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The Ability of Students with Dyslexia to Follow Sequential Oral Instructions

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by

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Abstract

There seems to be differences between children with dyslexia and those without in their ability to follow sequential oral instructions. In this paper this possibility was explored by testing children with and without dyslexia on nine short term memory tasks that represented the different aspects that make up serial instruction. My hypothesis was that those students with dyslexia would have a smaller recall span than the controls for all sequential recall tasks. My hypothesis was not supported by the data; children in the control group only showed a significant advantage on three tasks: memory for items, non-sequential verbal memory span, and non-sequential memory for oral instructions. I also found that the correlation between age and performance was much higher for the children with dyslexia than those without. This could suggest larger differences for younger members of the two groups.

Keywords: dyslexia, working memory, sequential memory, oral instructions

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List of Abbreviations

APA	American Psychological Association
CCon	Children without dyslexia (Control group)
CDys	Children with dyslexia
SLI	Specific Language Impairment

Introduction and Literature Review

The purpose of this paper is to explore what differences may appear between students with dyslexia and students without dyslexia when they are presented with oral instructions which must be acted on in a particular sequence. While breaking down the different components of working memory needed to process oral instructions, we hope to pin point any areas of difference between groups. Specifically, we seek to find if sequential instructions in particular cause more of a difference between groups.

The condition known as dyslexia is described as a neurobiological disorder that affects the individual's ability to process written language that occurs in spite of sufficient opportunity and exposure to reading instruction (Lyon, Shaywitz, & Shaywitz, 2003). The results include poor reading comprehension and spelling skills and can co-occur with other cognitive deficits. According to Cowen (2016), 15 to 20 percent of the general population either have dyslexia, or at least exhibit many of the signs and symptoms of dyslexia. Individuals with dyslexia can experience difficulty in many different areas such as phonological processing, organizing information, and memory (*Research into*, 2012). The individual can struggle when working through the decoding process of reading a word, have difficulty aligning math problems, or fail to recall spelling rules. Some people with dyslexia can also have trouble with processing speeds, executive function deficits, and visual attention deficits, among others (*Research into,* 2012). The report entitled *Research into Dyslexia Provision in Wales,* published by the Welsh government (2012) provides an accessible review of the current literature on the topic. Of the various deficits people with dyslexia can exhibit, one that has been researched extensively is that of memory, and specifically, working memory.

Working memory is a limited storage facility of immediate information we receive from interactions with our environment (Baddeley & Hitch, 1974). It contains information that we must act on in order to communicate with others, solve problems, follow instructions, etc. Without rehearsal (i.e. constant repetition), information is usually held in working memory for a few seconds or even fractions of a second, after which it lost or consigned to long term memory (Baddeley, 2003). Working memory is vital to successfully going throughout our day and achieving any tasks that come our way. It is especially crucial for students in younger elementary grade levels who are given numerous oral instructions they must act on in a timely manner in order to stay on course throughout their school day. As conceptualized by Baddeley et al. (1974), working memory is composed of three main elements, each of them serving a different function to help us process and act on immediate information. One element, the *central executive system* is the one that manages our attention and filters through the information from the other two components. Those two components are the *phonological loop*, which handles verbal information, and the *visuospatial sketchpad*, which processes the visual information (Garcia, Mammarella, Tripodi, & Cornoldi, 2014). All three of these components work together to allow a person receiving a set of instructions to be able to hold and act on all the information they need to complete the given task. Since working memory is a temporary storage facility used for tasks requiring immediate retrieval, it is important to look at research that has shown what happens when the working memory span is deficient. Research has found those with shorter spans made more mistakes following complex directions (Engle, Carullo, and Collins, 1991). Gathercole (2008) pointed out that when there are working memory deficiencies a child can lose information much quickly than their peers and become overloaded easily. Likewise, Yang, Gathercole, and Allen (2013) propose that working memory components are essential for recalling oral instructions.

