PRACTICE ORDER EFFECTS ON SEQUENCE LEARNING

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Submitted to the faculty of the University Graduate School in partial fulfillment of the

requirements for the degree

Master of Science in Kinesiology

in the School of Public Health,

Indiana University

May 2017

Accepted by the Graduate Faculty, Indiana University, in partial fulfillment of the requirements for the degree of Master of Science.

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First, I would like to thank Dr. John Shea for the countless hours of discussion and insight he provided for the entire duration of my Master Thesis work. From first meeting you as an undergrad to present, I have grown leaps and bounds in my academic career, with you being the major catalyst. I do appreciate all the stories and advice you have given me over the years. *Time and Interference*

Secondly, I would like to thank Dr. Hannah Block and Dr. Koceja for being instrumental in my coursework during my graduate career, as well as serving as committee members for my Master Thesis.

I would also like to thank Dr. Charles Pearce, for always “Pearce”ing my Power Points, and providing countless hole in the floor examples that illustrated human error concepts.

I would like to extend a special thank you to my parents, LaMont and Ann Freeze, sister, Andrea Kuhn, my Grandpa Knabenshue, and Grandma Freeze. Lastly, thank you to all my Aunts, Uncles, cousins, and all my friends and fellow graduate students for their support over the years-much love. *Freezy*

Grandma (1945-2013), my thesis is dedicated to you. “Forever in our hearts”

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Should a given motor task be learned in parts or as a whole? The answers to this question lies within the complexity of the motor task. A discrete sequential motor task was used to examine if learning constituent parts in two practice orders would produce similar performance upon two retention tests of the whole task. A third group that only practiced the whole task was used as a control. The results showed that during the first retention, the part group which practiced the whole task in the reverse order performed significantly faster than the other part group on the execution time and total time measures, and also produced very similar performance to the control group. The results suggest that the retroactive interference induced by the particular practice schedule plays a large role in the learning of the parts of the tasks, which manifests upon the transfer to the whole task in the performance of the group which practiced the parts in reverse order. In addition, this experiment showed that a simple task of low complexity had a part group and control (whole) group perform the task very similarly, producing somewhat contradictory evidence to Naylor and Brigg's original assertions on task complexity in part versus whole learning. Further studies should also focus on whether blocked order part groups produce similar results to the serial part groups utilized in this experiment.

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Chapter 1

Introduction

Background of the study

Motor control and learning is a field that addresses a wide array of topics related to human movement. Through experimental advancements made by motor behaviorists and psychologists alike, defining underlying processes associated with human movement has helped navigate a distributed but integrated cortical motor system (Wexler et al., 1997). By translating theoretical research into practical knowledge on how human movement is learned and retained, practitioners are presented with a viable guide to develop protocols for numerous motor skills which correspond to a myriad of tasks (Shumway-Cook and Woollacott, 2007).

Coordinated motor movement or some type of coordinated muscular movement can be described in relation to a task as modulated by a given task's constraints. Guthrie (1952) provides a simplistic and elegant definition of skill as consisting "in the ability to bring about some end result with maximum certainty and minimum outlay of energy, or of time and energy". To elaborate on the previous notion of skill, an example of a motor skill may be pressing a key (coordinated motor movement) while the task involves pressing three keys in a sequence.

Before humans are skillful at a particular task, learning must take place. The process of acquiring a skill is divided into different phases. A learning phase or acquisition phase may show an increase in specific performance measures. The acquisition performance trend may be slow in the beginning, but increase as time and the number of trials increase. Conversely, in a retention phase, the skill is retested to see how well the skill was learned. In addition, transferability of the learned skill onto a similar type of task may take the form of a transfer phase. Knowledge on both acquisition and retention helps illustrates all grades of understanding skill acquisition (Adams, 1987), from the rudimentary level, to competent, proficient, or expert performance.

The basic acquisition of a skill may involve a task that can be broken into natural parts. However, addressing when the parts should be practiced and when the whole task should be practiced is up for interpretation. How does the practice order of the parts effect the subsequent transfer to the whole task? How does this performance compare to a control group that only practices the whole sequence? Through both a historical and modern perspective, this question will be investigated. Through examining this part versus whole question as part to whole, a new perspective on the acquisition will hopefully be warranted.

Statement of the Problem

The purpose of this study is to investigate if there are any practice order effects on sequence learning using a part to whole paradigm.

Experimental Aims

1. To investigate the effect of learning constituent parts of a sequence in two serial orders and how this performance influences the transfer to the whole task sequence.

2. To compare the performance of the two serial groups in retention to a control group (WHOLE).

3. To investigate whether dwell time is a viable measure that can be used in sequence learning experiments.

Hypotheses

The following research hypotheses were investigated in regard to practice order effects for the acquisition and retention/transfer of a novel motor task, either by the parts or by the whole.

1. Acquisition of the parts by both serial groups (ABC and CBA) should be similar with no significant differences.
2. Transfer testing should benefit the serial ABC group over the serial CBA group due to the practice order of the constituent parts mirroring the whole task sequence.
3. The control (WHOLE) group should display superior performance over both serial part groups due to prior practice of only the whole task sequence during acquisition.
4. Dwell time will prove to be a viable measure in sequence learning by alluding to motor chunking.

Assumptions

The study was conducted under the following assumptions:

1. Subjects followed the instructions that were provided throughout the entire duration of the experiment.
2. Subjects consistently put forth their best effort throughout the entire duration of the experiment.

Delimitations

The study was delimited to the following:

1. All subjects will be between the ages of 18 and 25 years.

2. All subjects will be right handed.

3. All subjects will have reported no history of motor disorders.

4. The experiment was conducted in the motor learning laboratory.

5. The experiment was be conducted on a computer.

6. The tasks performed were key pressing tasks done on an external keypad.

Definition of Terms

Acquisition: initial period of self-generated, motor performance enhancement, within a variety of contextual and task constraints (Newell, 1991).

Execution Time: the time interval from the release of the start key to the final press of the sequence.

Initiation Time: the time elapsed from the presentation of the stimulus (to initiate movement) to the release of the start key.

Movement Time: the time interval from the release of a key to the press of the next key.

Practice Schedule: the order in which practice trials in acquisition are organized.

Retention: the period of self-generated, motor performance, of previously learned tasks, from acquisition.

Retention Interval: the period following the conclusion of the last trial of acquisition to the initiation of the first trial of retention. This interval includes a task which is a distracting activity.

Serial: non-repetition of events combined with perfect predictability of events (Lee and Magill, 1983). For example, the serial order may be ABCABCABC or CBACBACBA.

Total Time: the time interval which is a composite of initiation time and execution time.

Transfer: a period in which a new task is performed.

Chapter 2

Review of Literature

The following review of literature aims at documenting the experimental procedure by addressing the following: origins of the part versus whole question, part versus whole: the methods, human memory and motor learning, and task complexity and task organization.

Much of the following review will focus on ideas and/or terms that have been used extensively in verbal learning which is because verbal learning pre-dates motor control and learning by many years. Recently, certain ideas and/or terms bridge both domains and are sometimes used interchangeably. However, they in fact may describe different phenomena. The author's goal is to be consistent when describing these ideas and/or terms such that the interpretation is straight forward.

Origins of the Part Versus Whole Question

The part versus whole question has been examined for a very long time. The question is whether or not learning a task by its constituent parts or the whole will yield significantly better retention performance. The origins of the part versus whole question are attributed to Ebbinghaus's seminal work on human memory research in 1885 (Cunningham, 1971). Ebbinghaus tested himself for a lengthy period of time on learning various lists of nonsense syllables which were later termed consonant-vowel-consonant (CVC) trigrams (Ebbinghaus, 1913). The reason for using these nonsense syllables as opposed to words was to study memory at a fundamental level, meaning nonsense syllables would contain no known associations. To illustrate this point, dog, cat, and bat would form the association animal or mammal. However, even CVC trigrams were found to contain association values (Glaze, 1928). Association values aside and the fact that Ebbinghaus himself was the only subject in the experiment, a foundational paradigm for studying human memory was established.

Part Versus Whole: The Methods

The basic structure of Ebbinghaus's paradigm was learning a list of CVC trigrams during a learning phase (acquisition) and subsequently recalling as many CVC's as possible in a relearning phase (retention). Using this format of learning and relearning, various iterations with numerous tasks began in the early 20th century. The various methods of experimentation included maze tracing, prose learning, and paired associate learning, and mixed associate learning (Pechstein, 1917; Pyle and Synder, 1911; Cunningham, Brown, 1924).

Before diving into the problem, the actual methods, particularly the part methods, need to be defined. For example, if the part tasks to be learned are termed A, B, C, and D, the part method follows the order of A, then B, then C, then D. The progressive part method involves subjects learning A, then B, then A, B, then C, then A, B, C, then D, then A, B, C, D (Pechstein). The direct-repetitive part method involves learning A, then A, B, then A, B, C, and A, B, C, D (Naylor, 1962). In addition to these three different part methods, they may all be used in an inverse manner, i.e. reverse part, reverse progressive part, and reverse direct-repetitive part (Walls, Zane, and Ellis, 1981). The whole method is simply defined as learning A, B, C, D as ABCD, or W.

Early on, the whole method was found to be superior to the part method for the vast majority of instances (Cunningham). When given the task of learning poetry either by a part method or whole method, subjects who learned by the whole method showed superior performance (Pyle and Synder). However, in a maze tracing experiment, the progressive part method, proved in some circumstances, to be superior to learning the maze over the whole method (Pechstein). This was one of the first instances of a part method showing superiority over the whole method. In a study utilizing both maze tracing and CVC trigrams, Pechstein found that the part, progressive part, direct-repetitive part, and reverse direct-repetitive part methods to be superior to the whole method (1918).

Part method dominance remained suspect as Pechstein was one of the few researchers finding overwhelming support for the various part methods (Cunningham). By employing a card sorting task, the whole method was found superior to all part methods (Craft, 1919). Brown (1928) used a part, whole, and combination method (learned the whole task but with the stipulation that any errors could be corrected from the occurrence point) for learning a piano score. The task itself was highly cognitive and also required simultaneous integration due to the difficulty of playing the piano and the use of both hands. The whole method was found to be the best overall method of learning the score, with the combination method being second and the part method being third. Again, the whole method proved superior to the part method (and combination method).

The last historical example is very different than the aforementioned studies as it attempted to separate the cognitive and motor aspects of the task during the initial acquisition phase (part practice). Using a flight simulator task, part practice was found to elicit sufficient learning. This was done first by learning all of the procedures (cognitive) and followed by learning the flight controlling (cognitive/motor). The whole task required subjects to learn the procedures and corresponding flight controlling successively (Adams and Hufford, 1962). The optimal learning method was concluded to be practicing the integrated whole, as there was more practice required by the part subjects to maintain optimal performance over an extended period of 10 months.

The conclusions the above authors used for explaining particular method dominance are insufficient and many times limited. For instance, Pechstein offered an explanation of savings due to the associations formed with the parts as the explanation of part superiority. In disagreement, Pyle and Synder argued that the associations formed with the parts is what has to be overcome when forming the whole, creating slower performance (Pyle and Synder). In addition, the notion of part supremacy seems to be disproven by Tulving's work on list learning (Tulving, 1966). Learning a part of a list of words before learning the whole list retarded subsequent free recall of the whole list when compared to only learning the whole list. How the subjects organized items to be remembered in the part presentation was not in congruence with how the full list was learned. This is in disagreement with Pechstein's interpretation of the savings afforded by the part method. However, this particular conclusion should be taken with a grain of salt due to the varying cognitive demands of both experiments.

So far, the studies presented have provided a historical perspective that have been limited to reporting the basic methods utilized and the overall findings. There seems to be a 'consensus' superiority of the whole method over the part method. Cunningham describes the beginning of part versus whole research as being "distinguished for its inadequacy" (Cunningham). Although the research produced was many times inconclusive or conducted with very crude methods, this research helped provide foundational assertion's regarding the part and whole methods. Lastly and worth noting, the various part methods have remained relatively fixed since their inception around 1900 (Pechstein, 1917).

Human Memory and Motor Learning

Theories on human memory have been around since the middle of the 19th century (Atkinson and Shiffrin, 1971). The basic premise of human memory was information could be learned during the present and recalled sometime in the future. The distinction arising from this premise was originally referred to as short-term and long-term memory. As Atkinson and Shiffrin point out,

> "Despite its intuitive attractiveness, the short-versus long-term view of memory was largely discarded when psychology turned to behaviorism which emphasized animal as opposed to human research. The short-versus long-term distinction received little further consideration until the 1950's."

This lack of consideration was in large part due to the rise of behaviorism, which dominated the field of psychology for the first half of the 20th century. This dominating school of thought may also have served as one of the reasons minimal research directly or indirectly concerning the part versus whole question occurred during this timeframe. However, during the 1950's, new interest in understanding the higher order mental processes of human memory began as behaviorism provided inadequate and implausible explanations (Bargh and Ferguson, 2000).

Through the years, much refinement has occurred in regards to short-term memory. Originally, Atkinson and Shiffrin proposed a multistore model of memory which included a sensory register, short-term store, and long-term store (Atickson and Shiffrin, 1968). Short-term memory is regarded as a temporary retention of information before the information becomes permanent (Fuster, 2001). In addition, short-term motor memory is thought to parallel short-term memory, with the differentiating factor being the regions of the cortex that are activated with motor skills (Adams and Dijkstra, 1966). In a series of experiments, Miller (1956) famously suggested that the capacity of short-term memory was seven items plus or minus two. However, this limitation may in fact be overcome “by organizing the stimulus input simultaneously into several dimensions and successively into a sequence of chunks” (Miller).

Further complicating memory research was the introduction of working memory. Contrary to the view of the Attikinson Shiffrin model of human memory, Baddeley and Hitch proposed that working memory acts as the central executive that controls multiple slave systems which are various forms of short-term memory (Baddeley and Hitch, 1974). This essentially modified the existing view of how information was processed in short-term memory. With the knowledge of working memory as the central executive, working memory can be defined as “a basic cognitive mechanism (or set of mechanisms) that is responsible for keeping track of multiple task-related goals and sub goals, or integrating multiple sources of information” (Miyake and Shah, 1999). Presently, working memory and short-term memory are often used interchangeably. However, this is grossly incorrect as working memory is the mechanism while short-term memory is the store. This misnomer may be due to how the terms were originally used and the current understanding of human memory.

Finally, long-term memory, is the storage area where information can remain indefinitely, and is divided into two categories. The first, declarative memory, or more appropriately explicit memory, requires conscious recollection of information (Sweatt, 2009). The second, implicit memory, is performed in the unconscious, and may be appropriately termed long-term motor memory in regards to the store. Although these two differing categories exist, in terms of motor acquisition, cognition plays an inarguably large role. Understanding the cognitive-motor interactions are central to understanding acquisition of skill not only in short term, but also how this learning affects and dictates amalgamated performance in the long term.

On the acquisition of motor skills, several theories and hypotheses have been proposed that attempt to explain various aspects of motor learning. In 1975, Schmidt's schema theory provided several expectations in regards to what governs the acquisition of motor skills (Schmidt, 1975). Central to schema theory was the notion that as motor skills are acquired, rules or schema form that influence the performance during acquisition, retention, and transfer. Adding parameters to a generalized motor program (abstract representation, that when initiated, allows for a coordinated movement sequence) is what is abstracted into recall and recognition schema (Schmidt and Lee, 1988). By using the notion that motor learning is essentially rule based learning through the use of schema, which is parameterized by force and time and refined by knowledge of results, schema theory provided a tool in explaining how motor skills are acquired and retained (Schema theory does not give an explanation on how motor programs or generalized motor programs are initially formed).

Knowledge of results is often viewed as an essential mechanism for skill acquisition. However, the understanding of what constitutes knowledge of results has long been muddied in experimental paradigms (for a review, see Salmon, Schmidt, and Walter, 1984). Knowledge of results is defined as extrinsic “verbalized (or verbalizable) post-movement information about the outcome of the movement in the environment” (Schmidt and Lee). Knowledge of results is related to the outcome of the goal of the movement, but not the intricacies of the movement. In relation to experiments that examine the contextual effects of learning, knowledge of results may serve a guidance role (Salmon, Schmidt, and Walter). For instance, in a serial practice schedule, the learner may be guided through practice by the task cues and subsequent performance feedback in terms of time of completion. Due to many motor learning experiments having some form of knowledge of results, having a broad overview of the topic sheds light onto the complexity of research paradigms.

Alluding to the aforementioned contextual effects of learning, retroactive interference can be considered a hypothesis for why certain practice schedules yield superior performance during acquisition and retention. Retroactive interference is a very old explanation of why learned material is sometimes forgotten. The first series of experiments that investigated the phenomenon known as retroactive interference date back to 1900 (Müller and Pilzecker, 1900; Dewar, Cowan, and Della Sala, 2007). This was initially investigated by having the subjects learn a list of non-sense syllables and then comparing the group effects to either a filled or non-filled retention interval (Dewar, Cowan, and Della Sala). Having an interpolated task that was another list of non-sense syllables in the retention interval was found to cause poorer recall in retention testing when compared to an unfilled retention interval. Thus, a working definition of retroactive interference is the interference caused by tasks learned later on tasks learned prior.

