The degree of relationship between tests of cognitive mechanisms

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THE DEGREE OF RELATIONSHIP BETWEEN
TESTS OF COGNITIVE MECHANISMS

by
Craig Lane

A thesis submitted in partial fulfillment
of the requirements for the degree of

Master of Science
in
Kinesiology

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ABSTRACT

In a variety of fields interested in cognition and cognitive processes 'tests' have been developed to help scientists infer a variety of cognitive processes. In the current study, the extent to which these tests share commonality in a predicted direction was assessed. Four tests were employed including the Stroop task administered via computer, the Stroop task administered manually, the Simon task, and an Inspection Time task. Eighteen undergraduates served as participants. The study was a one-way within subjects design. The dependent measure for the Simon and Stroop (automated) tasks was reaction time, while the number of correct responses was the dependent measure for Stroop (manual) and Inspection Time. A Pearson's Product Moment Correlation revealed that several tests correlated in a predictable direction. However, several surprisingly low correlations were noted that are not consistent with test based assumptions.
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CHAPTER ONE

INTRODUCTION

In most branches of psychology, researchers and practitioners have been interested in examining cognitive processes. Examples of such processes include memory, intelligence, and information processing. Because these processes occur within the central nervous system they are not directly observable. Therefore, indirect tests of the processes have been developed. The developers of these tests claim that the tests are valid measures of cognitive processes and mechanisms. Validation of these claims is necessary both to advance the science and to continue investigations of cognition. If these claims are correct, measures of specific identical processes should be strongly correlated and measures of overall cognition should be correlated with other measures of more specific cognitive processes. The purpose of the current study is to determine the degree of relationship between tests of mechanisms.

To understand the logic of the tests of cognitive processes, a basic understanding of information processing and intelligence is necessary. First, in regard to information processing, it is generally believed that three stages of processing exist; stimulus identification, response selection, and response programming. Stimulus identification is defined as the detection and identification of an environmental change. In the response selection stage of processing, the participant decides on an appropriate response, based on the information provided through stimulus identification. In the response programming stage, the commands to the muscles are organized and sent to the periphery.
Manipulations of stimulus and/or response sets have been used to ascertain certain aspects of information processing. Specifically, the speed with which responses are initiated (i.e., reaction time) is used to assess one’s information processing abilities. One example of such a manipulation is the Simon task.

In a typical Simon task participants are seated at a computer and required to press either a left- or right-hand key in response to a stimulus presentation. Two variables are manipulated in the Simon task; stimulus position and stimulus color. For example, a stimulus light may be either red or green. The light may appear on the left or right side of the computer screen. When the light is red, the participant is to press a key directly under the right index finger and when the light is green, the participant is to press a key directly under the left index finger, regardless of stimulus position. This manipulation is of the response selection stage of information processing because the participant must choose between two potential responses (i.e., left or right key press). Additionally, the Simon task is believed to test one’s ability to inhibit irrelevant information. The colored light may appear directly above the left or right key. If the red light appears above the right key, the response is generally fast and accurate. If the red light appears above the left key the response is generally slow and potentially inaccurate. The location of the light provides an irrelevant spatial cue that interferes with processing the relevant symbolic cue (color of the light). Therefore, the Simon tasks is said to test the response selection stage of the information processing model, as well as selective attention.

Present Study

The present study employed four tests of cognitive processes that have been suggested to have some degree of relationship. The Simon task, mentioned above, is considered a measure of response selection and selective attention. Two other tasks fall
in the category of Stroop tasks, and are also considered measures of response selection and selective attention. One version of the task was administered manually (Traditional Stroop), and the other was administered on a computer (Automated Stroop). The final task is known as an Inspection Time task, and is purported to be a measure of overall fluid intelligence.

In a traditional Stroop task, color names (e.g., BLUE) are written in different colors of ink (e.g., BLUE in blue or green ink). Participants are asked to name the color of the ink. If the word and color of ink are the same (compatible) the responses are generally fast and accurate. However, if the word and the color of the ink are different (incompatible) (e.g., BLUE in green ink) the responses are generally slower, due to the interference from the incongruent color-word pairings. Two versions of the Stroop task were administered. The first version was administered manually, with the Stroop color words printed on an individual testing booklet. This test is widely used in educational and clinical settings. The second version was administered on a computer, with the Stroop color-word pairs appearing on a computer monitor. Again, the participant is to press a response key assigned to the color of the letters. This test is widely used in experimental settings.