According to the before-mentioned Welsh governmental research document, *Research into Dyslexia Provision in Wales* (2012), individuals with dyslexia exhibit deficits in working memory, but there is no consensus in the literature as to which of the three components of working memory is affected by dyslexia. For instance, Dawes, Leitão, Claessen, and Nayton (2015) found no overall differences in the performance of the visuospatial sketchpad between poor readers and controls but found differences in the performance of the central executive and phonological loop. However, the study included a group of poor readers who showed greater deficiencies in the visuospatial sketchpad tasks, and it is possible that those participants had dyslexia. This was not something accounted for in their study though. Some studies focusing specifically on individuals with dyslexia point to a deficit in both verbal and visual short-term memory (Varvara, Varuzza, Sorrentino, Vicari, & Menghini, 2014); while other studies (Banai, Ahissar, 2006; Fletcher, 2009; Snowling, 2000; Wolf, Bowers, & Biddle, 2000) only indicate a verbal memory deficit. Additionally, various studies have also pointed directly to visual short-term memory deficits concerning location of object (Menghini, Finzi, Carlesimo, Vicari, 2011; Smith-Spark & Fisk, 2007). One study performed by Bacon, Parmentier, and Barr (2013) set out to clarify whether people with dyslexia struggle with visuospatial tasks, and their findings pointed to the complexity of the task as the factor that made a difference in results. Menghini, et al. (2011) found people with dyslexia did not show a deficit in a visuospatial task unless the sequence mattered, which led them to suggest future research needed to focus on sequential and non-sequential versions of the same tasks. That brings us to the focus of this project, the component of sequencing which is an additional load on working memory.

Sequencing is an important component of every person's life. The ability to follow a sequence of instructions in the correct order can mean the difference between success and failure of a task. This is particularly true in the classroom, where a student will hear numerous instructions daily that will include specific items they must interact with, and likely will include a location as well as a given sequence to execute. For example, students must get their book out before they sit down at their desk, line up in the exact order the teacher tells them which may be different daily depending on who is "line leader", and remembering to wash their hands after they use the restroom, but before they eat. Sequence is a vital part of successfully moving through a school day. As reported by Majerus and Cowan (2106) on a review of current literature about serial order (or *sequence*) learning and the connection with verbal working memory, a child having a deficit in serial order short term memory can be associated with later language difficulties in both oral and written form. They also point out sequencing and working memory tasks are very rarely tested using child subjects with dyslexia. Morey and Miron (2016) looked at different aspects of sequence and short term memory and their results indicated a difference in the role interference plays in sequences. They found that the ability to recall spatial sequences tends to decline faster than verbal sequences during tasks relying on working memory. They propose this is due to the specific resources for language recall (auditory rehearsal) versus just general resources used to recall spatial and visual information. There is a lack of research in this area focusing specifically on individuals with dyslexia, but it is useful to look at what research has been done on memory for sequences with participants without dyslexia. For instance, a recent study investigating whether children with smaller working memory capacity could learn the same amount of new words as controls found they could not learn as many new words as their peers (Côté, Rouleau, & Macoir, 2013). This finding was attributed, among other things, to their inefficiency in holding serial order information in their short term memory. Briscoe and Rankin (2009) sought to find out if there was an issue for children with specific language impairments (SLI) among different components of working memory. In their findings they report a lack of strength in the phonological loop, but they also point out those children with SLI showed a large deficit compared with their peers on serial order tasks especially. Studies looking directly at those with dyslexia have generally found that sequence tends to be the area in which participants struggle the most. Perez, Majerus, Mahot, & Poncelet (2012) compared two groups of controls, chronological-age and reading-age matched children, against children with dyslexia, and found those with dyslexia made more errors on tasks involving sequence. A study focusing on adults with dyslexia saw a substantial difference in their ability to recall sequences, and concluded a potential working memory deficit was to blame due to the structure of their test (Ben-Yehudah & Ahissar, 2003). Das (2009) proposes that along with a list of other factors, whether a child can follow a sequence of instructions is an indicator that they need to be checked for dyslexia. Das points out that there is evidence that sequencing is one of the main factors that delineates between a child that merely has difficulty reading and one that has dyslexia. Riddick (2010) reviewed a number of studies and personal life history accounts and found a pattern: those children who struggled in their early years with motor tasks involving sequence (e.g. tying shoelaces) were later found to have dyslexia. As previously mentioned, Menghini et al. (2010) found it was the sequencing component of working memory tasks that the participants with dyslexia made more errors on, and proposed tasks should have sequence and non-sequence components to test this further. The purpose of this study is to find out if children with dyslexia do indeed show a specific impairment in following a sequence of instructions, beyond what would be expected from basic working memory deficits associated with dyslexia, and to determine which aspect of following sequential instructions may be affected by dyslexia.