In opposition to retroactive interference, the interference caused by tasks learned prior on later tasks is known as proactive interference. In a study examining serial position effects on learning a linear positioning tasks of lengths of three positions, six positions, and nine positions, proactive interference was found with the short three position group (Magill and Nann Dowell, 1977). However, for the six and nine position groups, retroactive interference was the explanation. Interestingly, the paper also addressed two very old concepts in experimental psychology which are the primacy and recency effects. These two plausible hypotheses add yet another layer on attempting to explain the acquisition and retention of motor skills. For example, when three tasks are executed in a serial order, the first task learned can be described as having a primacy effect (stored in long-term memory), the second task being neutral, and the third task exhibiting a recency effect (present in short-term memory) (Baddeley, 2004). For both primacy and recency effects to be present, a bowed shape should be present when analyzing performance. Magill and Nann Dowell found this bowed shape and concluded the primacy effect was found to be substantial in both the six and nine position groups, whereas the recency effect was present but minimal (Magill and Nann Dowell).

Task Complexity and Task Organization

In the early 1960's, Naylor and Briggs (1963) provided specific expectations regarding task complexity and task organization in regards to the part versus whole question,

> "For a relatively highly organized (integrated) task, whole task training methods should be superior to a part schedule at all levels of task complexity; however, for a relatively unorganized task (all dimensions independent), an increase in task complexity will result in a part-task training schedule becoming superior to whole training".

Categorically speaking, tasks may be broken down into serial (maze learning, poetry learning, simulator training, medical training), non-serial (paired-associate learning, free recall, card sorting), continuous (walking, running, operational studies on steering), and discrete (keying, many sports skills) in nature. In addition, discrete tasks may also be strung together in sequential parts (sequence learning) and simultaneous parts (playing the piano). In the description of task complexity provided by Naylor and Briggs, task complexity is subject to interpretation. In motor learning, task complexity has been recently defined as the number of movement segments, whereas task organization refers to the temporal relationship between the composite movement segments (Magill, 2000; Brydges et. al, 2007).

The recent literature has been sparse on part versus whole practice and motor learning. However, there are a few examples that will lend clarification on the relative superiority of one method versus the other given Naylor and Briggs assertions and the recent refinements on both task complexity and task organization. The following examples focus on tasks that are both serial and discrete, and discrete-sequential.

Two examples of a discrete approach to the part versus whole problem come from a medical training task involving bone plating (Dubrowski, Backstein, Abughaduma, Leidl, and Carnahan, 2005; Brydges, Carnahan, Backstein, and Dubrowski, 2007). Medical students watched a professional perform the task (consisting of five steps varying in difficulty) error free, and then performed a pre-test before being split into part groups and a whole group. The part groups performed the task in either a blocked or random manner (Shea and Morgan, 1979) and the whole group performed the task in its entirety. The whole group was found to show superior performance over both the blocked-part and random-part groups. Due to the serial task structure and the integrated nature of the task, whole superiority is in line with Naylor and Briggs notions on task complexity and task organization.

The two prior examples are of course complex. Unfortunately, parsing out the relative theoretical contributions with these complex tasks remain difficult due to a specific, uncontrolled aspect, of the experimental design utilized by both experiments. All subjects watched a video of a surgeon performing the entire bone-plating task and then subsequently performed the entire task before being randomly assigned to a particular group. This critical aspect of the experimental design should be noted when examining their finding which was whole task superiority. Nonetheless, the medical field, especially education in surgical skills, has taken a proactive approach in regards to teaching students these complex skills (Spruit, Band, Hamming, and Ridderinkhof, 2014).

Before discussing discrete-sequential tasks, there is an interesting example of part vs. whole learning which involves a discrete task. Lersten found that subjects who practiced two separate parts which consisted of a circular and linear task performed worst in transfer tests when compared to subjects who performed the whole (Lersten, 1968). What is especially worth noting about this experiment is that the duration to complete the parts and the entire task was less than one second. Even with such a short but integrated task, whole superiority was shown.

A discrete-sequential task can be defined as discrete by the short duration to complete the task, and sequential in the fact that the task is made up of a sequence of elements. When subjects performed either the entire task made up of 16 elements or performed the parts broken into 8 elements a piece on separate days, neither part or whole practice was significantly different during a retention/transfer test. (Park, Wilde, and Shea, 2004). When both groups performed the initial 8 elements after the retention/transfer training, there was similar performance. However, when subjects were asked to perform the second 8 elements, the part group performed significantly faster than the whole group, alluding to the inherent organization characteristics of the task.

When addressing task complexity and task organization, the idea of motor chunking is paramount to the discussion. Drawing on Miller's initial premise that 7+- 2 bits of information are stored in short-term memory, motor chunking refers to the "segregation of long sequences of movements into subparts, and concatenation of motor responses into groups of responses, characterized by increased temporal intervals and probability of errors at chunk boundaries" (Diedrichsen and Kornysheva, 2015). Depending on the task organization as well as the task complexity, part and whole groups may in fact form motor chunks differently (Park, Wilde, and Shea). This formation most likely helps signify the relative superiority of one method over another given a particular task. The idea of motor chunking fits well with Naylor and Briggs original assertion.

Although the present definition of motor chunks is characterized by in part to the increased temporal intervals which signify the motor chunk boundary, the characterization may be in fact be incomplete. Dwell time was first recognized as a curious part of a reciprocal aiming task such as Fitt's task (Fitts, 1954; Adam and Paas, 1996). In this task, a subject moves from the first target, then to a second target, and then repeats this procedure a specified number of times. Instead of relying only on the movement times from target to target, the concept of dwell time is the “finite time (that) may elapse at the end of a movement before the next movement is initiated” (Fitts and Radford, 1966). What was problematic is that researchers tended to neglect dwell time and only report the given movement times: “these dwell times are included in the average times for serial responses” (Fitts and Radford, 1966). Although this notion was first addressed with a reciprocal aiming task, to the author’s knowledge, no discrete-sequential learning studies that have addressed the part versus whole problem have attempted to partition out dwell time. What would dwell time in this type of task be? Taking into account the initial descriptions Fitts and Radford provided about dwell time and applying it to a discrete-sequential task, dwell time may be defined as the time interval from the press of a key to the release of the same key. Even though these time intervals may be extremely short, dwell time may help define, in conjunction with movement time, motor chunks.

Chapter 3

Methods

Participants

Thirty-six Indiana University students (11 men, 25 women); *M* age = 21.19 years, *SD* = 1.31 years, participated in the study. The study was approved by the Indiana University Human Participants Review Board (protocol number: 1601409058). All participants were between the ages of 18-25, had self-declared normal to corrected normal vision, were self-declared right handed, and reported no history of any motor disorders.

Instrumentation

The testing apparatus consisted of a Dell Optiplex used to execute the experiment and store data, an 18” color display monitor, and a Targus numeric key pad. The key pad was modified to limit key options to only those required by the experiment and to prevent vision of any notations on the keys. Experimental tasks were controlled by a customized E-Prime Professional Program (version 2.08, Psychology Software Tools, Pittsburgh, PA, USA).

Design

The tasks used in this experiment were diagrams illustrating a sequence of keys to be pressed on the external keypad. The diagrams were colored, and the movements were represented by arrows pointing to the correct sequence of keys. All the numbers on the external keypad were covered and placed with white sticky notes. All other keys that were of no use on the external keypad were covered in black to signal to the subject not to use. See Figure 1 for the task diagrams used in the experiment.

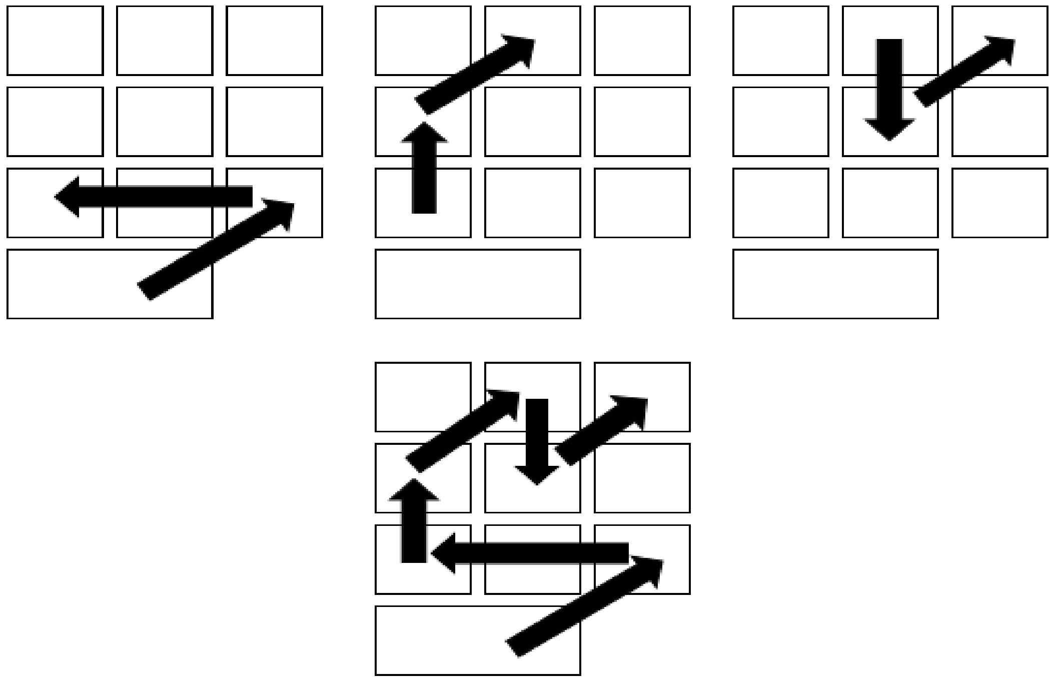

Figure 1. The corresponding keys to the presses are as follows: red-0,3,1 (top left); blue-1,4,8 (top middle); yellow-8,5,9 (top right); and green-0,3,1,4,8,5,9 (bottom).

Three experimental (see Figure 2) groups were used to address the part versus whole question. Group ABC and Group CBA addressed the practice order effects on sequence learning. Both Group ABC and Group CBA involved the practice of only the parts of the whole task during acquisition, with the only difference being the practice schedule. The serial practice schedule used during acquisition for Group ABC was red (A), blue (B), and then yellow (C). Group CBA performed in the opposite manner with yellow (C) being first, blue (B) second, and then finally red (A). The Whole Group served as the control and performed only the green Whole (W) task during acquisition. After the retention interval, both Group ABC and CBA were then presented with the green (W) task for the first time. This severed as a transfer test from the constituent parts to the whole for both Group ABC and Group CBA. After the same retention interval, the

Whole Group went on to perform a retention test of the green (W) task. Following a 2 minute delay, all three groups performed a retention test of the green (W) task.

	Acquisition			Interpolated Period	Retention 1 (Transfer 1)*	Delay 2 Min	Retention 2 (Transfer 2)**
Block	1	2	3	Tetris	1	Wait	1
Trials	9	9	9	0	6	0	6
Groups							
Group 1: ABC							
Group 2: CBA							
Group 3: Whole	9 Trials of Whole Task						

*Transfer 1 consisted of performing the Whole Task with the task diagrams provided as in Acquisition.
*Transfer 2 consisted of performing the Whole Task without the task diagrams present (the stimulus was presented only).

Figure 2. Experimental Overview.

The dependent variables calculated for all three groups consisted of the following: initiation time (IT), movement time (MT), dwell time (DT), execution time (ET), and total time (TT). These measures served as factors for the theoretical inquiry for the part versus whole question.

Procedure

In Groups ABC and CBA, all subjects proceeded to read and sign an informed consent form. The program was then initiated and the experiment proceeded. The subjects were told all presses are to be performed with only the right index finger. The following instructions were both displayed on the screen and verbalized: “Welcome to the experiment. Please press the SPACEBAR to begin. For this experiment, you will perform a series of sequences. Press the SPACEBAR to continue. A task diagram will appear on the screen. Study the task diagram. You will be expected to tap out the diagram using the keypad when prompted. Press the SPACEBAR to continue. After the task diagram is displayed, you will be asked to hold the “start” key. The starting position will vary. Please keep this in mind. A color screen will then be presented after some time. It will match the color of the task diagram. Press the SPACEBAR to continue. Release the “start” key and complete the task as quickly and as accurately as possible. Press the SPACEBAR to continue with some practice trials”.

After the instruction slides were presented, the subjects were then asked if they understood what they would be doing, and informed that they would now proceed to practice trials. In total, five practice trials served to familiarize the subjects with the experimental procedure (see Figure 3 for an example). Afterwards, the acquisition phase commenced.

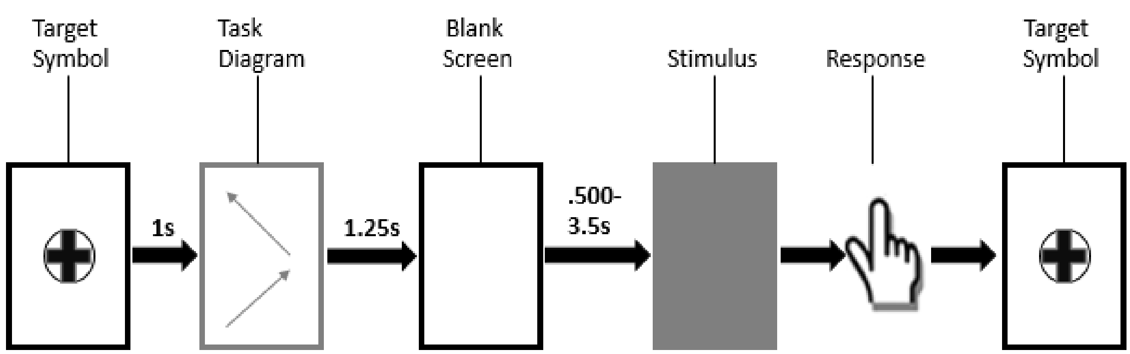

Figure 3. Shows an example of one trial during the experimental procedure.

The following are all the instructions a subject received during a trial and through the duration of the experiment: “You will now begin the experiment. Any questions? Press the SPACEBAR to continue.” Acquisition consisted of three blocks of nine trials for a total of twenty-seven trials. At the end of blocks 1 and 2, subjects rested briefly for 30 seconds. “Please wait for further instructions. Press the SPACEBAR to continue.” After the conclusion of the last trial of the third block, the subjects were now in the retention interval. “There will be a 10 minute rest period. Please refrain from touching the keyboard.” Subjects then played Tetris for 10 minutes as an interpolated task in the retention interval. Following this retention interval, both groups were then introduced to the green (W) task for the first time. “You will now complete trials where you are expected to tap out a sequence. The same procedure will be used. Press the SPACEBAR to continue. You will now perform trials that will replicate a task diagram (shown to before each trial) by tapping out keys on a keyboard. Press the SPACEBAR to continue.” Subjects practiced the green (W) task six times. After the sixth trial, subjects were then instructed to wait two minutes. “Please wait. When instructed, press the SPACEBAR to continue.” The subjects were then informed that they would now perform the same green (W) task from memory (no task diagram assistance). “You will now perform the same task you practiced without the aid of a task diagram. Instead of a task diagram being shown, you will be asked to press and hold the “start” key. The rest of the procedure remains the same. Press the SPACEBAR to continue.” Subjects performed the green (Whole) task six more times. Upon the completion of the sixth and final trial, the experiment was over. “Thank you for participating in the experiment”.

The Whole group followed the same initial procedures described above until the start of acquisition. However, there was nothing noted about the “start” key changing position. The subjects then proceeded to perform the green (W) task a total of nine times successively in acquisition. At the conclusion of the ninth trial, the retention interval and interpolated task (Tetris) began. Following the retention interval, subjects proceeded to perform the green (W) task six times (with aid of the task diagram) with the same instructions as Groups ABC and CBA. Following the completion of the sixth trial, subjects waited for two minutes. Afterwards, six more trials of the green (W) task were performed without the aid of a task diagram. After the completion of the sixth trial, the experiment was over.

Before debriefing, all subjects were ask to respond to a series of questions (see Appendix B). All subjects were then debriefed and thanked for their time.

Chapter 4

Results

This chapter presents the results and graphic representations of the present study. To account for the repeated observations for subject, a linear mixed model was used to analyze the data. The within-subjects effect was participant, and between-subjects effects were group, part, and trial. A variance components covariance structure was assumed for the random effects. Separate 2 x 3 x 9 (Group x Part x Trials) mixed linear models were constructed for acquisition IT, MT, DT, ET, and TT measures for the ABC and CBA groups. Separate one-way mixed linear models were constructed for acquisition IT, MT, DT, ET, and TT measures for the Whole group. Finally, separate 3 x 2 x 6 (Group x Retention Test x Trials) mixed linear models were constructed for retention test IT, MT, DT, ET, and TT measures for the ABC, CBA, and Whole groups.