As discussed above, in a typical Simon task participants press either a left- or right-hand key, depending on the color of a stimulus light which appears on a display panel. The location of the light provides an irrelevant spatial cue that interferes with processing the relevant symbolic cue (color of the light). Stroop and Simon tasks are both said to test the response selection stage of the serial information processing model, as well as selective attention. In addition, both tasks test the level of inhibition of the irrelevant stimuli associated with each task. However, the interference in the Simon task
is the result of innate qualities rather than learned tendencies. These innate qualities are in terms of the "natural" spatial correspondence of the stimulus and response set. In the Simon task, the irrelevant cue that is to be inhibited is the spatial location of the stimulus. In the Stroop task, the irrelevant cues that are to be inhibited may be learned effects, such as the color or meaning of the Stroop color word. The two tasks seem to be similar on a superficial level, but may actually test different aspects of similar cognitive processes.

In the Inspection Time task, accuracy, rather than reaction time, is the critical variable. Participants view a visual array on a computer screen and are required to make judgments as to the nature of the array. The Inspection Time task is believed to test general, or fluid intelligence. Fluid intelligence is understood to be responsible for abstract thinking or reasoning. An Inspection Time task will help determine the extent to which these measures are global.

Several predictions could be made about the extent to which the previously mentioned measures are related. The first would be the extent to which the Stroop (automated) and Simon task are related. Both tasks are said to examine response selection and selective attention. The second correlation of interest would be between both Stroop tasks; automated and manual. The only difference between these tasks would be the way in which they are administered. The last correlation of interest would be between IT and all of the others. If IT is truly a measure of fluid intelligence, then the specific measures that Stroop (automated & manual) and Simon are believed to assess should be medium to highly correlated. The correlation with among Stroop tasks should be very highly correlated, as should the correlation between the Stroop tasks and the Simon task. The locus of interference in each task is not under question, merely the correlation between the tasks.
CHAPTER TWO

REVIEW OF LITERATURE

Introduction

In a variety of fields interested in cognition and cognitive processes such as memory and intelligence, 'tests' have been developed to help scientists view the processes of the mind. However, this view is figurative because to date no direct measures have been developed to examine cognitive functioning. Rather, tests have been constructed that are believed to examine such processes as memory, information processing, and intelligence. The extent to which these tests measure these processes is in question in the current study. Because the processes can not be directly measured, the means by which they will be assessed in the current study is to evaluate the degree to which measures that are presumed to test common cognitive processes are correlated.

Information Processing

Some of these processes are measured by manipulations of discrete stages of the serial information processing model. Information processing can be understood as the processing required to initiate a response once a stimulus has been presented. The time from the presentation of a stimulus to the onset of a response is termed reaction time. The information processing approach is a common way to study reaction time. Reaction time has been divided into three stages; central processing, peripheral processing or motor time, and movement time. The central processing time has been further fractionated into a number of discrete cognitive stages, the three general stages being stimulus identification, response selection, and response programming. The role of these three central processing stages is to recognize the external stimulus, select an appropriate
response to that stimulus, and program the commands to carry out that response.

Sternberg has argued that each one of the three stages is in fact discrete, or additive. This is the basis of his additive factors method (Sternberg, 1969).

The first stage of the information processing model is termed stimulus identification. Here the model begins with the input of information from the environment through one or more of the senses. There are two separate parts to this stage; sensation and perception. Sensation involves the detecting and/or selecting of specific sensory transmissions from the continual bombardment of transmissions impacting the central nervous system. Of course, there is so much information available (environmental stimuli) that it is unlikely that the resources for information processing act on all of them. Perception involves long-term memory because the sensations are being given meaning. It is essentially how we as humans perceive a stimulus. Important studies of chess players have demonstrated how perception is effected by memory (Chase & Simon, 1973). Master and good to average chess players were asked to reconstruct the location of the chess pieces from a half-finished game after viewing the board for 5 seconds. The master chess players were much more proficient than were the good to average players. The process of stimulus identification is thought to improve in the masters through years of experience in game situations. It is thought that the superiority of the chess masters in the given task is not due to the fact that they have learned to remember the patterns better, but that they are superior in their inherent perceptual ability (deGroot, 1965; Chase & Simon, 1973).