The purpose of this experiment is to walk through various components needed for successful recall of oral instructions, and additionally will use a sequence versus non-sequence format for each task. This will help to clarify if there is a difference between participant groups in processing a specific component of instructions, or if indeed it is the need to recall a specific sequence that exposes differences in successful completion. Participants will include students in 2nd through 6th grades that have a dyslexia diagnosis or have been identified as having strong dyslexia tendencies, and a group of grade level matched controls. Each participant will be tested using a series of tasks that test the visuospatial and verbal components of working memory involved in the ability to successfully follow a sequence of oral instructions. In order to successfully follow a sequence of oral instructions, a person must be able to:

1. Recall the item.
2. Recall the location.
3. Recall the oral component.
4. Recall the sequence.
5. Put all previous components together to act on oral instructions.

Each task will have a series of trials beginning with a presentation of two units of the component being tested, increasing by one stimulus per trial until the participant can no longer recall all presented units correctly. Additionally, each component will have a series of trials that test for recall of that particular component in any order and a series of trials that are seeking to test their ability to recall the component and the order of presentation (sequence).

1. Item recall – black and white shapes flashing one at a time on screen.
2. Location recall – black and white grid which the participant will recall the location of the black squares in the grid.
3. Oral recall – two word adjective-noun phrases.
4. Sequence – each of the three previously listed components will be tested additionally for sequence recall.
5. Oral instruction – participant will have a section of items and a section of locations. They will hear a series of instructions to match specific items to specific locations.

My hypothesis is that those students with dyslexia will have a smaller recall span than the controls for all sequential recall tasks.

Methods

Participants

A total of 30 children were tested. Half of them (6 males and 9 females) were children with dyslexia (henceforth referred to as the CDys group) and half were age-matched children without dyslexia (7 males and 8 females) and served as the control group (henceforth referred to as CCon). Participants ranged in age from 7 to 12 years of age (CCon mean age = 9.8, S.D.= 1.74; CDys mean age 9.7, S.D.= 1.39). Children in the CDys group were students from Dubard School of Language Disorders, and from the “3-D School” in Petal, MS. Children in the CCon group were recruited from personal acquaintances of the author. In all cases, parental consent was obtained, and participants also expressed their assent prior to testing. Each child received a small toy to thank them for their participation.

Materials and Procedure

Participants completed a total of nine short memory tasks administered through a laptop computer. The tasks were presented in a power point slide show format that was controlled by the experimenter. What follows is a description of each task, including the materials used. An example of one item from each task is included in the Appendix.

<u>Visual working memory tasks:</u>

Task 1. Visual Memory for Items:

Stimuli: black and white line drawings of simple objects (e.g. sun, star, heart, etc.).

<u>1a. Memory for items</u>: Target items were shown on a laptop screen one at a time for one second each. Participants then saw a "recall screen" with target items and distractors distributed randomly (equal number of distractors and target items). Participants were asked to pick the targets, in any order they remember them. A response was considered "correct" when all and only target items were chosen. The task started with the presentation of a sequence of two targets and increased by one until the participant failed to respond correctly or until nine targets were presented in the study phase, whichever came first.

<u>1b. Memory for sequence</u>: Same as "1a" but the recall screen was only display target items in random order (with no distractors). Participants were asked to point to the targets in the order in which they were presented. A

response was counted as correct if the shapes were pointed at in the same order they had appeared.

1c. Memory for items in sequence: Same as “1a”, but in the recall screen participants were asked to identify the targets in the same order in which they were presented. A response was counted as correct only if the targets were identified in the right sequence.

Task 2: Memory for position (based on Della Sala, et al., 1999)

Stimuli: Grids of black and white squares

2a. Non-sequential position memory task: Participants were presented with a grid containing multiple squares filled either white or black. They were shown the entire pattern at once and had one second per black square to study it. They were then presented with a grid of all white squares, and were asked to point, in any order they chose, to the squares that should be filled black for the pattern to match the one they studied previously. The size of the grid was determined by the square of the number of black squares in each trial, so for example, for the first trial there was a 2X2 grid with two black squares and two seconds to study it, for the second there was a 3X3 grid with three black squares and three seconds to study it, etc. The task starts with a grid with two black squares and continued until the child failed to recall the location of each, and only each, black square that was presented.

2b. Sequential position memory task: Similar to “a”, but the black squares appeared one at a time at one second intervals until the final pattern was complete and one second has passed since the last black square appeared. During the recall phase, participants had to identify the squares that should be black in the same order in which they were presented in the study phase.

Verbal working memory tasks:

Task 3: Verbal working memory span.

Stimuli: Pre-recorded short noun-adjective phrases

3a. Non-sequential verbal span: Participants listened to a list of two-word noun-adjective phrases (e.g.: blue car, long bench, white mug, etc.) and were asked to recall them in any order. The trials began with two phrases and increased by one additional phrase per trial. A correct response was recorded when the participant recalled all of the phrases presented for that particular trial. The task ended when the child could not recall all of the phrases presented.