Acquisition: ABC and CBA Groups

Initiation time. Figure 4 shows mean IT measures in ms for the A, B, and C task components for the ABC and CBA groups during acquisition. The effect of group, F(1,62.99) = 1.24, p = .268, was not significant. However, the effect of part, F(2,559.01) = 2.83, p = .059, approached being significant. In addition, the Group x Part interaction, F(2,559.01) = .11, p = .891, was not significant. Lastly, the Trial slope was -6.49.

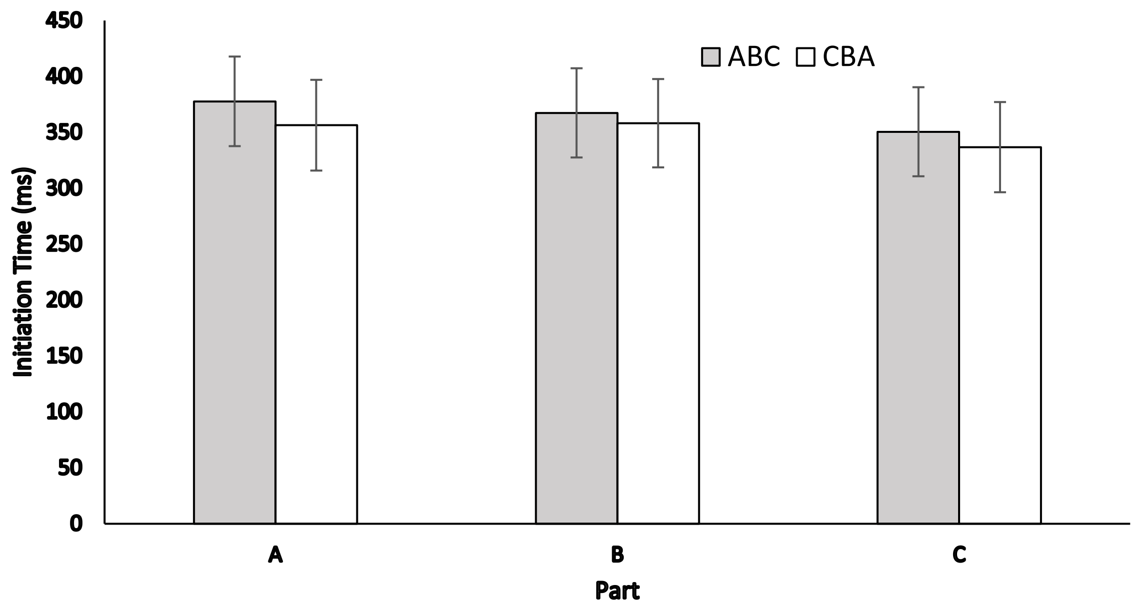

Figure 4. Shows mean IT measures in ms for the A, B, and C serial task components for the ABC and CBA groups during acquisition. Error bars indicate 95% confidence intervals of the means.

Execution time. Figure 5 shows mean ET in ms for the A, B, and C task components for the ABC and CBA groups during acquisition. It can be seen that ET was faster for the CBA group than for the ABC group for all three task components. The Trial slope was -29.43. The ANOVA performed on ET measures showed that the effects of group, F(1,45.50) = 10.13, p = .003, and part, F(2,558.92) = 6.54, p = .002, were significant. However, the Group x Part interaction, F(2, 558.92) = 1.30, p = .273, was not significant. The post hoc test revealed that the ABC group (*M* = 473.81 ms, 95% CI [423.92, 523.65]) was significantly slower than the CBA group (*M* = 392.70 ms, 95% CI [342.79, 442.61]), p = .026. Additionally, Part A, (*M* = 451.69 ms, 95% CI [413.36, 490.01]), was shown to be significantly slower than Part B, (*M* = 413.94 ms, 95% CI [376.01, 451.87]), *p* = .017.

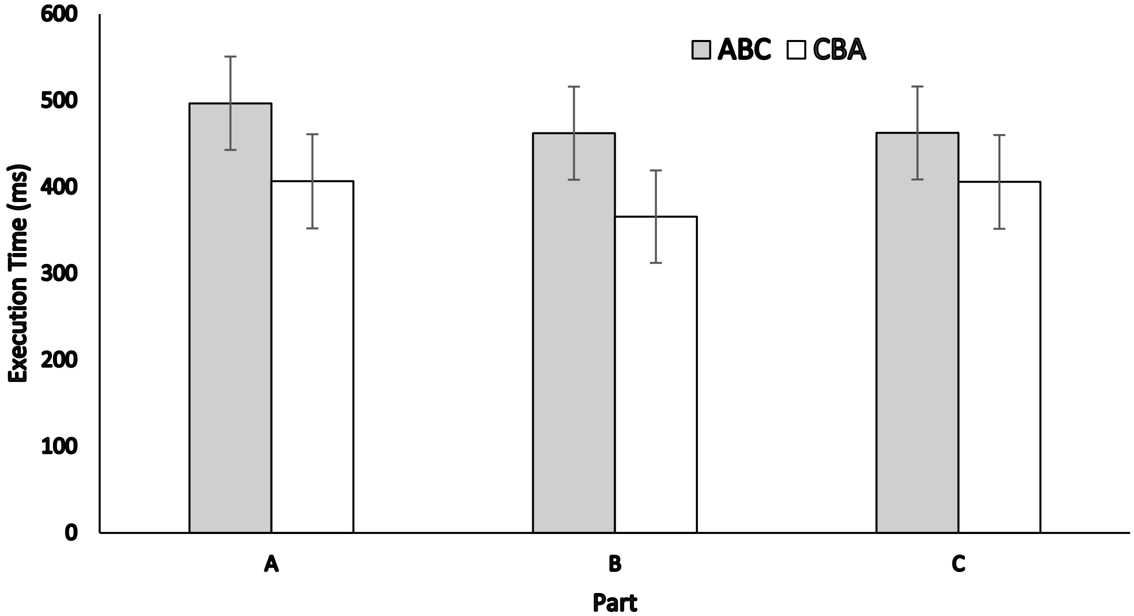

Figure 5. Shows mean ET measures in ms for the A, B, and C serial task components for the ABC and CBA groups during acquisition. Error bars indicate 95% confidence intervals of the means.

Total time. Figure 6 shows mean TT measures in ms for the A, B, and C task components for the ABC and CBA groups during acquisition. It can be seen that TT was faster for the CBA group than for the ABC group for all three task components. The Trial slope was -36.03. The ANOVA performed on TT measures showed the effect of group, $F(1,41.75) = 8.16$, $p = .007$, was significant. However, the effects of part, $F(2,558.63) = .72$, $p = .485$, and the Group x Part interaction, $F(2,558.63) = .75$, $p = .473$, were not significant. While the ABC group (*M* = 839.26 ms, 95% CI [767.34, 911.18]) was slower than the CBA group (*M* = 743.50 ms, 95% CI [671.49, 815.52]), the post hoc test narrowly missed being significant, $p = .064$.

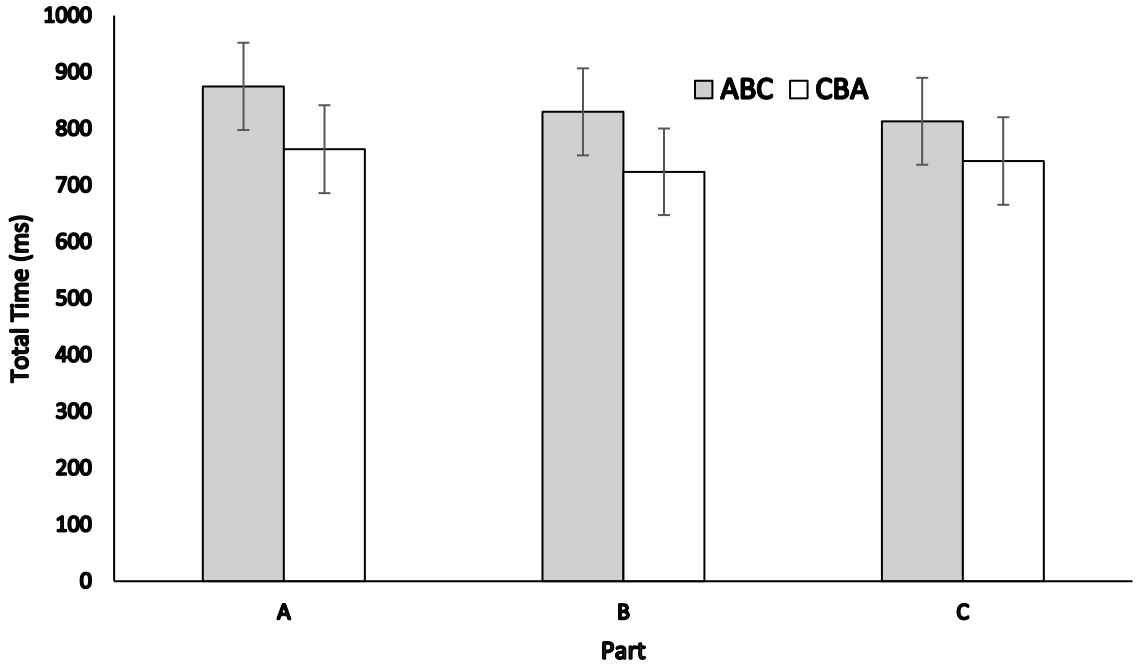

Figure 6. Shows mean TT measures in ms for the A, B, and C serial task components for the ABC and CBA groups during acquisition. Error bars indicate 95% confidence intervals of the means.

Movement Time 1. Figure 7 shows mean MT1 measures in ms for the A, B, and C task components for the ABC and CBA groups during acquisition. It can be seen that MT1 was faster for the CBA group than for the ABC group for all three task components. The Trial slope was found to be -6.94. The ANOVA performed on MT1 measures showed that the effects of group, F(1,50.30) = 18.90, p < 0.001, and part, F(2,559.00) = 4.28, p = 0.014, were significant. However, the Group x Part interaction, F(2,559.00) = 2.81, p = .061, was not significant. The post hoc test revealed that the ABC group (*M* = 210.78 ms, 95% CI [180.29, 241.27]) was significantly slower than the CBA group (*M* =136.63 ms, 95% CI [116.09, 177.18]), p = .005. Additionally, MT1 for Part A (*M* = 198.07 ms, 95% CI [174.29, 221.85]) was found to be significantly slower than MT1 for Part B (*M* = 161.46 ms, 95% CI [137.96, 184.96]), p = < .001.

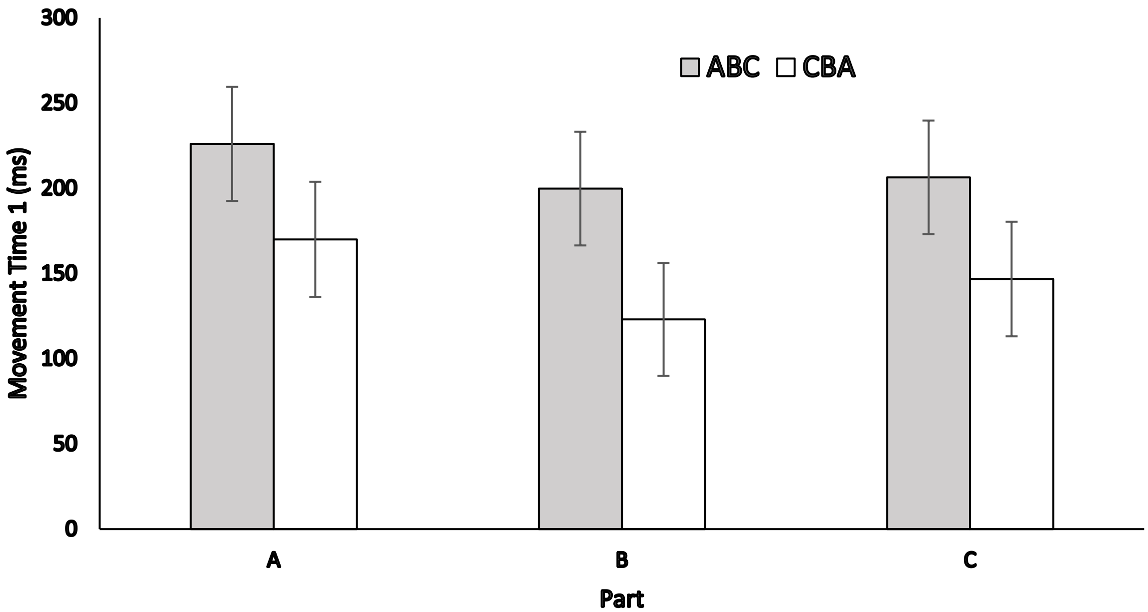

Figure 7. Shows mean MT1 measures in ms for the A, B, and C serial task components for the ABC and CBA groups during acquisition. Error bars indicate 95% confidence intervals of the means.

Movement Time 2. Figure 8 shows mean MT2 measures in ms for the A, B, and C task components for the ABC and CBA groups during acquisition. It can be seen that MT2 was faster for the CBA group than for the ABC group for the task components A and B. The ABC group was faster than the CBA group for task component C. The Trial slope was -18.62. The ANOVA performed on MT2 measures showed the Group x Part interaction, $F(2,560.89) = 7.41$, $p = .001$, was significant. However, the effects of group, $F(1,145.98) = .29$, $p = .591$, and part, $F(2,560.89) = 2.47$, $p = .085$, were not significant. The post hoc test revealed that there were no differences between the ABC and CBA groups and Parts A, B, C, $p > .05$.

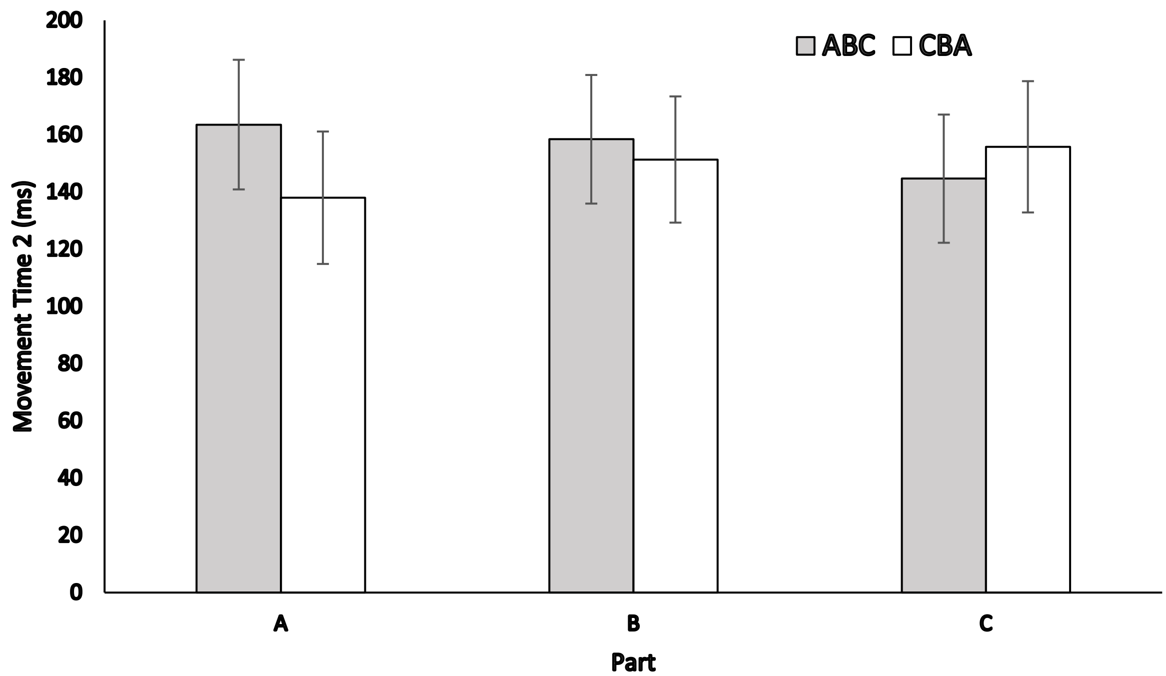

Figure 8. Shows mean MT2 measures in ms for the A, B, and C serial task components for the ABC and CBA groups during acquisition. Error bars indicate 95% confidence intervals of the means.

Dwell time. Figure 9 shows mean DT measures in ms for the A, B, and C task components for the ABC and CBA groups during acquisition. It can be seen that DT was faster for the CBA group than for the ABC group for all three task components. The Trial slope was found to be -3.61. The ANOVA performed on DT measures showed that group, F(1,32.90) = .92, p = .344, part, F(2,558.44) = 1.33, p = .264, and the Group x Part interaction, F(2,558.44) = 1.31, p = .268, were not significant.

