software.

Version 3 (*Figure 3*) was similar to the final series of version one, during which one target stimulus was presented along with five distracter stimuli. The contrast of these distracter stimuli, when compared to the target stimulus, gradually decreased with each trial until a time when the distracters and the target were identical. This version assessed the point where the participants were unable to distinguish between the two stimuli.

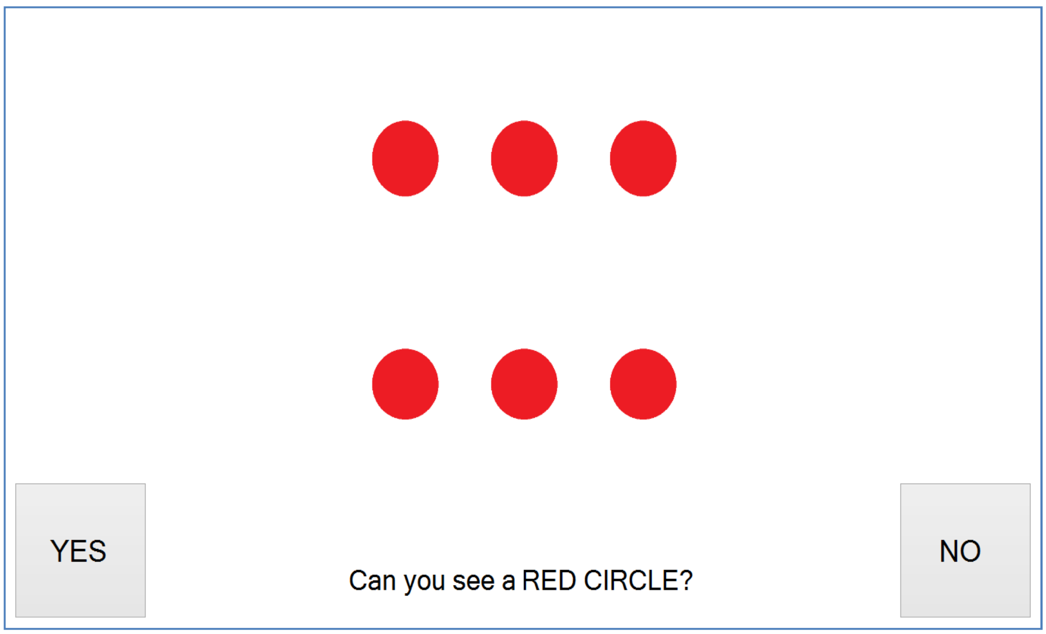

Figure 3: The final series for version 3 of the signal detection software.

CHAPTER 3

RESULTS

Response Latency

Throughout the study, Participant 1's performance speed on the task improved. During version 1, the average response latency for Participant 1 (*Figure 4*) dropped from 5.56 seconds in series one to 3.93 seconds in series six. The average response latency for Participant 1, during version 2, dropped from 4.18 seconds in series one to 2.40 seconds in series six. Her average response latency for version 3 dropped from 3.25 seconds during series one to 2.84 seconds in series five.

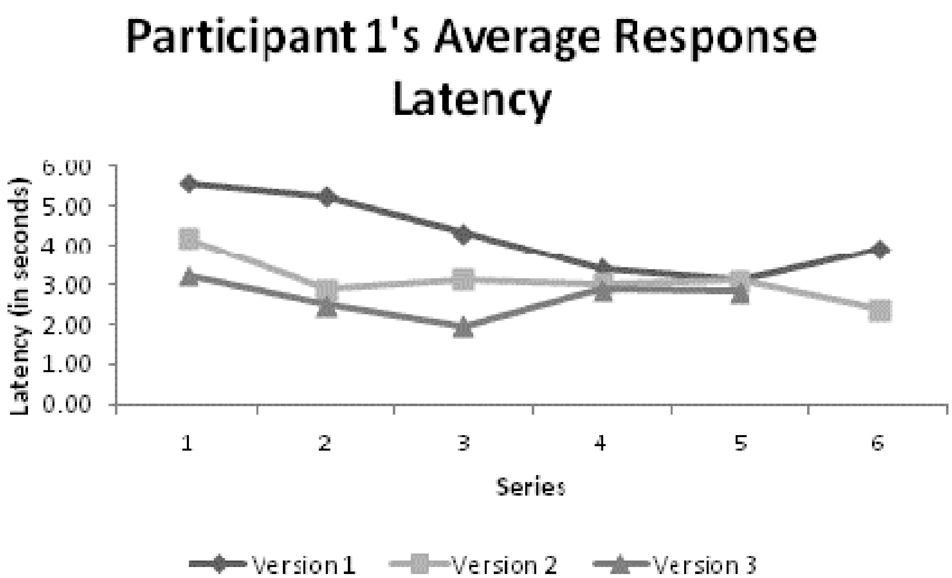

Figure 4. The average response latency for Participant 1 across each series of three versions of the program.