After the individual has analyzed the information from the environment in the stimulus input, the subject then decides to respond to the stimulus. The next stage of the information processing model is termed response selection. Response selection utilizes
current information and past experience to formulate a course of action. For example, a batter in baseball must utilize the information in the SI (stimulus identification) stage for processing the pitcher's motion, movement of the ball, instruction from the coach, situation in the game, position of the players, and so forth. As the number of alternative choices increases, so does the complexity and difficulty of the response. Hick (1952) and Hyman (1953) studied the relationship between the choice RT and the number of stimulus alternatives. The basic concept is that RT increases linearly as the number of stimulus alternatives increases. In equation form, \( RT = a + b \cdot \log_2 (N) \), where \( N \) is the number of stimulus-response alternatives and \( a \) and \( b \) are the empirical constants. In the previous case, the response is a conscious decision. In some cases there can be a nonconscious translation. Decisions are required when two or more alternatives are considered. Translation involves the relation of a particular stimulus to a particular response. Sometimes stimuli and responses are highly compatible. S-R compatibility refers to the extent to which the stimulus and the associated response are connected in a natural way. The more compatible the stimulus and response, the faster the RT.

The third and final stage of the IP model is termed response programming. Once the individual has identified the stimulus and selected a response, the organization and initiation of a response must be made. Once the response has been selected, the actions will be sent to the musculature thus achieving the desired outcome. The events that occur in response programming are very complex, requiring that some program of action be called from the performer's memory, that the program be prepared for activation, that the relevant portions of the motor system be readied for the program, and that the movement be initiated (Schmidt, 1988). Much like the stimulus identification stage, here the individual will have the opportunity to communicate with the environment. This stage of
processing can also be separately manipulated. Henry and Rogers (1960) studied the
nature of the movement to be made in a simple RT paradigm in which subjects knew on
any given trial which response was to be made. In different series of trials, Henry and
Rogers had subjects make different movements, while keeping constant the stimulus for
the movement, as well as the response alternatives. The first movement involved merely
lifting the finger from a key a few millimeters and had essentially no accuracy
requirement. For the second movement, the subject lifted the finger from the key and
moved approximately 33cm forward and upward to grasp a tennis ball suspended on a
string, which stopped a timer measuring MT. The third movement involved a second
suspended ball mounted 30cm to the right of the first ball. The subject lifted the finger
from the key, moved forward and upward to strike the first ball with the back of the hand,
move forward and downward to push a button, and then move forward and upward again
to strike the second suspended ball. Remember that the stimulus and responses for the
three movements were all exactly the same (so the processing speed of the SI and RS
stages should be the same), the only variation was the nature of the movement. Henry
and Roger's data revealed that as the manual complexity of the task increased, the RT
increased accordingly. The supposition was that motor commands are loaded into a
memory drum or motor output buffer when a stimulus is presented and, therefore, the
actual programming of the increased number of responses increased as well.

Attention

How we process information is effected greatly by the amount of interference that
occurs within the system. The interference can be virtually anything that we are aware of
at any given time that will divert the attention of the individual from performing the task
at hand. Attention can be defined as "taking possession of the mind, in clear and vivid
form”, out of what seem several simultaneously possible objects or trains of thought (James, 1890). Attention has always been a topic of major interest to psychologists and motor-behavior researchers alike. A number of features are important when talking about attention. The first being that attention is presumed to be limited, so we can only attend to one thing at a time or think only one thought at a time. This is essential to the field of psychology and motor-behavior, in that, humans seem limited in the number of things in which they are able to do at a given time, as if there were some capacity that were exceeded if too much was to be attempted at once. Attention also seems to be serial, that is we appear to attend to or perform first one thing then another. Furthermore it becomes very difficult to mix certain activities. These features enable researchers to manipulate distinct mechanisms of cognitive tasks, allowing a very special focus to be placed on different aspects of human information processing.