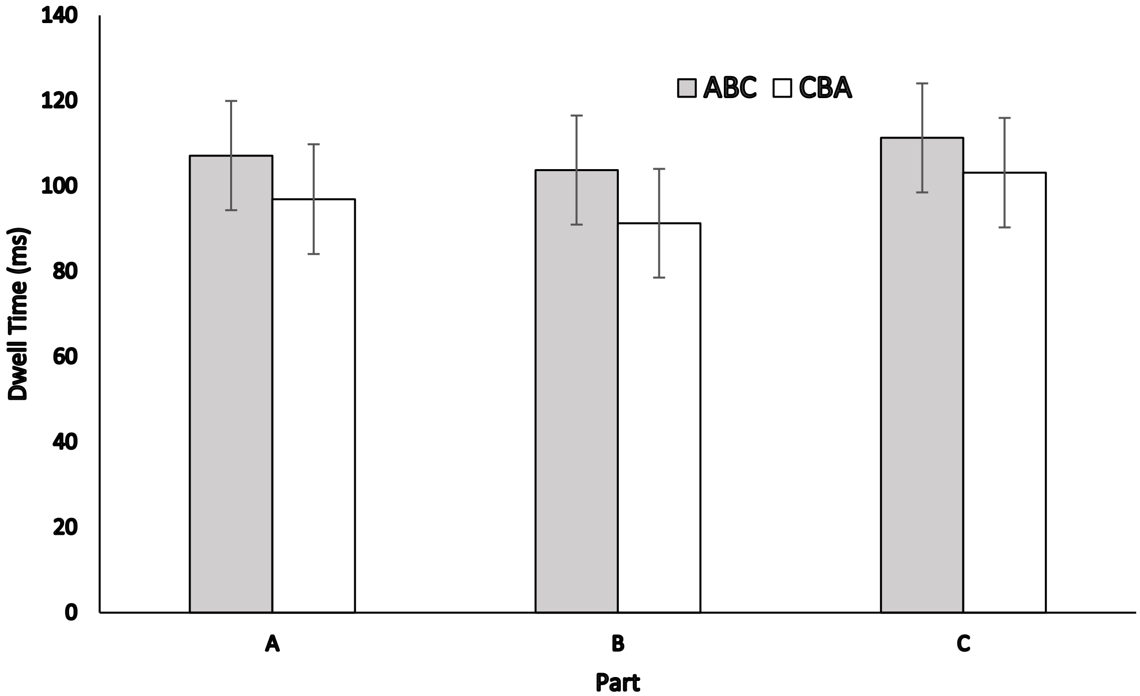

Figure 9. Shows mean DT measures in ms for the A, B, and C serial task components for the ABC and CBA groups during acquisition. Error bars indicate 95% confidence intervals of the means.

Acquisition: WHOLE Group

The ANOVA performed on the IT measures showed that the effect of Trials, $F(1,61) = 3.30$, $p = .074$, $M = 403.22$, 95% CI [374.68, 431.75], was not significant. The Trial slope was -13.36.

The ANOVA performed on the ET measures show that the effect of Trials, $F(1,58.15) = 11.83$, $p = .001$, $M = 1773.29$, 95% CI [1521.51, 2025.08], was significant. The Trial slope was -173.84.

The ANOVA performed on the TT measures show that the effect of Trials, $F(1,58.04) = 13.18$, $p = .001$, $M = 2176.75$, 95% CI [1915.46, 2438.04] was significant. The Trial slope was -188.12.

The ANOVA performed on the MT1 measures show that the effect of Trials, $F(1,52.05) = 27.77$, $p = < .001$, $M = 312.74$, 95% CI [250.60, 374.88], was significant. The Trial slope was -32.86.

The ANOVA performed on the MT2 measures show that the effect of Trials, $F(1,55.45) = 31.59$, $p = < .001$, $M = 198.41$, 95% CI [164.46, 232.36], was significant. The Trial slope was -27.15.

The ANOVA performed on the MT3 measures show that the effect of Trials, $F(1,57.91) = 20.77$, $p = < .001$, $M = 211.44$, 95% CI [164.31, 258.58], was significant. The Trial slope was -41.72.

The ANOVA performed on the MT4 measures show that the effect of Trials, $F(1,54.63) = 33.61$, $p = < .001$, $M = 191.19$, 95% CI [150.01, 232.38], was significant. The Trial slope was -30.92.

The ANOVA performed on the MT5 measures show that the effect of Trials, $F(1,61) = .79$, $p = .37$, $M = 203.44$, 95% CI [129.74, 277.14], was not significant. The Trial slope was -16.97.

The ANOVA performed on the MT6 measures show that the effect of Trials, $F(1,61) = .48$, $p = .487$, $M = 203.20$, 95% CI [130.42, 275.98], was not significant. The Trial slope was -13.11.

The ANOVA performed on the DT1 measures show that the effect of Trials, $F(1,51.86) = 34.96$, $p = < .001$, $M = 106.88$, 95% CI [89.35, 124.41], was significant. The Trial slope was -7.99.

The ANOVA performed on the DT2 measures show that the effect of Trials, $F(1,52.53) = 27.97$, $p = < .001$, $M = 101.24$, 95% CI [86.33, 116.16], was significant. The Trial slope was -7.85.

The ANOVA performed on the DT3 measures show that the effect of Trials, $F(1,52.20) = 24.90$, $p = <.001$, $M = 87.05$, 95% CI [73.03, 101.06], was significant. The Trial slope was -5.91.

The ANOVA performed on the DT4 measures show that the effect of Trials, $F(1,52.15) = 7.50$, $p = .008$, $M = 90.32$, 95% CI [74.33, 106.31], was significant. The Trial slope was -3.59.

The ANOVA performed on the DT5 measures show that the effect of Trials, $F(1,56.10) = 2.33$, $p = .132$, $M = 85.27$, 95% CI [71.71, 98.83], was not significant. The Trial slope was -3.21.

Retention: ABC, CBA, and WHOLE Groups

Initiation time. Figure 10 shows mean IT measures in ms for the ABC, CBA, and WHOLE groups for Retention Tests 1 and 2. It can be seen that IT was faster for the CBA group than for the ABC and WHOLE groups for both Retention Tests 1 and 2, and that IT for the CBA group was faster for Retention Test 2 than for Retention Test 1. IT for the ABC group was approximately the same for Retention Tests 1 and 2, while IT was slower for Retention Test 2 than for Retention Test 1 for the WHOLE group. The Trial slope was -14.61. The ANOVA performed on IT measures show the effects of group, $F(2,218.81) = .50$, $p = .602$, retention test, $F(1,325.65) = .23$, $p = .629$, and the Group x Retention Test interaction, $F(2,322.26) = 1.23$, $p = .291$, were not significant.

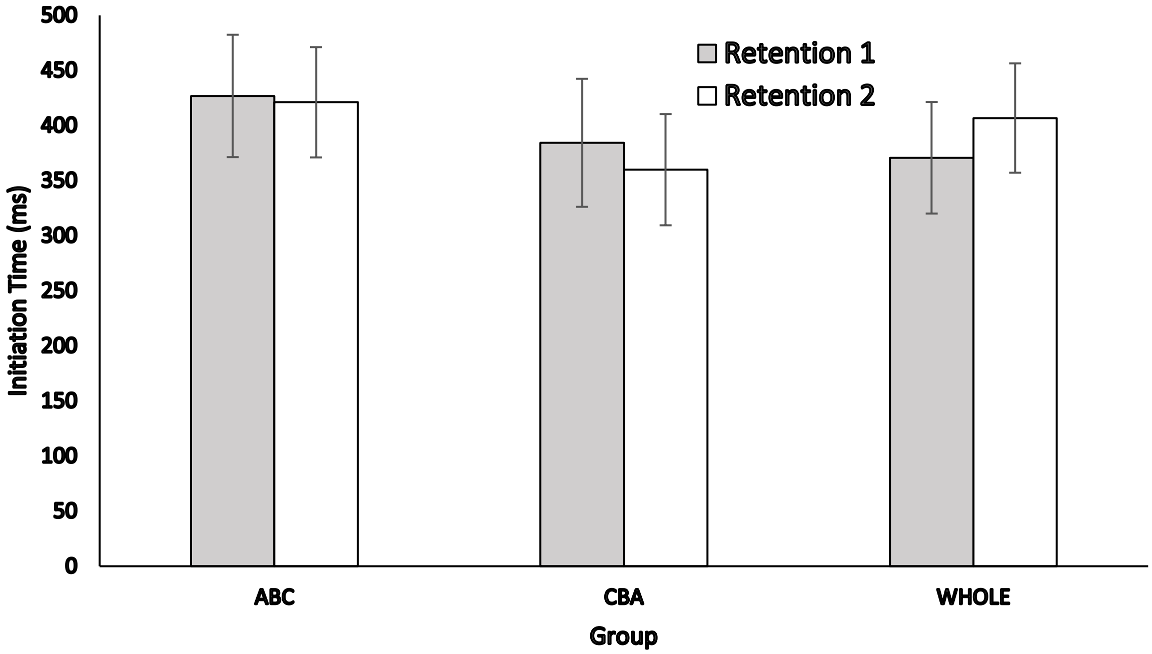

Figure 10. Shows mean IT measures in ms for the ABC, CBA, and WHOLE groups during retention. Error bars indicate 95% confidence intervals of the means.

Execution time. Figure 11 shows mean ET measures in ms for the ABC, CBA, and WHOLE groups in Retention Tests 1 and 2. It can be seen that the CBA and WHOLE groups performed significantly faster than the ABC group for Retention Test 1. However, there was a noticeable decrease in ET for the ABC group between Retention Test 1 and Retention Test 2. The ET differences between groups were small for Retention Test 2. The Trial slope was found to be -6.58. The ANOVA performed on ET measures showed that the effects of group, $F(2,124.89) = 8.81$, $p = < .001$, retention test, $F(1,323.13) = 42.29$, $p = < .001$, and the Group x Retention Test interaction, $F(2,321.51) = 20.76$, $p = < .001$, were significant. The post hoc test revealed that the ABC group (*M* = 1696.32 ms, 95% CI [1545.88, 1846.75]) was significantly slower than the CBA group (*M* = 1315.85 ms, 95% CI [1164.06, 1467.64]), p = .003, and Whole group (*M* = 1294.95 ms, 95% CI [1146.69, 1443.21]), p = .001, for both Retention Tests 1 and 2. Post hoc analysis of the retention tests revealed that ET for Retention Test 1 (*M* = 1624.71 ms, 95% CI [1528.05, 1721.36]) was significantly slower than ET for Retention Test 2 (*M* = 1246.70 ms, 95% CI [1155.10, 1338.31]), p = < .001. Finally, the post hoc test performed on the group ET measures for each retention test revealed that ET for the ABC group (*M* = 2054.95 ms, 95% CI [1886.94, 2222.97]) was significantly slower than ET for the CBA group (*M* = 1443.20, 95% CI [1270.55, 1615.84]), p = < .001, and WHOLE group (*M* = 1375.97 ms, 95% CI [1216.49, 1535.44]), p = < .001, for Retention Test 1 but that ET group differences for Retention Test 2 were not significant.

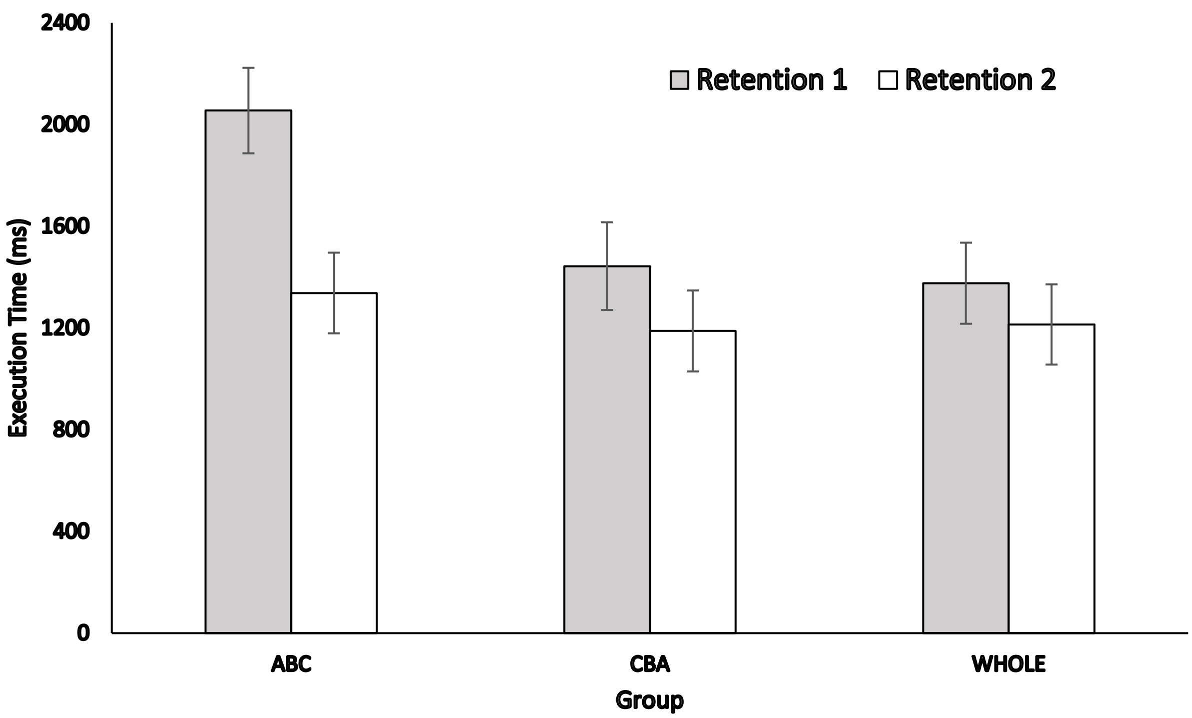

Figure 11. Shows mean ET measures in ms for the ABC, CBA, and WHOLE groups during retention. Error bars indicate 95% confidence intervals of the means.

Total time. Figure 12 shows mean TT measures in ms for the ABC, CBA, and WHOLE groups for Retention Tests 1 and 2. It can be see that TT for the ABC group was noticeably slower than for the CBA and WHOLE groups for Retention Test 1. In addition, there was a large reduction in TT between Retention Tests 1 and 2 for the ABC group. There was a small decrease in TT for the CBA and WHOLE groups between Retention Tests 1 and 2. The trial slope was -21.46. The ANOVA performed on TT measures showed the effects of group, F(2,115.00) = 6.24, p = .003, retention test, F(1,322.78) = 31.78, p = < .001, and the Group x Retention Test interaction, F(2,321.32) = 18.38, p = < .001, were significant. The post hoc test revealed that TT for the ABC group (*M* = 2121.37 ms, 95% CI [1944.73, 2298.01) was significantly slower than TT for the CBA group (*M* = 1688.01, 95% CI [1509.94, 1866.09]), p = .004, and WHOLE group (*M* = 1683.53, 95% CI [1509.20, 1857.86]), p = .003, for both Retention Tests 1 and 2. The follow-up test for the retention test difference revealed that TT for Retention Test 1 (*M* = 2019.68 ms, 95% CI [1907.27, 2132.10]) was significantly slower than TT for Retention Test 2 (*M* = 1642.26 ms, 95% CI [1535.24, 1749.28]), p = < .001. Finally, follow-up post hoc comparisons of group differences across the two retention tests revealed that TT for the ABC group (*M* = 2483.27 ms, 95% CI [2288.08, 2678.77]) was significantly slower than for the CBA group (*M* = 1828.87 ms, 95% CI [1628.56, 2029.18]), p = < .001, and Whole group (*M* = 1746.75 ms, 95% CI [1560.52, 1932.99]), p = < .001, for Retention Test 1, but that the differences in TT between groups were not significant for Retention Test 2.