While Participant 1 showed an increase in speed across all three versions, Participant 2 was slowed down during versions 2 and 3, displaying a latency decrease only during version 1. During version 1, the average response latency for Participant 2 (*Figure 5*) dropped from 9.94 seconds in series one to 4.63 seconds in series six. The average response latency for Participant

2, during version 2, increased from 9.06 seconds in series one to 11.28 seconds in series six. Her average response latency for version 3 increased from 2.65 seconds in series one to 3.31 seconds during series five.

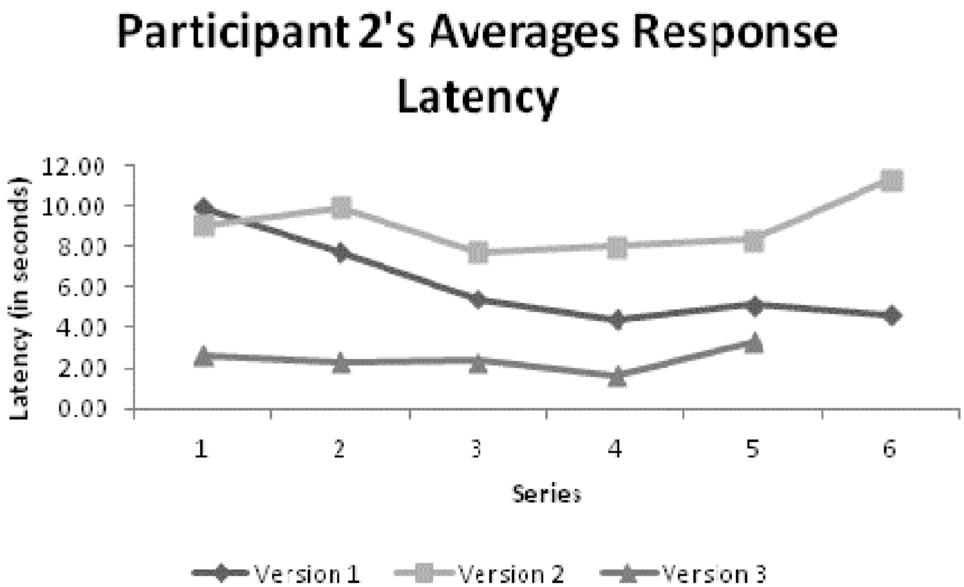

Figure 5. The average response latency for Participant 2 across each series of three versions of the program.

Response Accuracy

During version 1, for series one through three, Participant 1's accuracy for *Correct Rejection* responses was 50%, 44%, and 71% respectively, and 100% for series four through six *(Figure 6).*

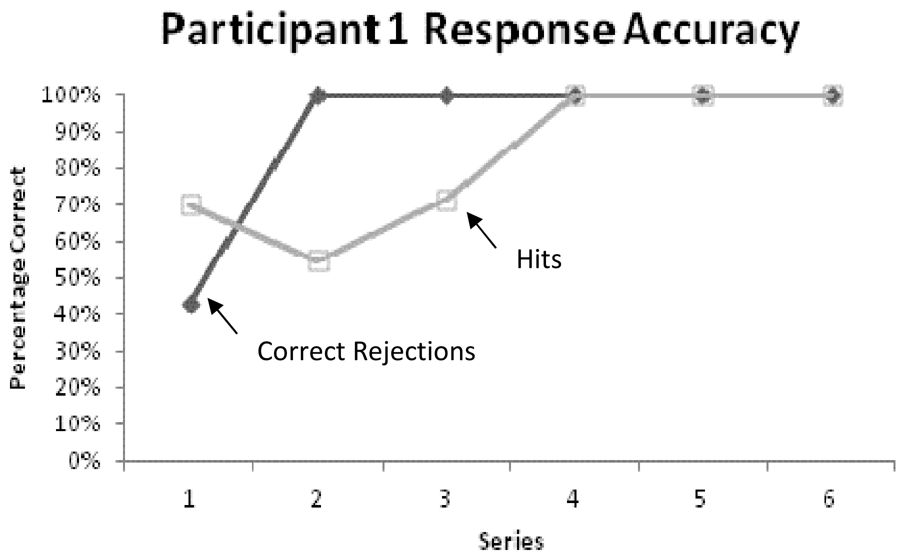

Figure 6. Participant 1's overall accuracy for version one of the signal detection software.