3b. Sequential verbal span: Same as in "a" but participants had to recall the items in the order of presentation. An answer was counted as correct if the items were recalled in the correct order.

Task 4: Memory for complete oral instructions (integrating item, location, and oral instruction)

Stimuli: First, pre-recorded instructional phrases, then color images of common locations (e.g. a sky, a mountain, a tree, a house, etc.) at the top of the screen with a black line of separation from the items (e.g. a stuffed animal bear, a rock, a pencil, a ruler, etc.).

4a. Non-sequential memory of oral instructions: Participants first heard a recording instructing them on which item to put with which location (e.g. Put the soft bear on the long bench, put the smooth rock in the pretty jar.). The next screen showed images of a group of "locations" across the top of the screen with a black line separating the "item" images across the bottom screen. The participant had to draw a line with his/her finger from the item to the location it belonged based on the instructions heard. A response was considered correct when the participant drew a line from the exact item to the exact location that had been presented together in the recording. Additionally, in order to be correct all pairs, and only the pairs instructed, had to be identified as a match.

4b. Sequential memory of oral instructions: Same as in "a" except this time a correct response was only recorded if the participant identified all exact pairs in the exact order the instructions were given.

For each task, the experimenter controlled the progression of each slide with the exception of the slides containing the presentation of the visual stimulus. These slides were set to a timer of one second per item to recall and would progress automatically to the slide of items to choose from. This means that if the participant had to recall 5 items, the slide would be present on the screen for 5 seconds. Participants had a total of one minute to recall items before moving to the next task. All tasks began with a total of two items to recall and increased by an additional item with each correctly recalled trial.

Each participant was tested individually. The experimenter gave a brief explanation for all nine memory activities at the beginning of the experiment, with more detailed instructions immediately before each task. Participants were asked to give their answers by pointing on the screen to what they remembered or repeat what they heard. The experimenter recorded each response manually on a score sheet. Each activity started with two items to remember and increased by one more item each time they got a group right. A task did not begin unless the participant acknowledged they understood the instructions, and the participant was told "good job" after each response whether correct or incorrect.

Results and Analysis

The mean and standard deviation of memory span for each task are presented in Table 1. We used a between participants ANOVA to make planned pairwise comparison between the two groups of participants for each task. Only three tasks yielded significant differences between the CDys and the CCon groups, in each case CCon participants performed better than CDys: Task 1a – visual memory for items (F (1,28) = 3.150, p = .087); Task 3b – sequential verbal span (F (1,28) = 7.865, p = .009); Task 4a – non-sequential memory of oral instructions (F (1,28) = 6.300, p = .018). Differences between groups for all other tasks were nonsignificant: Task 1b – memory for sequence (F (1,28) = .106, p = .747); Task 1c – memory for items in sequence (F (1,28) = .000, p =1.000); Task 2a – non-sequential position memory task (F (1,28) = 1.628, p =.212); Task 2b – sequential position memory task (F (1,28) = .745, p =.395); Task 3a – non-sequential verbal span (F (1,28) = .091, p =.765). Most importantly, there was no significant difference between groups for Task 4b – sequential memory of oral instructions (F (1,28) = .160, p =.692).

Table 1. Mean and standard deviation of accuracy for each task.

Participants	Task 1a	Task 1b	Task 1c	Task 2a	Task 2b	Task 3a	Task 3b	Task 4a	Task 4b
CCon	3.4 (0.51)	2.67 (1.18)	2 (0.76)	5 (1.07)	3.67 (0.90)	2.33 (0.72)	2.93 (0.60)	2.4 (0.63)	1.93 (0.70)
CDys	2.8 (1.21)	2.53 (1.06)	2 (0.66)	4.33 (1.72)	4 (1.20)	2.27 (0.46)	2.27 (0.70)	1.8 (0.60)	1.8 (1.08)

We also ran a Pearson's correlation to explore the relationship between chronological age and span for each for each of the two groups (See Table 2 for results). For the CCon group, most correlations were weak to moderate while in each case the correlation for the CDys group went from moderate to stronger (see Cohen, 1988).

Table 2. Correlation coefficient between chronological age and span for each task.