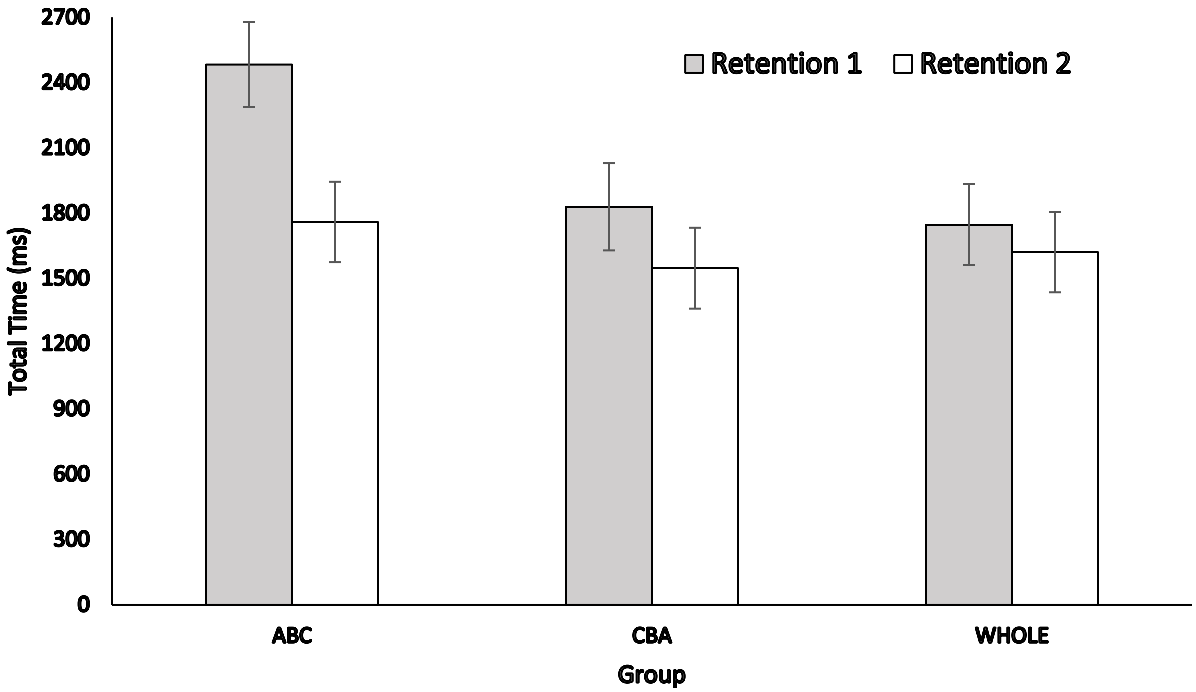

Figure 12. Shows mean TT measures in ms for the ABC, CBA, and WHOLE groups during retention. Error bars indicate 95% confidence intervals of the means.

Movement Time 1. Figure 13 shows mean MT1 measures in ms for the ABC, CBA, and WHOLE groups for Retention Tests 1 and 2. It can be seen that MT1 was slower for the ABC and WHOLE groups than the CBA group for both Retention Tests 1 and 2. The Trial slope was -9.95. The ANOVA performed on MT1 measures showed that the effect of retention test, $F(1,321.50) = 16.65$, $p = < .001$, was significant. In addition, the effect of group, $F(2,75.15) = 2.93$, $p = .059$, was marginally significant. The Group x Retention Test interaction, $F(2,320.69) = 1.52$, $p = .219$, was not significant. The post hoc test revealed that MT1 measures were significantly slower for Retention Test 1 (M = 243.07 ms, 95% CI [215.25, 270.88]) than for Retention Test 2 (M = 200.201 ms, 95% CI [173.17, 227.22]), $p < .001$.

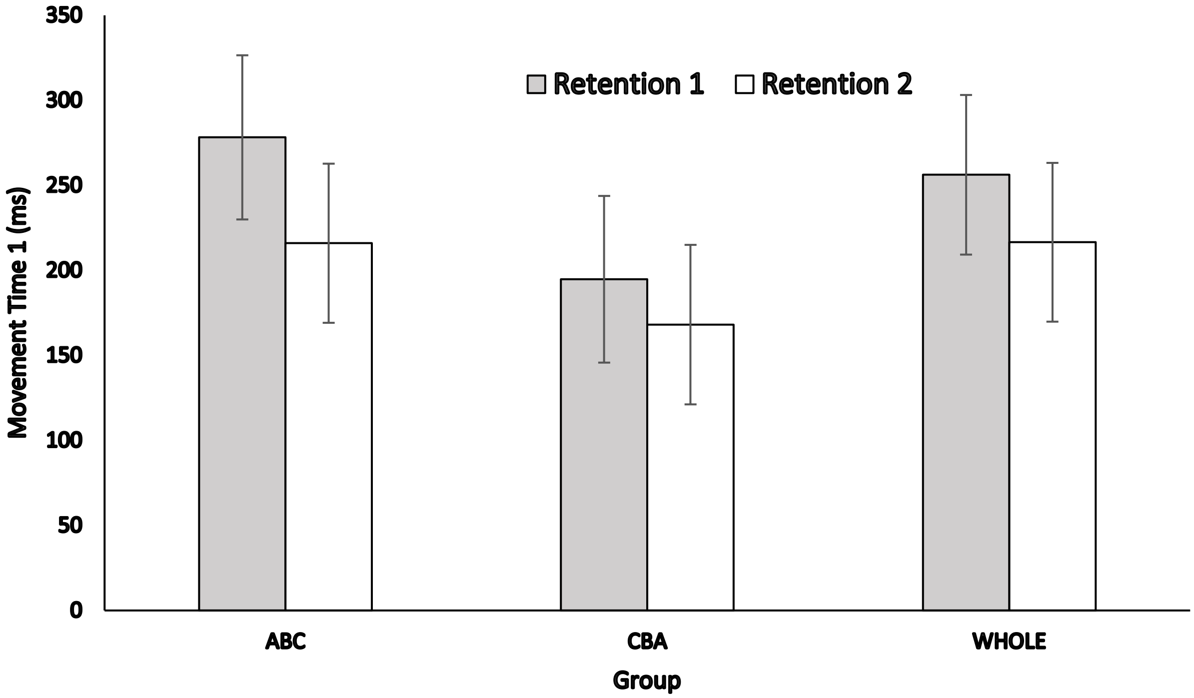

Figure 13. Shows mean MT1 measures in ms for the ABC, CBA, and WHOLE groups during retention. Error bars indicate 95% confidence intervals of the means.

Movement Time 2. Figure 14 shows mean MT2 measures in ms for the ABC, CBA, and WHOLE groups for Retention Tests 1 and 2. It can be seen that MT2 was noticeably slower for the ABC group than the CBA and WHOLE groups for Retention Test 1. The Trial slope was found to be < .01 The ANOVA performed on MT2 measures showed that the effect of retention test, F(1,327.52) = 3.95, p = .048, and the Retention Test x Group interaction, F(2,323.25) = 7.65, p = .001, were significant. However, the effect of group, F(2,257.06) = 2.22, p = .110, was not significant. The post hoc test revealed that MT2 was significantly slower for Retention Test 1 (*M* = 190.98 ms, 95% CI [170.68, 211.27]) than for Retention Test 2 (*M* = 148.44 ms, 95% CI [130.34, 166.55]), p = < .001. In addition, the post hoc test performed on group differences across the retention tests revealed that for Retention Test 1 the ABC group (*M* = 261.77 ms, 95% CI [226.34, 297.19]) was significantly slower than the CBA group (*M* = 163.41 ms, 95% CI

[126.09, 200.73]), p = .001, and the WHOLE group (*M* = 147.76 ms, 95% CI [116.02, 179.49]), p = < .001, but that the difference between the CBA and WHOLE groups were not significant. The group MT2 differences for Retention Test 2 were not significant.

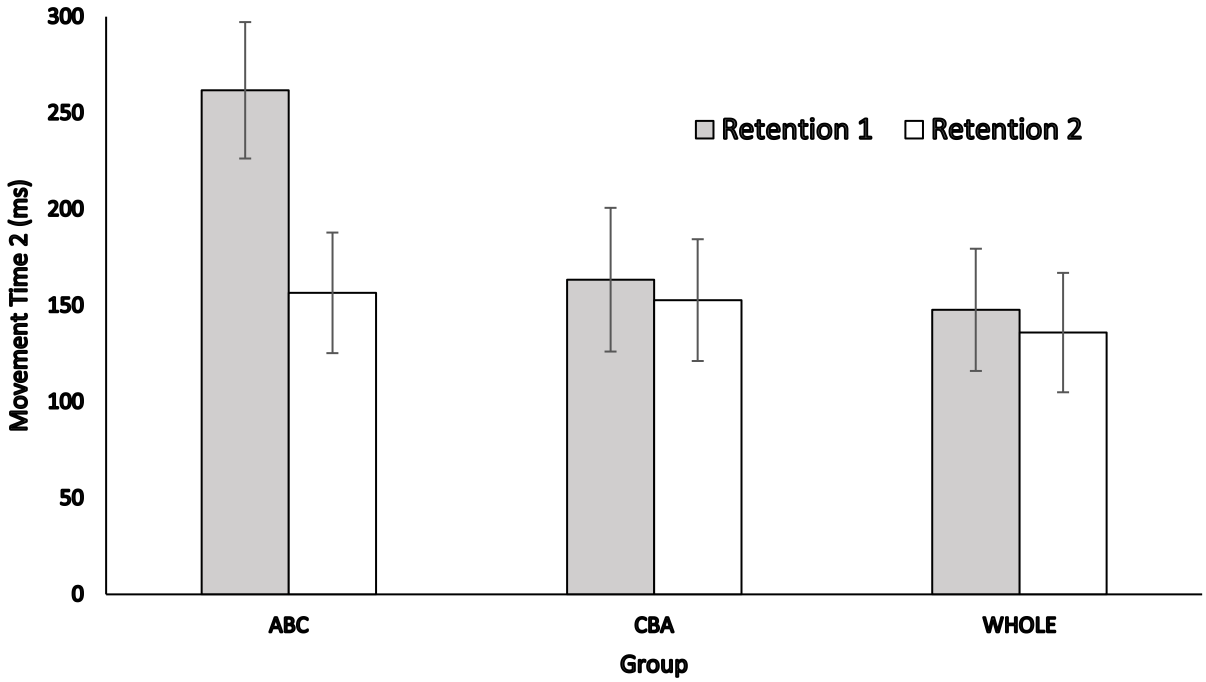

Figure 14. Shows mean MT2 measures in ms for the ABC, CBA, and WHOLE groups during retention. Error bars indicate 95% confidence intervals of the means.

Movement Time 3. Figure 15 shows mean MT3 measures in ms for the ABC, CBA, and WHOLE groups in Retention Tests 1 and 2. It can be seen that the ABC group had noticeably slower times for Retention Test 1 than the CBA and WHOLE groups. The Trial slope was -5.06. The ANOVA performed showed that retention test, F(1,324.37) = 6.53 , p = .011, and the Retention Test x Group interaction, F(2,321.68) = 6.79, p = .001, were significant. The effect of group, F(2,183.55) = , p = .096, was not significant. The post hoc follow-up test performed on the retention test main effect revealed that Retention 1 (*M* = 194.75 ms, 95% CI [169.99, 219.52]) was significantly slower than

Retention 2 (*M* = 131.08 ms, 95% CI [108.22, 153.93]), p = < .001. In addition, the post hoc follow-up test performed on the Group x Retention Test interaction revealed that the ABC group (*M* = 268.16 ms, 95% CI [225.03, 311.29]) was significantly slower for Retention Test 1 than the CBA group (*M* = 170.34 ms, 95% CI [125.50, 215.18]), p = .007, and the WHOLE group (*M* = 145.76 ms, 95% CI [105.86, 185.66]) p = < .001. However, the group differences for Retention Test 2 were not significant, all *ps* > .05.

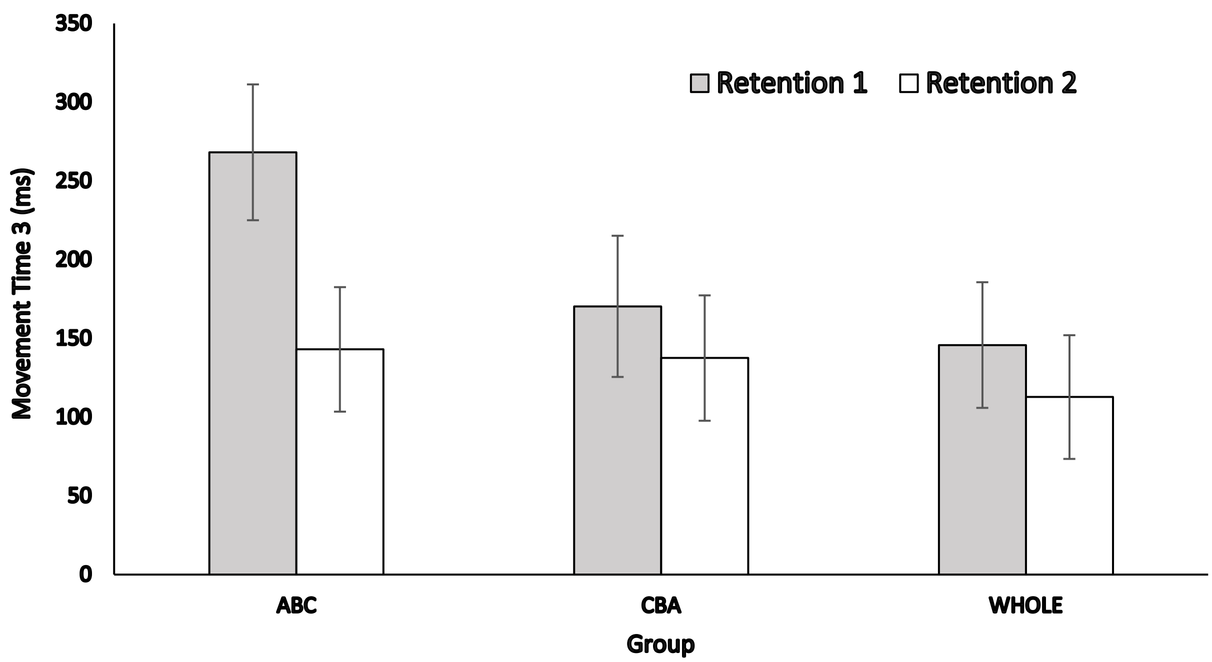

Figure 15. Shows mean MT3 measures in ms for the ABC, CBA, and WHOLE groups during retention. Error bars indicate 95% confidence intervals of the means.

Movement Time 4. Figure 16 shows mean MT4 measures in ms for the ABC, CBA, and WHOLE groups for Retention Tests 1 and 2. It can be seen that the ABC group performed slower for Retention Tests 1 and 2 than the CBA and WHOLE groups. The Trial slope was -2.91. The ANOVA performed on MT4 measures showed that group, F(2,145.16) = 4.56, p = .012,, was significant, and that retention test, F(1,323.00) = 3.75, p = .054, was marginally significant. The Group x Retention Test interaction, F(2,320.97) = 1.59, p = .205, was not significant. In spite of the obtained group significant main effect, the post hoc test revealed there were no significant group differences.

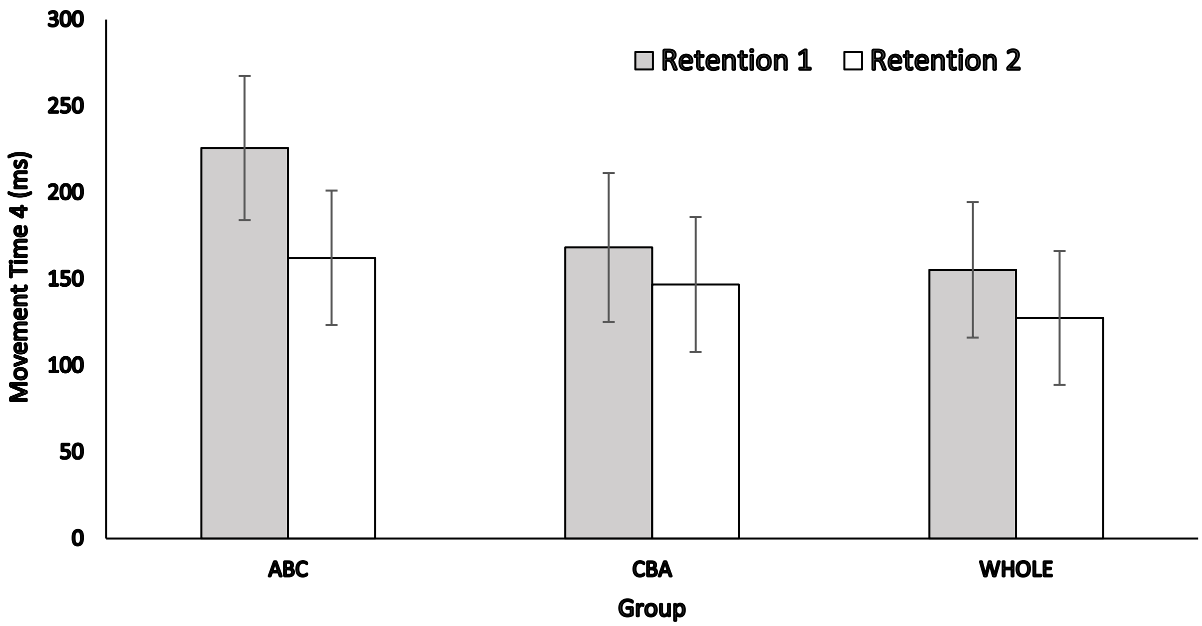

Figure 16. Shows mean MT4 measures in ms for the ABC, CBA, and WHOLE groups during retention. Error bars indicate 95% confidence intervals of the means.