During version 1, Participant 1 only displayed errors during series one for the *Hit* trials, with an accuracy of 64%. Her accuracy was 100% for all subsequent series. For version 2, correct responses to *Correct Rejection* trials for series one through three, was 80%, 44%, and 71% *(Figure 7)*.

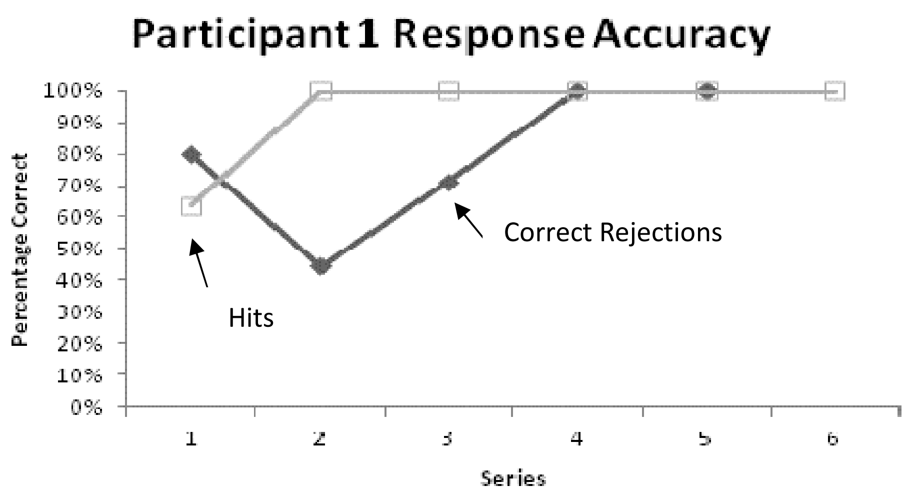

Figure 7. Participant 1's overall accuracy for version two of the signal detection software.

Once again, for series four through six, her accuracy was 100%. During Participant 1's performance for *Hit* trials, her accuracy was 64% during series one, and 100% during series two through six. For version 3, while her speed increased, Participant 1's accuracy decreased when responding for *Correct Rejections*, scoring 40%, 40%, 100%, 40%, and 0% correct on series one through five respectively *(Figure 8)*. For *Hit* trials, she scored 100% across all five series.

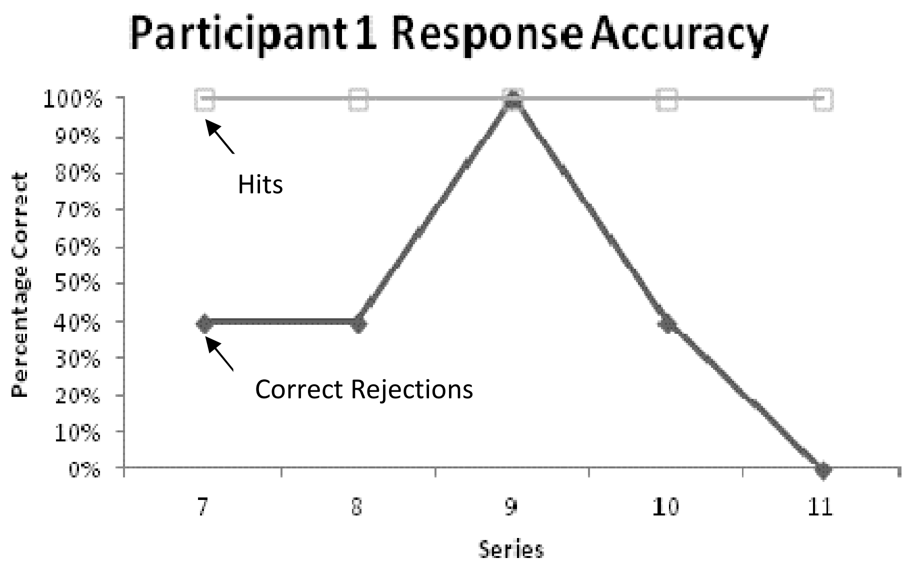

Figure 8. Participant 1's overall accuracy for version three of the signal detection software.

During version 1, for series one through three and series five and six, Participant 2's accuracy for *Correct Rejection* responses was 100 *(Figure 9)*. During series four, no opportunities to respond with a correct rejection occurred due to the random presentation of the stimuli. During version 1, Participant 2 only displayed errors during series two and three for the *Hit* trials, with an accuracy of 23% and 57% respectively. Her accuracy was 100% series one and four through six.