Participants	Task 1a	Task 1b	Task 1c	Task 2a	Task 2b	Task 3a	Task 3b	Task 4a	Task 4b
CCon	0.26	0.00	0.22	0.38	0.36	0.11	0.12	-0.05	0.16
CDys	0.44	0.44	0.24	0.55	0.73	0.57	0.22	0.09	0.53

Discussion

As seen in the results, my main hypothesis was not supported by the data: there was no significant difference between children with dyslexia and the control group in following sequential oral instructions. Some of the tasks did produce significant differences between the groups. For instance, Task 3a showed a difference between groups. This task involved recalling two-word phrases in the sequence given. What is most interesting about this result is the controls actually improved their score on this task which created the difference seen in the results. In the preceding task involving recalling two-word phrases in any order, there was barely a difference between the two groups at all. However, as with every task the “a” version was to recall in any order and the “b” version was to recall in the exact sequence and all task began with two items to remember. This could have created an unanticipated practice effect on this task for the controls of which the students with dyslexia did not benefit from. In fact, their mean was the same for both versions of this task. The controls were able to improve their score in spite of there being an addition requirement on the task, because both groups were naturally repeating what they heard in the order given anyway. The last task, Task 4, showed a significant difference in the non-sequential version of the task. As with Task 3, there was no difference in the students with dyslexia’s scores on either the “a” or “b” versions of this task which involved oral instructions and then matching pictures based on instructions given. This in line with Engle et al., (1991) findings that differences are most often seen between those with dyslexia and those without when the task is complex. Therefore, there could be no significant difference because the students with dyslexia had already show a difference in being able to complete the complex task before the sequence component was added. Their best score without sequence was lower than the students without dyslexia’s best score with sequence. In this way, it is seen that perhaps the problem lay in complex instructions and future research should seek to find what ways instructions could be presented to students with dyslexia, so they can be as successful as their peers at accomplishing complex tasks. An additional task showed a difference in the non-sequential version of the task, Task 1a, involving the presentation of black and white line drawings of simple shapes. This task involved the students picking target items from a group which included distractors. Often the students with dyslexia would point to a shape that had similarities of the target shape but was not the correct shape.

It is possible that the fine details of a target item may be what caused the incorrect shape to be identified. Again, this is an additional area that needs further testing. Especially, when thinking about the alphabet and letters that are very similar, this could indicate why letter reversals are a common problem for those with dyslexia (Brooks, Berninger, & Abbott, 2011). One area those students with dyslexia did better during the sequence version of the task was Task 2. This task involving presentation of black and white squares in a grid was one the students with dyslexia once again were fairly consistent between the sequential and non-sequential version of the tasks. Interestingly, almost every student with dyslexia mentioned that once the black squares went away, they could still "see" them where they were. This was not something any of the students without dyslexia mentioned experiencing. This also is a finding I believe could benefit from future research.

As seen by the results of the correlation analysis, the correlation between age and memory span for all tasks was much stronger for the CDys group than the CCon group. There are several ways of interpreting these results, but one possibility is that younger participants in the CCon group start off with better performance than the age matched participants in the CDys group. Indeed, an inspection of the data looking just at participants between the ages of seven and nine shows larger advantages for the CCon group than for the older participants. However, there is not enough data to perform a full statistical analysis splitting the groups by age. This narrowing of the gap could be due to the effects of maturation or improvement from treatment for the children with dyslexia (all of them receive treatment). I have already collected another thirteen children with dyslexia, and within the near future I will finish collecting their age matched controls which will allow me to conduct this analysis.

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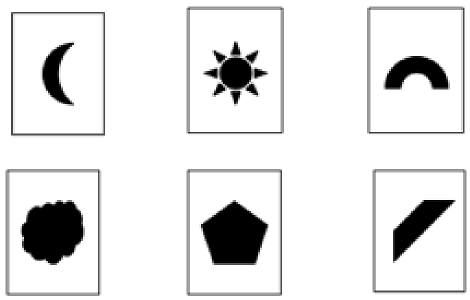
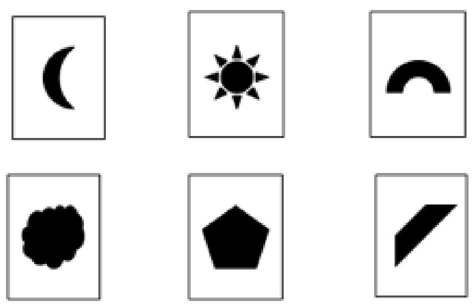
Appendix A