Movement Time 5. Figure 17 shows mean MT5 measures in ms for the ABC, CBA, and WHOLE groups for Retention Test 1 and 2. It can be seen that both the ABC and CBA groups were slower during Retention Test 1 than the WHOLE group, but that between group differences for Retention Test 2 were negligible. The Trial slope was found to be 7.77. The ANOVA performed showed that the effect of group, F(2,327.93) = 4.32, p = .014, retention test, F(1,335.86) = 20.56, *p* = < .001, and the Group x Retention Test interaction, F(2,329.52) = 4.78, *p* = .009, were significant. The post hoc revealed that the ABC group (*M* = 164.22 ms, 95% CI [140.87, 187.57]) was significantly slower than the Whole group (*M* = 115.33, 95% CI [93.56, 137.10], p = .011, for both Retention Tests 1 and 2. Additionally, Retention Test 1 (*M* = 174.10, 95% CI [154.37, 193.81] was found to be significantly slower than Retention Test 2 (*M* = 111.05, 95% CI [94.39, 128.01], p <.001. The post hoc follow-up test performed on the Group x Retention Test interaction revealed that the ABC group (*M* = 211.94 ms, 95% CI [177.40, 246.48]) and CBA group (*M* = 190.27 ms, 95% CI [153.31, 227.41]) were both significantly slower than the Whole group (*M* =120.08 ms, 95% CI [90.45, 149.71]) for Retention Test 1, p = <.001, but the between group differences were not significant for Retention Test 2, all *ps* > .05.

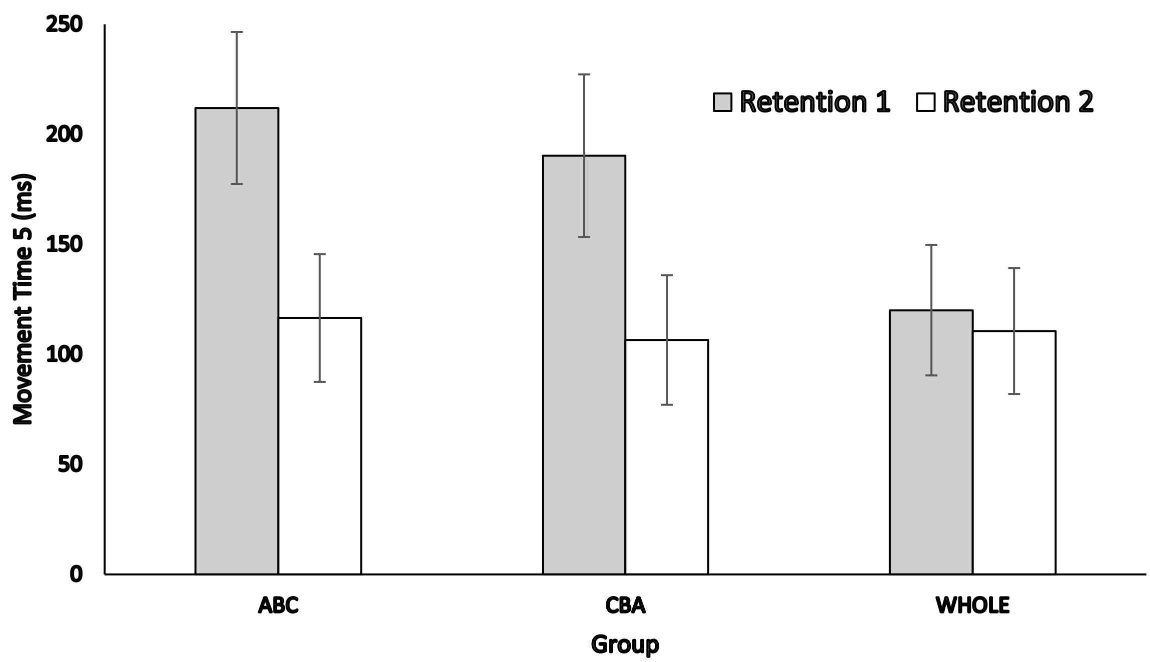

Figure 17. Shows mean MT5 measures in ms for the ABC, CBA, and WHOLE groups during retention. Error bars indicate 95% confidence intervals of the means.

Movement Time 6. Figure 18 shows mean MT6 measures in ms for the ABC, CBA, and WHOLE groups for Retention Tests 1 and 2. It can be seen that the ABC group performed noticeably slower during Retention 1 than both the CBA and WHOLE groups, but that between group differences for Retention Test 2 were small. The Trial slope was found to be 2.36. The ANOVA performed on MT6 measures showed that the effect of group, $F(2,307.44) = 3.42$, $p = .034$, retention test, $F(1,331.24) = 5.25$, $p = .023$, and the Group x Retention Test interaction, $F(2,325.13) = 7.75$, $p = .001$, were significant. The post hoc test performed on the group effect revealed that the ABC group (M = 188.32 ms, 95% CI [160.22, 216.42]) was significantly slower than the CBA group (M = 116.64 ms, 95% CI [87.667, 145.62]), $p = .003$, and WHOLE group (M = 120.19 ms, 95% CI [93.65, 146.74]), $p = .003$, but that the CBA and WHOLE groups did not differ, $p > .05$. When both retention tests were examined, Retention Test 1 (M = 170.01 ms, 95% CI [147.43, 192.60]) was found to be significantly slower than Retention Test 2 (M = 113.42 ms, 95% CI [93.88, 132.96]), $p = < .001$. Finally, the follow-up post hoc test performed on the Group x Retention Test interaction revealed that the ABC group (M = 255.77 ms, 95% CI [216.27, 295.28]) was significantly slower for Retention Test 1 than the CBA group (M = 122.73 ms, 95% CI [80.67, 164.79]), $p = < .001$, and WHOLE group (M = 131.53 ms, 95% CI [97.15, 165.91]), $p = < .001$. In addition, the between group differences for Retention Test 2 were not significant, ps > .05.

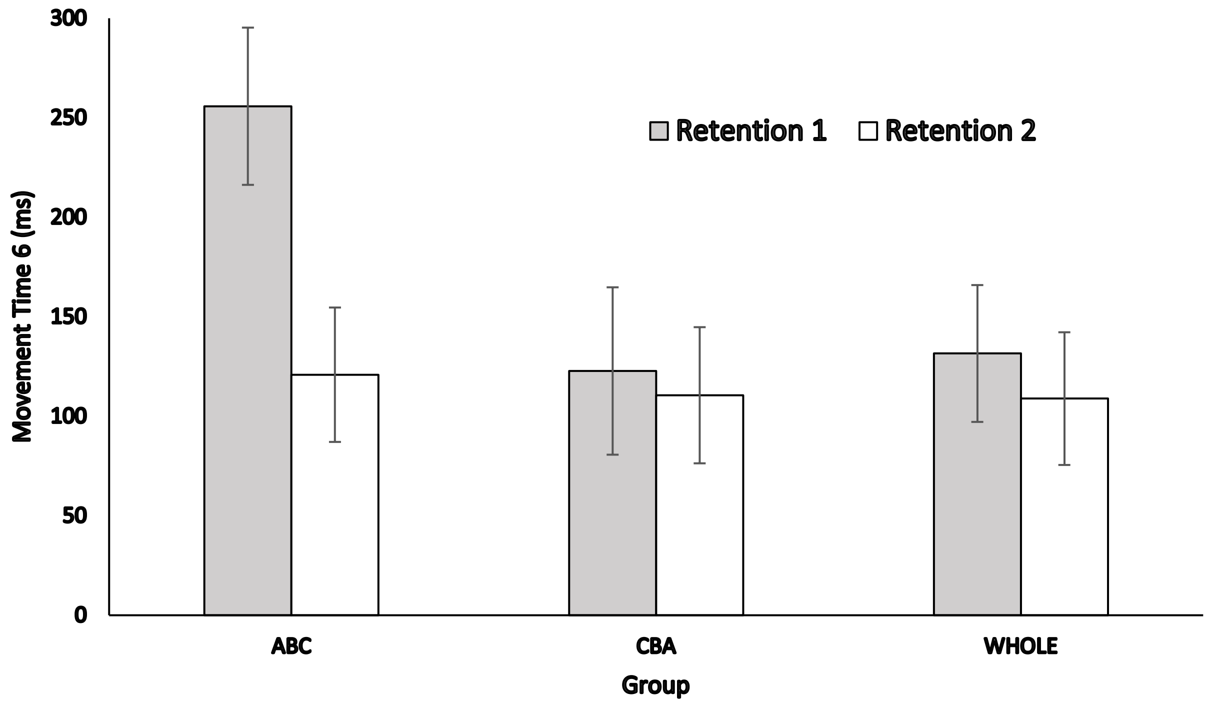

Figure 18. Shows mean MT6 measures in ms for the ABC, CBA, and WHOLE groups during retention. Error bars indicate 95% confidence intervals of the means.

Dwell Time 1. Figure 19 shows mean DT1 measures in ms for the ABC, CBA, and WHOLE groups for Retention Tests 1 and 2. It can be seen that the ABC group performed slower than both the CBA and WHOLE groups for Retention Test 1. The Trial slope was -1.53. The ANOVA performed on DT1 measures showed that the effect of group, $F(2,76.39) = 1.73$, $p = .184$, was not significant. The effect of retention test, $F(1,321.69) = 14.24$, $p < .001$, was significant. Post hoc analysis revealed that Retention Test 1 (M = 104.68 ms, 95% CI [97.75, 111.60]) was significantly slower than Retention Test 2 (M = 89.83 ms, 95% CI [83.10, 96.56]), $p = < .001$. In addition, the Group x Retention Test interaction, $F(2,320.86) = 7.43$, $p = .001$, was significant. The follow-up post hoc test revealed that DT1 for the ABC group (M = 120.63 ms, 95% CI [108.61, 132.66]) was significantly slower than the WHOLE group (M = 92.71 ms, 95% CI

[81.02, 104.39]) for Retention Test 1, p = < .005, but that the between group differences for Retention Test 2 were not significant, ps > .05.

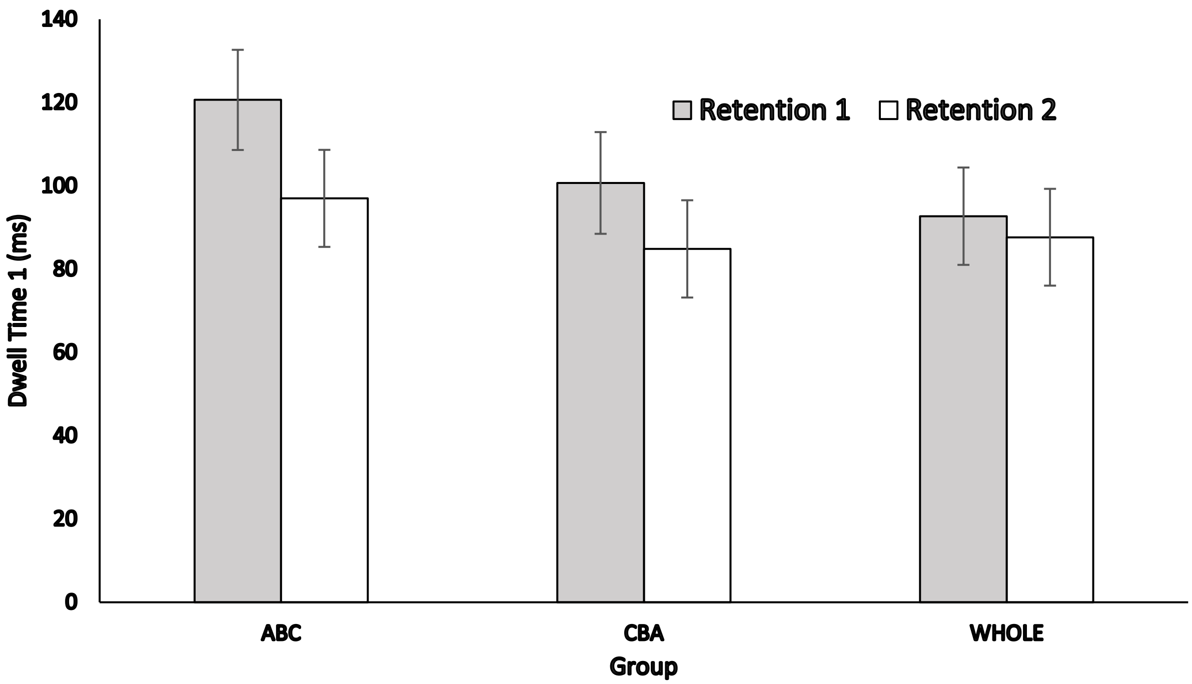

Figure 19. Shows mean DT1 measures in ms for the ABC, CBA, and WHOLE groups during retention. Error bars indicate 95% confidence intervals of the means.

Dwell Time 2. Figure 20 shows mean DT2 measures in ms for the ABC, CBA, and WHOLE groups for Retention Tests 1 and 2. It can be seen that DT2 for the ABC group was slower during Retention Test 1 than for the CBA and WHOLE groups. The Trial slope was 0.41. The ANOVA performed on DT2 measures showed that the effect of group, $F(2,98.11) = 4.52$, $p = .013$, was significant. The post hoc test revealed that the difference between the ABC group (M = 100.00, 95% CI [90.04, 109.96]) and the CBA group (M = 82.63 ms, 95% CI [72.61, 92.66]), $p = .05$, was significant. The effect of retention test, $F(1,322.52) = 34.82$, p = < .001, and the Group x Retention Test interaction, $F(2,321.35) = 13.08$, p = < .001, were significant. Further post hoc analysis confirmed Retention Test 1 (M = 96.32 ms, 95% CI [90.10, 102.55]) was significantly slower than Retention Test 2 (*M* = 81.73 ms, 95% CI [75.75, 87.71]. Follow-up post hoc analysis revealed that the ABC group (*M* = 112.91 ms, 95% CI [102.09, 123.73]) was significantly slower during Retention Test 1 than the CBA group (*M* = 91.41 ms, 95% CI [80.36, 102.45]), *p* = .021, and WHOLE group (*M* = 84.66 ms, 95% CI [74.26, 95.05]), p = .001, but that the CBA and WHOLE groups did not differ from each other.

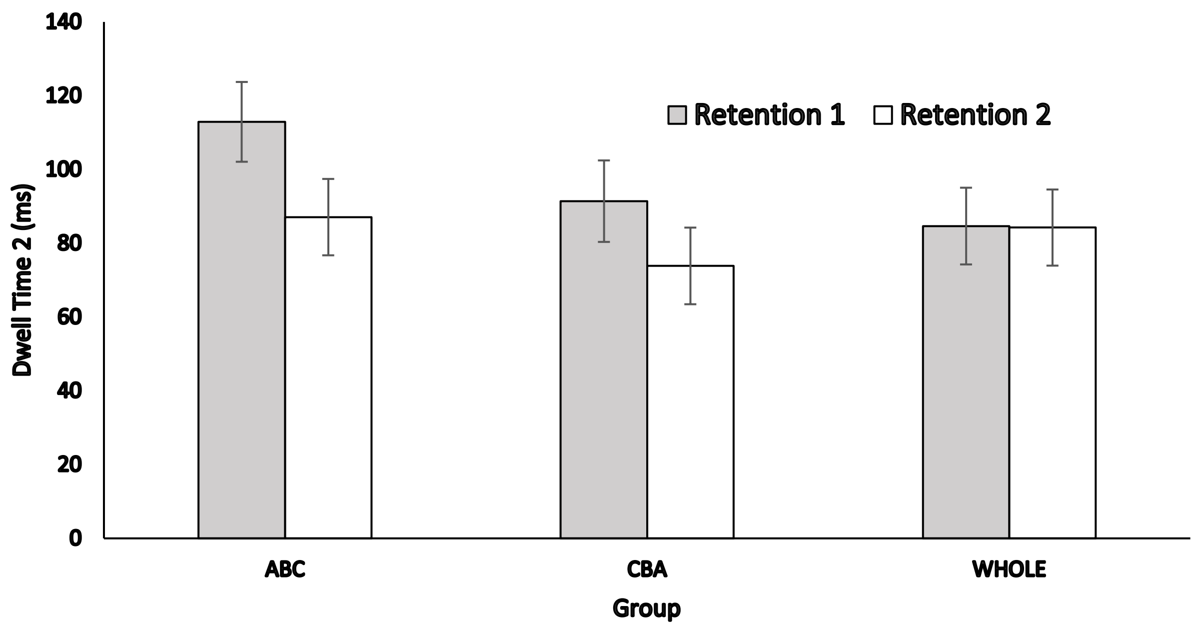

Figure 20. Shows mean DT2 measures in ms for the ABC, CBA, and WHOLE groups during retention. Error bars indicate 95% confidence intervals of the means.