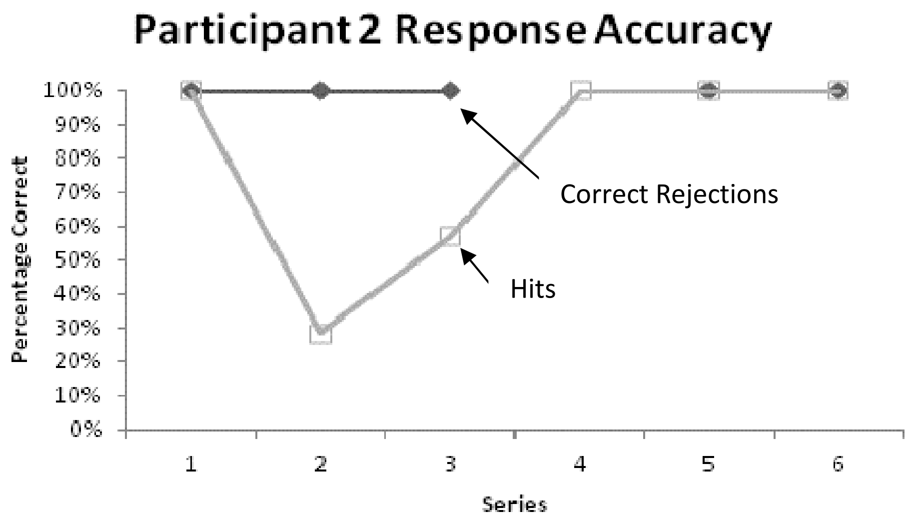

Figure 9. Participant 2's overall accuracy for version one of the signal detection software.

For version 2, correct responses to *Correct Rejection* trials for series one and two, was 67%, and 57% *(Figure 10)*. During series three through six, her accuracy was 100%. During Participant 2's performance for *Hit* trials, her accuracy was 100% during series one, three and five, and 63% during series two, 90% during series four, and 82% during series six.

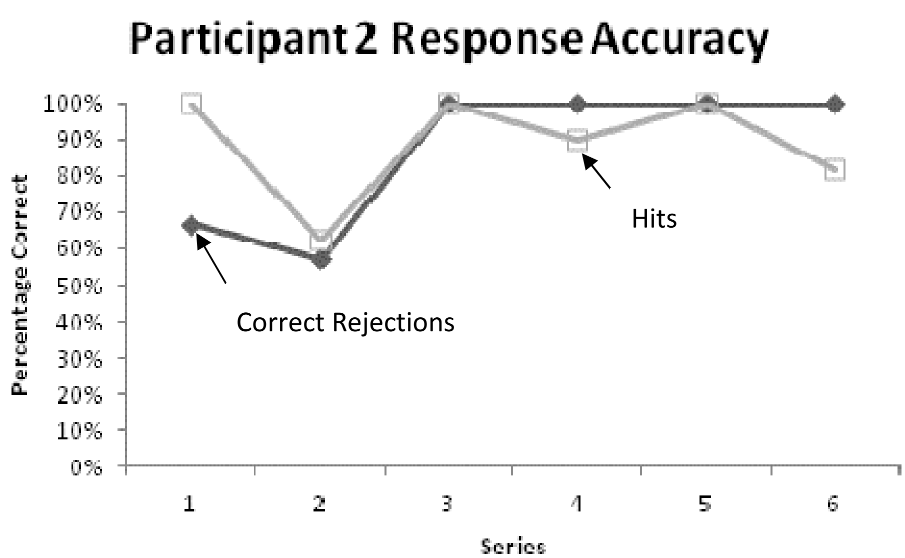

Figure 10. Participant 2's overall accuracy for version two of the signal detection software.

For version 3, while her speed increased compared to versions one and two, Participant 1's accuracy decreased when responding for *Correct Rejections*, scoring 80%, 100%, 100%, 20%, and 0% correct on series one through five respectively. For *Hit* trials, she scored 100% across all five series *(Figure 11)*.