Examples of stimuli from each task

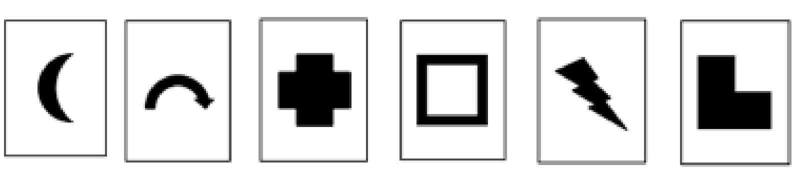
Task 1a – Memory for items



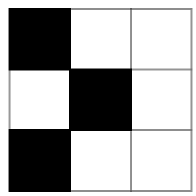
Task 1b – Memory for sequence



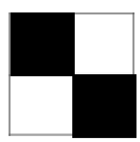
Task 1c – Memory for items in sequence



Task 2a – Non-sequential position memory task



Task 2b – Sequential position memory task



Task 3a – Non-sequential verbal memory span

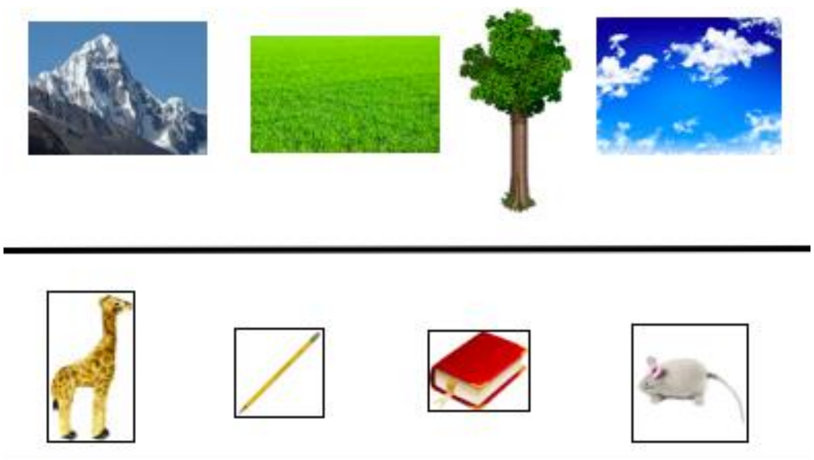
Blue car
Green grass

Task 3b – Sequential verbal memory span

Soft bear
Closed door
Green ball

Task 4a – Non-sequential memory for oral instructions

Put the friendly mouse in the bright sky.
Put the good book in the green grass.



Task 4b – Sequential memory for oral instructions

Put the smooth rock in the pretty jar.
Put the silver ruler in the round box.

Appendix B

IRB approval letter

THE UNIVERSITY OF
SOUTHERN MISSISSIPPI

INSTITUTIONAL REVIEW BOARD

118 College Drive #5147 | Hattiesburg, MS 39406-0001
Phone: 601.266.5997 | Fax: 601.266.4377 | www.usm.edu/research/institutional.review.board

NOTICE OF COMMITTEE ACTION

The project has been reviewed by The University of Southern Mississippi Institutional Review Board in accordance with Federal Drug Administration regulations (21 CFR 26, 111), Department of Health and Human Services (45 CFR Part 46), and university guidelines to ensure adherence to the following criteria:

- The risks to subjects are minimized.
- The risks to subjects are reasonable in relation to the anticipated benefits.
- The selection of subjects is equitable.
- Informed consent is adequate and appropriately documented.
- Where appropriate, the research plan makes adequate provisions for monitoring the data

  collected to ensure the safety of the subjects.

- Where appropriate, there are adequate provisions to protect the privacy of subjects and to

  maintain the confidentiality of all data.

- Appropriate additional safeguards have been included to protect vulnerable subjects.
- Any unanticipated, serious, or continuing problems encountered regarding risks to subjects must

  be reported immediately, but not later than 10 days following the event. This should be reported

  to the IRB Office via the "Adverse Effect Report Form".

- If approved, the maximum period of approval is limited to twelve months.

Projects that exceed this period must submit an application for renewal or continuation.

PROTOCOL NUMBER: 18031508
PROJECT TITLE: The Ability of Students with Dyslexia to Follow Sequential Oral Instructions PROJECT TYPE: Honor's Thesis Project
RESEARCHER(S): Crystal Hermann
COLLEGE/DIVISION: College of Education and Psychology
DEPARTMENT: Psychology
FUNDING AGENCY/SPONSOR: Eagle SPUR Award
IRB COMMITTEE ACTION: Expedited Review Approval
PERIOD OF APPROVAL: 03/22/2018 to 03/21/2019
Lawrence A. Hosman, Ph.D.
Institutional Review Board