Dwell Time 3. Figure 21 shows mean DT3 measures in ms for the ABC, CBA, and WHOLE groups for Retention Tests 1 and 2. It can be seen that the ABC group performed slower than the CBA and WHOLE groups for Retention Test 1. The Trial slope was found to be 1.09. The ANOVA performed on the DT3 measures show that the effects of group, $F(2,105.98) = 7.63$, $p = .001$, was significant. The post hoc analysis revealed that the difference between the ABC (*M* = 89.58, 95% CI [80.75, 98.41]) and CBA group (*M* = 73.75, 95% CI [64.86, 82.65]), p = .043, was significant. In addition, retention test, $F(1,323.20) = 37.06$, $p = < .001$, was significant. Follow-up analysis revealed that the slower DT3 for Retention Test 1 ($M = 87.22$ ms, 95% CI [81.66, 92.78]) than for Retention Test 2 ($M = 74.19$, 95% CI [68.87, 79.51]), $p = < .001$, was significant. Finally, the Group x Retention Test interaction, $F(2,321.95) = 10.92$, $p = < .001$, was significant. Post hoc analysis revealed that the differences in DT3 for Retention Test 1 between the ABC group ($M = 101.92$ ms, 95% CI [92.26, 111.58]) and the CBA group ($M = 79.65$ ms, 95% CI [69.77, 89.53]), p = .006, and WHOLE group ($M = 80.09$ ms, 95% CI [70.83, 89.34]) p = .006, were significant. However, between group differences for Retention Test 2 were not significant, *p*s > .05.

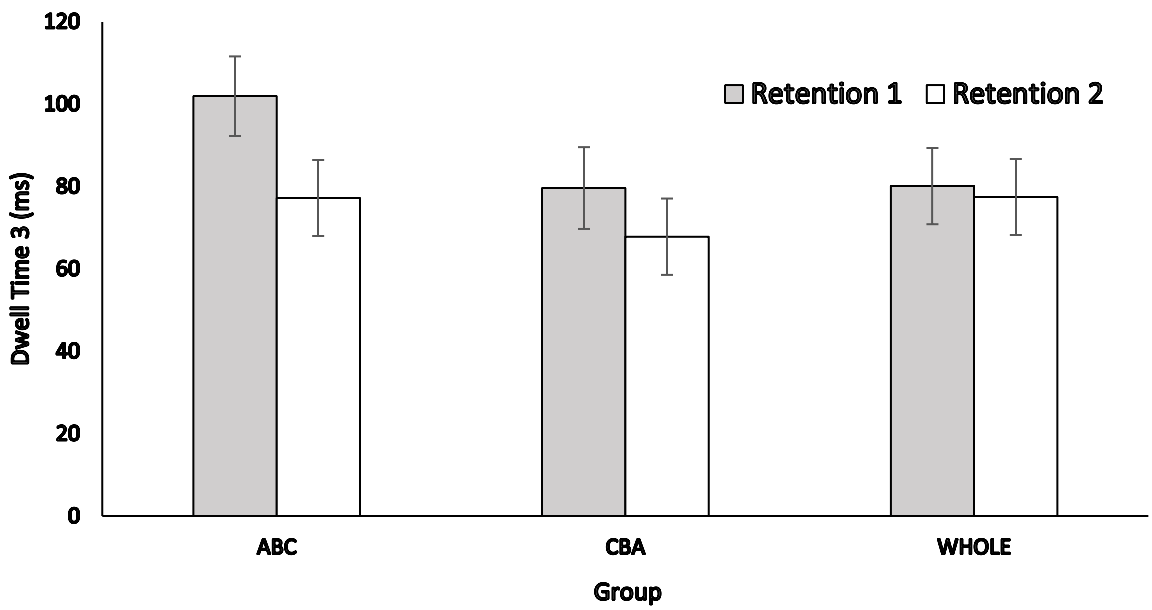

Figure 21. Shows mean DT3 measures in ms for the ABC, CBA, and WHOLE groups during retention. Error bars indicate 95% confidence intervals of the means.

Dwell Time 4. Figure 22 shows mean DT4 measures in ms for the ABC, CBA, and WHOLE groups for Retention Test 1 and 2. It can be seen that the ABC group performed slower than both the CBA and WHOLE groups for Retention Test 1, but the differences between groups for Retention Test 2 were small in size. The Trial slope was

0.46. The ANOVA performed on the DT4 measures showed that the effect of retention test, $F(1,322.84) = 27.03$, $p = < .001$, and the Group x Retention Test interaction, $F(2,321.70) = 8.58$, $p = < .001$, were significant. The effect of group, $F(2,98.17) = 2.91$, $p = .059$, was not significant. The post hoc test revealed that when both retention periods were examined, Retention 1 (*M* = 89.63, 95% CI [84.44, 94.81]) was significantly slower than Retention 2 (*M* = 77.32, 95% CI [72.34, 82.30]), p = < .001. Additionally, examining each Group x Retention Test revealed that the ABC group (*M* = 101.69 ms, 95% CI [92.68, 110.70]) performed significantly slower than the WHOLE group (*M* = 81.11 ms, 95% CI [72.45, 89.78]), p = .005, and the CBA group, (*M* = 86.08, 95% CI [76.88, 95.27], p = .05. There was no significant difference between the CBA group and the ABC or WHOLE groups. There were also no significant differences in Retention Test 2.

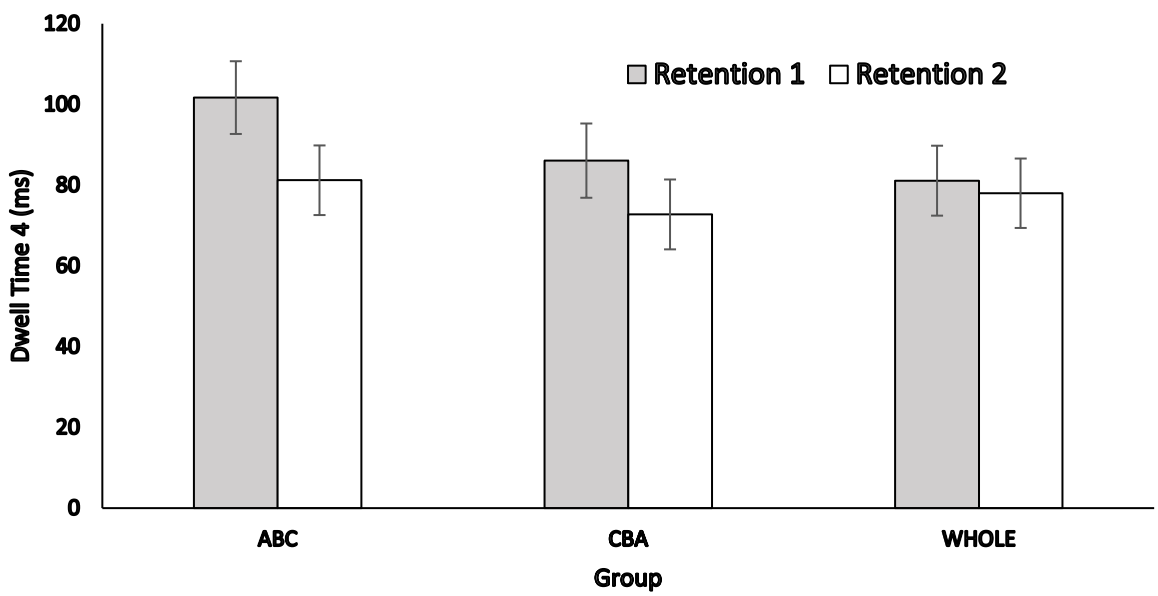

Figure 22. Shows mean DT4 measures in ms for the ABC, CBA, and WHOLE groups during retention. Error bars indicate 95% confidence intervals of the means.

Dwell Time 5. Figure 23 shows mean DT5 measures in ms for the ABC, CBA, and WHOLE groups for Retention Tests 1 and 2. It can be seen that DT5 for the ABC group was slower than for the CBA and WHOLE groups for Retention Test 1, and that the between group differences for Retention Test 2 were small. The Trial slope was found to be 0.87. The ANOVA performed on DT5 measures show that the effect of group, $F(2,95.30) = 8.16$, $p = .001$, retention test, $F(1,322.57) = 21.06$, $p = < .001$, and the Group x Retention Test interaction, $F(2,321.46) = 11.77$, $p = < .001$, were significant. The post hoc follow-up test revealed that the ABC group (*M* = 106.83 ms, 95% CI [84.92, 102.83]) was significantly slower for Retention Test 1 than the CBA group (*M* = 80.17 ms, 95% CI [65.80, 83.82]), $p = .001$, and WHOLE group (*M* = 79.37 ms, 95% CI [68.27, 86.00]), $p = .001$. Further post hoc analysis confirmed Retention Test 1 (*M* = 88.79 ms, 95% CI [83.21, 94.37]) was significantly slower than Retention Test 2 (*M* = 75.09 ms, 95% CI [69.72, 80.45]. Follow-up post hoc analysis revealed that the ABC group (*M* = 106.83 ms, 95% CI [97.14, 116.53]) was significantly slower during Retention Test 1 than the CBA group (*M* = 80.17 ms, 95% CI [70.28, 90.07]), $p = .021$, and WHOLE group (*M* = 79.37 ms, 95% CI [70.04, 88.70]), $p = .001$, but that the CBA and WHOLE groups did not differ from each other. There were also no significant differences in Retention Test 2.

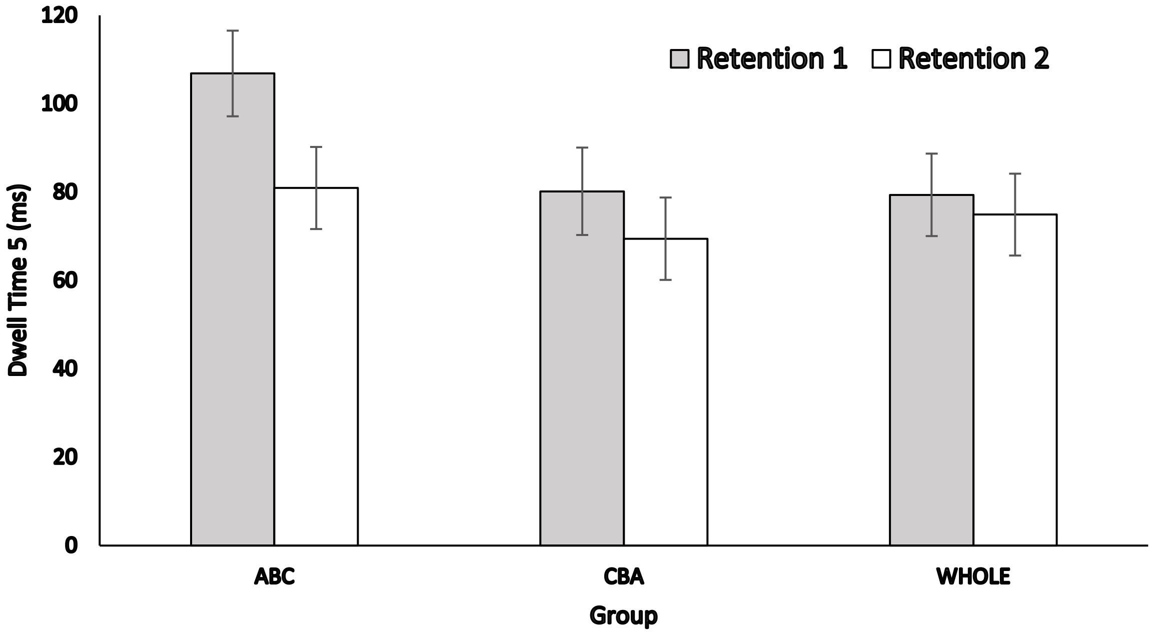

Figure 23. Shows mean DT5 measures in ms for the ABC, CBA, and WHOLE groups during retention. Error bars indicate 95% confidence intervals of the means.

Chapter 5

Discussion

The practice order of the two part groups showed interesting results during the acquisition phase. There were no IT differences between the ABC or CBA groups which showed both groups responding to the stimulus roughly equally. ET differences were evident as the CBA group was overall faster than the ABC group. Additionally, Part B was significantly faster than Part A, but not Part C. This is interesting because there was no significant Group X Part interaction, and the fact that Part B was the second part practiced for both groups. The fact that Part C was not significantly slower than part B also complicates ascertaining any rational explanation for this significant difference. Lastly TT revealed a significant Group effect difference, but missed significance in a further post hoc analysis.

Breaking down ET, MT1 showed that the ABC group was significantly slower than the CBA group, and Part A was significantly slower than Part B. This difference in MT1 between Part A and Part B looks to be caused by the CBA group's performance on Part B. However, the Group x Part interaction failed to reach significance, not allowing for further meaningful conclusions. MT2, there was a significant Group x Part interaction. However, post hoc analysis found no significant differences. DT measures revealed no significant differences as well.

In summary, there were very few differences between the ABC and CBA groups in the acquisition phase. This was to be expected, as both groups were learning the same parts but in a reversed order. Based on these results, one group did not appear to perform significantly faster at any one aspect of the sequences during the acquisition phase. The CBA group's performance advantage in ET's appears to stem from MT1 alone, as MT2 and DT1 did not produce any major differences.

The Whole group, which acted as a control group, overall showed a significant improvement during acquisition over trials for all dependent measures except IT, MT5, MT6, and DT5. Similar to the findings of the two part groups, IT did not improve. None of the groups changed their overall planning processes prior to MT1. Interestingly, MT5, DT5, and MT6 all did not improve over trials. Although possible, the recency effect during acquisition is an unlikely explanation for this performance discrepancy due to the low number of trials. This explanation would stem from the notion that the last two presses, which are associated with the dependent variables MT5, DT5, and MT6, were always in short-term memory. Another plausible explanation is the retroactive interference induced on the first three presses by the last three presses, which is plausible given the short amount of time allotted to view the task diagram and the subsequent execution of the task. Although interesting comparisons of the various dependent variables can be made with the retention data, no analyses were run due to the number of trials being different.

Both retention phases produced interesting results. Beginning with Retention 1, there were no significant differences for IT between the three groups. The ABC group, which previously had learned the same three parts in acquisition as the CBA group, performed significantly slower on ET, on the order of .6 seconds and .7 seconds, for the CBA and Whole groups, respectively. In addition and not surprising, TT results showed the same performance differences when examined. With IT not being significant, clearly, all differences in performance occurred within ET.

The ABC group was significantly slower than both the ABC and Whole groups for numerous MT's and DT's during Retention 1, respectively. In order to provide better context, see Figure 24 and Figure 25 in Appendix A. The ABC group performed significantly slower for MT 2, MT 3, MT 5, and MT 6 than the Whole group. The CBA grouped performed significantly slower for MT5 compared to the Whole group, but performed significantly faster than the ABC group for MT 2, MT 3, and MT 6. MT 1 and MT 4 saw no differences between the three groups in Retention 1. DT significant differences were found for the ABC group, which performed significantly slower compared to the Whole group in DT1, DT2, DT3, DT4, and DT5 during Retention 1. The CBA group was significantly faster than the ABC group for DT2, DT3, DT4, and DT5 measures in Retention 1. The CBA and Whole groups performed relatively similar during

Retention 1 for all the DT measures, with no significant differences resulting. Retention 2 yielded no significant differences for any of the MT or DT measures.

When examining the three groups, the ABC and CBA groups, in theory, should have had no differences, as the only distinguishing factor was the practice order in acquisition. However, and to the surprise of the author, this practice order appears to produce the aforementioned differences. In further investigating the differences between the three groups, it becomes apparent, that one of the explanations to this difference in performance is the CBA group benefiting from the recency effect during acquisition, allowing the CBA group to potentially form unique motor chunks, allowing for superior performance time of the Whole task. Since the CBA group in acquisition had part A as the very last practice trial, Part A was thus in short-term memory. Conversely, the ABC group had part C as the very last practice trial. Part C could then be deduced as have been in short-term memory. After the interpolated task, the consolidation of the three tasks should follow the order learned for each group. Looking at the significant differences in MT's between the ABC and Whole groups, CBA and Whole groups, and the ABC and CBA groups, the ABC group's main differences occurred during the first half of the Whole sequence and towards the very end. The recency effect, the author's knowledge, has not been directly linked to the performance found in part-whole learning experiments. The more appropriate approach to describing the findings would be a recency facilitation effect. By learning Part A last, as was the case for the CBA group, the learning of the Whole task was made easier due to expedited reorganization and subsequent formation of motor chunks. This is not the recency effect by standard usage in verbal learning studies, but relates to the serial position effect of the individual parts.