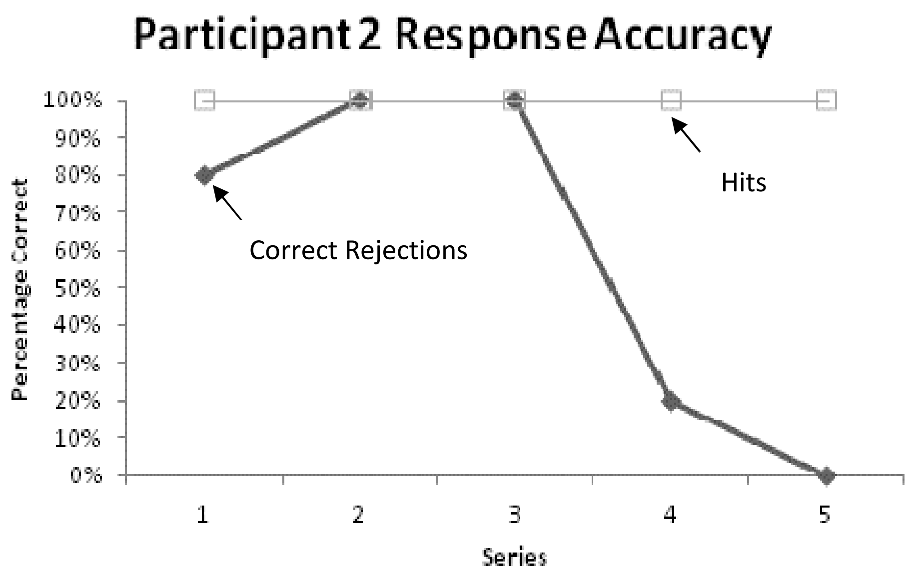

Figure 11. Participant 2's overall accuracy for version three of the signal detection software

CHAPTER 4

DISCUSSION

The purpose of this study was to assess the ability of an individual with NCD to detect the presence of a stimulus when presented along with several distracter stimuli, and to assess if increasing the number of comparison stimuli act as a hindrance for older participants on visual tasks. The results of the study showed that while the performance of each participant varied, both displayed some level of impact on their performance when the stimulus images began looking more similar to one another. This supports the idea that further research into the impact of subtle variance in stimulus presentation could impact performance on tasks related to stimulus equivalence. Indeed, this study might serve as a pilot study for future research in this area.

During the third version of the program, both Participant 1 and 2 correctly responded on every trial that the red circle was present when it was; however, they failed to respond correctly when asked to respond "No" when the red circle was in fact not present several trials. This could indicate that both Participant 1 and Participant 2 could not identify the subtle changes made to the color of the distracter stimuli when compared to the target stimulus. Both participants became less accurate, the more similar to the target the distracter stimuli became. Future research should continue to assess the ability of participants to detect changes, and when those changes may be too subtle to be detected. It is possible that this lack of discrimination ability, could impact overall performance on tasks related to match-to-sample or stimulus equivalence.

There were some limitations to this design revealed by the pilot testing. Participants were asked to press a touch screen with their fingers. After they pressed, each participant placed their hands in different positions between presses. Participant 1 rested her hands on the keyboard or table near the computer screen. Participant 2 rested her hands on the arms of her chair. This variant in resting positions may account for some differences in the response latency between the two participants. The laptop used in the study presented another issue. The participants struggled with pressing the screen appropriately. These limitations could be overcome by utilizing eye tracking software to determine how quickly the participants locate the target stimulus. Future versions of this study should take into account the possible impact of speed on the accuracy of the participants, and include trials where the participant is given an extended length of time to find the target stimulus. This could reduce the impact of time restraints on accuracy levels for the participants.

Another limitation to this pilot study includes the design of the program. While the presentations of the stimuli were randomized during each trial, the positioning of the stimulus presentation was fixed throughout. Randomizing the positioning of the stimulus displays could reduce the chances of the participants memorizing the positions of possible presentation locations. Varying the types of stimuli presented could also increase the validity of this design, including multiple designs of distracters, and utilizing secondary distracters, that would change in appearance similar to the variations of the target stimulus. This design also included the use of preferred pictures as reinforcement. It is possible that the utilization of actual tangible reinforcement could alter performance on the task.

The type of stimuli used during this study could also impact the performance on the task. The shapes and colors were selected to simplify the task as much as possible and future research should include the introduction of various shapes and colors to better assess discrimination of contrast, orientation, and location. While the number of distracter stimuli increased slowly, until reaching one target and five distracter, during version one, the number of distracters increased to 35 distracters and one target in version two. Gradually increasing the number of stimuli, rather than the use of a larger quantity increase, could possibly lead to a greater understanding of how increasing visual "noise" can impact performance.

Future research should continue to pursue this area as a possible conduit for discovering a more sensitive, more accurate, earlier detection measurement for neurocognitive decline. The use of signal detection, as a screening tool for variations to presented stimuli, could strengthen the use of stimulus equivalence procedures to create this new measurement tool, and increase the control researchers have on these procedures by reducing possible confounds due to vision. Using a study similar to the presented study with a greater level of randomization, slower increases in "noise", and an increased level of variance in terms of location, orientation, and contrast, could lead to a better understanding of how a stimulus equivalence task could lead to earlier detection of NCD.

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