In addition to the recency effect being a possible explanation to the superior performance of the CBA group over the ABC group, retroactive interference may have played a key role. Based on the findings, Part A experienced close to no retroactive interference, while Part B may have experienced minimal, and Part C the most for the CBA group and vice versa for the ABC group. As mentioned, the MT's were much faster for the CBA group initially, having finally slowed at MT5. Conversely, the ABC group would experience a great deal of retroactive interference on Part A and Part B, which were shown in very slow MT's in general compared to the other two groups. Part C did not appear in the Whole task until the end, further making the argument that retroactive interference is another plausible explanation to the performance differences between the two part groups.

In examining the Whole sequence with both MT and DT measures, MT2, DT2, MT3, and DT3 were significantly slower in the ABC group when compared to the CBA group. MT1 and DT1 produced no differences, and this may in fact be due to the planning involved for the Whole task. However, the temporal differences shift immediately in favor of the CBA group with the remainder of the first three movements and key presses. MT4 produces no significant differences. DT 4, DT 5, and MT6 are then significantly faster for the CBA group compared to the ABC group. Very interestingly, the Whole group is significantly faster than both the ABC and CBA groups during MT5.

Between the three groups, the results suggest three separate approaches to the task for each group. The ABC group produces the sequence slow compared to the other groups, with each movement and key press occurring in the same temporal range, respective of the measures. The CBA group performs very similar to the Whole group.

Although MT1 was not significant, the times for the CBA group are faster than the Whole group, with the Whole and ABC groups producing similar times. The CBA group's performance becomes significantly slower than the Whole group at MT5, suggesting that a motor chunk has occurred at this point. Online processing occurs, and the remainder of the sequence is finished. Although beneficial to have Part A be the last trial in acquisition, the CBA group does not fully demonstrate a primacy effect, as the integration of part C into the Whole task does not occur based on the results. Lastly, the Whole group seems to perform the sequence unique to both part groups. After a brief temporal increase for MT1, both MT's and DT's decrease and remain constant, with no large increases for the remainder of the sequence.

Examining only Group differences for both Retention Tests, 1 and 2, the ABC group was significantly slower than both the CBA and Whole groups for ET, TT, MT6, and DT1. The ABC group was significantly slower than the Whole group for MT5. In addition, the ABC group was significantly slower than the CBA group for DT2 and DT 3. The effect of Group shows that although the ABC group did improve considerably during Retention 2, the improvement could not outweigh the performance for the same measures in Retention 1. Lastly, the overall times in Retention 1 were significantly slower than Retention 2 for all measures except IT and MT4. There was definitely an improvement for all groups during Retention 2, with the ABC group showing the largest improvement in times.

Although retention 2 produced no significant results, the improvement for the ABC group cannot be understated. The ABC group showed the greatest improvement of the three groups over all measures. This signifies that any performance advantage previously gained by the CBA group had been nullified after only six trials and a two minute rest period. Unfortunately, addressing this significant improvement becomes difficult from the standpoint of the current results since there was no significant differences for any measures in retention 2. However, it appears that the ABC group is performing similar to the Whole group due to IT, and the similar performance across all the MT's, especially MT1. The CBA group performs faster on MT1 than the other groups, but again, not fast enough to suggest different motor chunks between the three groups in Retention 2. In conclusion, all three groups have very similar performances, negating the profound learning effect found in Retention 1.

Chapter 6

Conclusion

This experiment investigated the practice order effects on sequence learning by utilizing a discrete sequential motor task. The part versus whole problem was examined, from the origins of the question to present day research inquires.

The initial hypotheses were correct and incorrect. The acquisition performance for both part groups was very similar, with no major significant differences that would allude to any inherent advantage going into retention testing. However, once the part groups were exposed to the Whole task, the ABC group performed significantly slower in numerous measures, including ET and TT. Simply practicing the constituent parts in order did not benefit performance upon transfer to the Whole task. However, after only six trials, the performance differences washed out with all three groups mirroring each other. The Whole group did not display a superior performance over both part groups during retention. Instead, the superior performance was localized to Retention 1, and particularly compared to the ABC group. Finally, dwell time did provide a unique measure to analyze in this experiment. To the author's knowledge, this is the first instance where dwell time has been examined during a sequence learning experiment of this nature. Dwell time may in fact prove to be a viable measure in sequence learning by either directly, or indirectly and in conjunction with other measures (MT), allude to motor chunking.

The actual distance between keys was not measured, as controlling individual movements made by the subjects for the task performed was not possible. This may in fact be valuable information that was unfortunately not examined. The force that subjects use to hit the key, and the actual location of the index finger between keys could also shed light on MT and DT data. In particular, was a subject pressing very hard on every key, potentially causing longer DT's? Was a subject spending more time in between movements closer or farther from the previous pressed key? To be able to visualize the actual pattern, 2D or 3D recordingsmay help confirm or disprove current findings.

In regards to Naylor and Briggs original description of part versus whole learning and task complexity, this experiment did not necessarily align smoothly (Naylor and Briggs) (task complexity defined as the number of movement segments; task organization refers to the temporal relationship between the composite movement segments (Magill; Brydges et. al)). The Whole group was superior in almost all measures compared to the ABC group in Retention 1. However, and minus MT5, the Whole group did not display superior performance over the CBA group. The error data, which was not fully analyzed, may be very informative when deciding whether or not to train highly organized, integrated tasks of simple complexity. The ABC and CBA groups appeared not to differ at all during acquisition, which again, was not surprising given the nature of the task. The Whole group showed large numbers of errors to begin acquisition, and quickly tapered off by the last trials. In the first Retention, both Part groups followed a similar pattern of errors around the first and seconds trials, and then quickly tapered off. The Whole group showed few if any during Retention 1. By Retention 2, all three groups had virtually no errors.

Finally, when designing and implementing different types of tasks for research and real world scenarios, which tradeoff is the most beneficial? Part or Whole? The question has been around for well over 100 years. Further research into the Part versus Whole question, with greater emphasis on cognitive psychology, may allude to a better understanding and more complete picture of how short-term, working, and long-term memory operate. Altogether, practice order effects on sequence learning were found in a discrete sequential task, suggesting that underlying cognitive processes and motor specific areas play a large role in shaping the acquisition of a motor skill.

Appendices

Appendix A: Expanded Figures

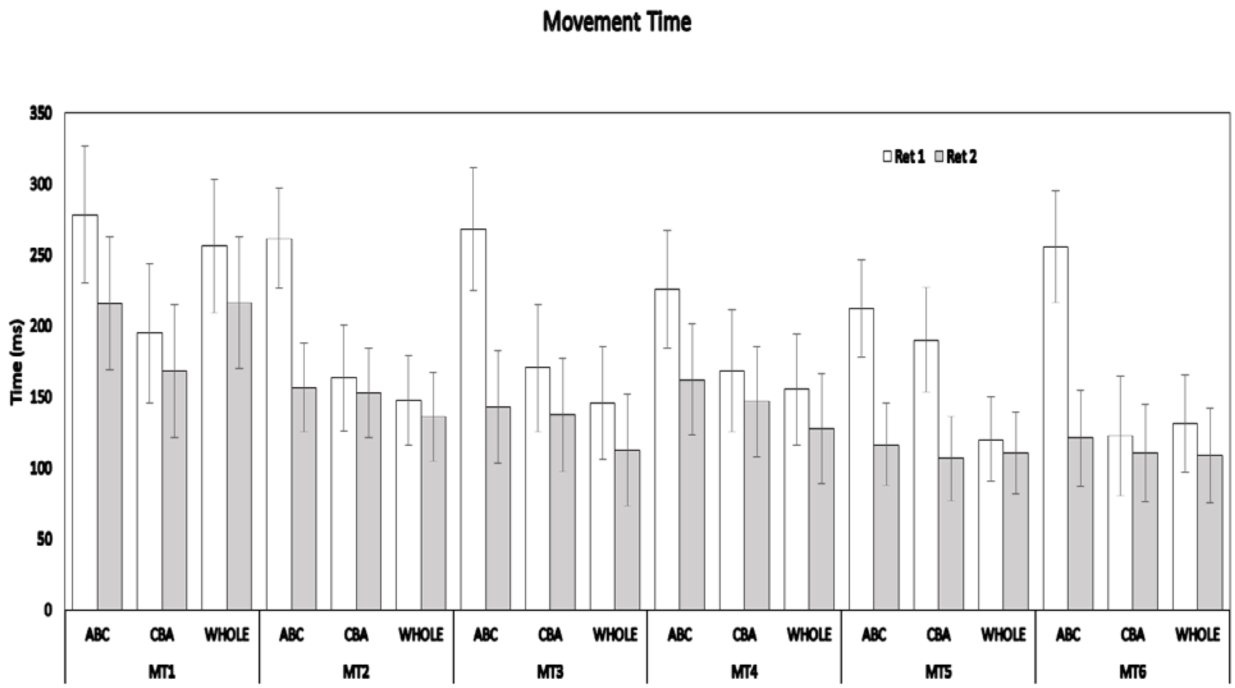

Figure 24. Figure 24 shows all the MT's for the ABC, CBA, and Whole groups, from Retention 1 and 2. Error bars indicate 95% confidence intervals.

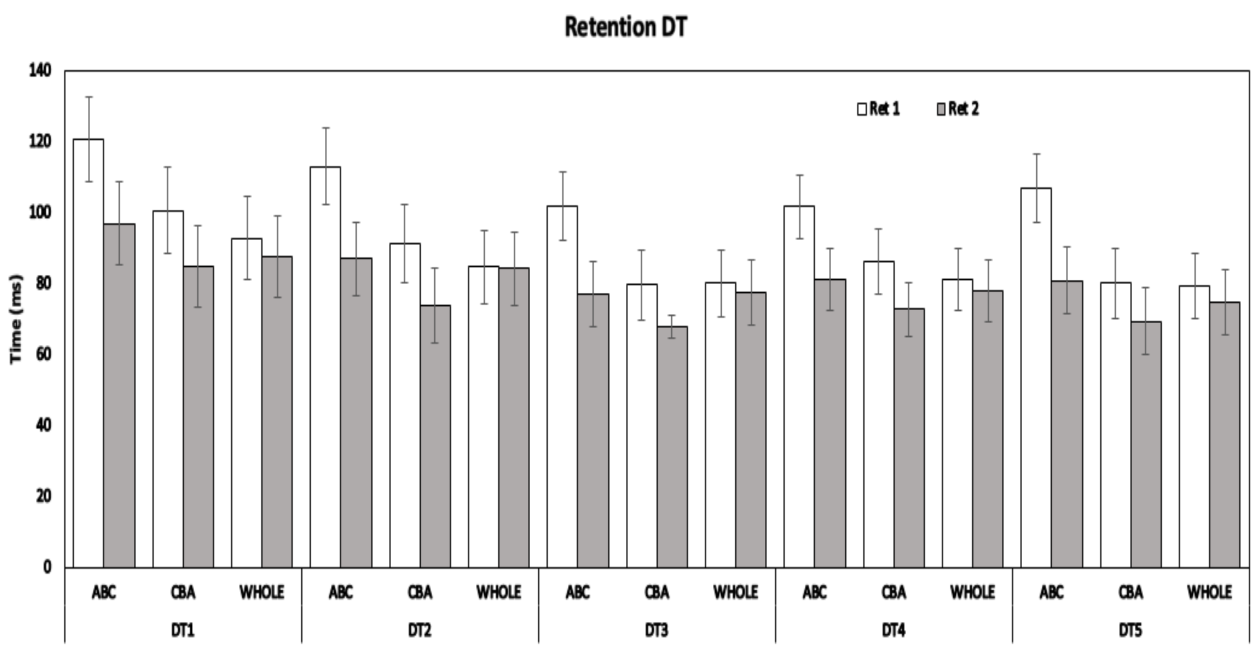

Figure 25. Figure 25 shows all the DT's for the ABC, CBA, and Whole groups during Retention 1 and 2. Error bars indicate 95% confidence intervals.

Appendix B: Subject Verbal Responses

Before debriefing, all subjects were ask to respond to a series of questions (the author recorded the verbal responses). Subjects in the ABC and CBA groups were asked the following questions:

1. Did the color of the diagrams serve any purpose?

2. Tell me about the task you performed after Tetris. Had you practiced this earlier in the experiment?*

*No comment initially. This occurred for numerous subjects. However, upon revealing the true nature of the experiment, no subject, no matter if they answered question 2 or not, when asked if they had explicitly known this to be the case after question 2, answered yes that they had practiced the parts of the whole. Afterwards, for many of the two part group members, the experimenter showed them himself or asked those to replicate the initial sequences they had learn. To their surprise, they saw that what they had practiced was indeed the parts to the green task (W). This was rather unexpected, and may have very interesting implications for future research.

In the Whole Group, the following question was asked:

1. What was the difficulty of the task during acquisition?

All subjects were then debriefed and thanked for their time. Some subjects declined to answer, and will be listed below with the word “declined” next to the letter. A total of 7 subjects declined to answer.

<u>ABC group</u>

Subject A

1. Color did not matter, if anything, served as a placeholder. Not a difficult task

2. I did not recognize the parts from earlier

Subject B

1. Maybe, jumped the gun on start key at first, became easier

1. No comment initially

Subject C

1. They served a purpose of knowing the start key. Quicker stimulus, easier than the longer ones

2. No comment initially

Subject D

1. Colors did not matter, did notice colors changed

2. Noticed that green task was all the parts after asked

Subject E

1. After a few times, would not have to look at diagram, just the color

2. Educated guess was off, did not know the parts were the whole

Subject F

1. Where does the starting point go in relation to the color? Focused on the starting point to remember the task

2. No comment initially

Subject H

1. The colors did not matter

2. I only looked at the bottom half of the task diagram at first, hard time getting the top half down. I got the task down around the end of the first retention period.

Subject I

1. No comment

2. Second part of the green task was hardest, I had to get the first part down

Subject J

1. No comment

2. Did not notice anything unique about the green task

Subject K-L Declined

<u>CBA group</u>

Subject M

1. No comment

2. Did not notice that the subject practiced parts of the whole

Subject N

1. Served as a pattern

2. Realized that what was practiced was parts of the whole as I was debriefing about the tasks

Subject O

1. Colors helped remember the association to the keys

2. No comment

Subject P

1. No comment

2. Did not recognize anything about the green task

Subject Q

1. Colors did not matter, task were relatively easy

2. No comment initially

Subject R

1. Helped know where the start key was located

2. Green task was harder to remember because it was longer

Subject S

1. Colors did not matter

2. Did not notice anything about the green task

Subject T

1. Colors did not matter

2. Green task went very quick, focused on the latter part of the task

Subject U

1. Colors did not matter

2. Beginning of green task was easy, focused on the arrows towards the end

Subject V

1. Colors helped with the placement of keys on the keypad; colors signified the start of the task

2. Beginning was easy, end was a bit of an issue for first few trials

Subject W

1. No comment

2. Part of the green task I knew, but I couldn't tell you why

Subject X Declined

<u>Whole group</u>

Subject Y

1. Easy task although took time to get used to

Subject Z

1. Color served no purpose, easy task

Subject AA

1. Focused on the first three arrows and then second three arrows

Subject AB

1. Diagrams, arrows, showed up very quickly. Thrown off during acquisition to begin, after Tetris, much easier

Subject AC

1. Remembered the task first by creating a "line", then by key

Subject AD

1. Followed arrows to begin, remembered the first few. Afterwards, pay attention to the last ones

Subject AE

1. Looked at entire diagram to begin, then focused on hardest part, developed a picture

Subject AF

1. Focused on arrow heads, looked at different points

Subject AG-AJ Declined

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Work History

Customer Service Associate, Lowe's Companies, Inc., South Bend, Indiana 2016-Present

Understand and perform all functions at the customer service desk

Enrollment Assistant, Office of the Registrar, Indiana University Bloomington 2015-2016

Part of a group of 60 individuals, including University Division Advisors, that assisted over 7,000 students each summer with a career path choice for each person's specific field of study, and acted as their liaison to the Registrar's Office

Adjunct Instructor, Department of Kinesiology, Indiana University Bloomington 2014-2016

Instructor for two classes: Weight Training and Personal Fitness

Weight Training: Emphasis on learning and implementing exercises specifically related to free weights and machines. ~120 total students

Personal Fitness: Emphasis on developing a personalized exercise program ~320 students

Float, Kroger, S College Mall Rd, Bloomington, Indiana 2013

Hired on as a cashier. Knowledge and experience allowed fluid movement between cashiering, floral, produce, natural foods, non-foods, and grocery departments

Martin's Super Markets, Erskine Plaza, South Bend, Indiana 2007-2011

Front-end cashier/bagger. Provided excellent customer service throughout tenure

Education

Fall 2013-2017 Indiana University, Bloomington, Indiana

Master of Science, Kinesiology, specializing in Motor Learning/Control

Thesis Title: Practice Order Effects On Sequence Learning

Graduate Award: 2014 Gallahue-Morris Research Scholarship

Fall 2009-May 2013 Indiana University, Bloomington, Indiana

Bachelor of Science, Kinesiology, specialized in Exercise Science

Minor: Psychology

References

Available upon request