**Intelligence**

Processing information and responding to the changing environment are essential for aspects for humans to learn and adapt. Intelligence is defined as being just that; the ability to learn from experience and adapt to the surrounding environment. Today, there is an implicit idea of what intelligence is or should be. Within these ideas of what intelligence is or should be, researchers have come to realize that intelligence has different meanings in different contexts. Smart automobile mechanics may show different types of intelligence than smart neurosurgeons or smart lawyers. Some psychologists such as Edwin Boring (1923) have been content to define intelligence as whatever it is that the tests measure. In the case of human cognition, overall intelligence has come to be known as the ability for abstract thinking or reasoning. In terms of memory, overall intelligence is how one tends to remember bits or units of information in
an abstract form. Overall intelligence has been further broken down into two sub-categories; fluid and crystal intelligence. Crystal intelligence is information that seems to be hard wired in the system and/or has very strong neural connections. Examples of this are things like semantic (word knowledge) and procedural (how tasks are performed) memory. Examples of fluid intelligence include things such as episodic memory (previous occurrences or situations) and remote memory. Remote memory is the existing information that one puts together in a unique fashion (this is the stuff that wins you money on jeopardy). Overall intelligence is also referred to as fluid intelligence. Fluid intelligence is thought to decrease or decline as we age, therefore it is thought to be a global measure for human cognition.

Stroop Task

The first measure of interest has been around for many years and is widely used in the field today. It is called a Stroop color-word task. In 1935 Stroop published his monumental article on attention and interference. Strange as it may seem, the article is more influential now than it was then. The task taps into the cognitive operations of humans and offers ideas of how the process of attention works.

Evidence of the work on attention and interference were seen 50 years prior to Stroop in 1886 by Cattell. Prior to 1935, no one had attempted to combine colors and words until Stroop. His work provided insight to the interest in interference between conflicting processes. Stroop was primarily concerned with how best to explain interference.

In the traditional Stroop color-word task, the effect of incompatible ink colors on reading words aloud was examined. Stroop used five words and their matching ink colors: red, blue, green, brown, and purple. For each of the experimental conditions, each
ink color appeared twice in each row and column of 10 x 10 stimulus card. Each word appeared an equal number of times. The booklet used in this particular study employs only three words; red, green, and blue. The traditional test is sometimes referred to as the Serial Color-Word Test. In a typical test, subjects are tested on naming the colors of incompatible words and control patches. The interference is expressed in the difference in time between the two cards. The total time per card divided by the number of stimuli on the card is sometimes used to estimate time per stimulus.

There is now an extensive data base showing the work done on the Stroop color-word task as well as the work done on the relationship between word and picture naming (Babbitt, 1982; Bryson, 1983; Dunbar, 1986; Irwin & Lupker, 1983; Lupker & Katz, 1981, 1982; Lupker & Sanders, 1982; Magee, 1982; Rayner & Springer, 1986; Reiner & Morrison, 1983; Smith & Kirsner, 1982; Smith & Magee, 1980; Toma & Tsao, 1985). This particular relationship is interesting in that it attempts to locate the locus of interference. Many of the proposed models attempt to explain the interference in terms of response competition. These views are often referred to as "late selection" accounts, in that the conflict occurs late in processing at a response stage as opposed to "early selection" at encoding, for example (MacCleod, 1991). The most favorable trend for researchers has been to lean toward the late stages of information processing. This trend has been consistent for many years.

The most prominent version of early selection was the perceptual encoding account (Hock & Egeth, 1970). The overall idea was that perceptual encoding of ink colors was slowed by the color of the word serving as incompatible information, as opposed to a neutral control. They suggested that color related words are recognized earlier and thereby more likely to distract from encoding ink color.
The interpretation was questioned by Dalrymple-Alford and Azkoul (1972) and Dyer (1973c) arguing that the interpretation by Hock & Egeth (1970) failed to distinguish between identification and covert naming, and that the conclusions of Hock and Egeth (1970) rested on accepting the null hypothesis. The only other finding that was consistent with Hock and Egeth (1970) was that of Teece and Dimartino (1965). They stated that words spoken at the time of ink color encoding can either facilitate or inhibit that encoding.

The most recent development of models of cognition contends that attention was limited during each stage of processing, and the processing involved in each stage must be completed before moving on to the next stage. In the recent views, many explanations vary, but the overall idea still holds true that the majority of the interference effect occurs in the response selection stage. Some parallel distributed models have been presented (McCleland, 1979; Rumelhart, Hinton, & McCleland, 1986) but nothing to date has been presented to show an overall explanation of the interference effect that occurs within the Stroop color word task.

Simon Task

Simon and his associates (Craft & Simon, 1970; Simon 1969; Simon, 1970; Simon & Rudell, 1967) have used a paradigm that is similar to the Stroop paradigm to investigate the effect of conflicting cues on information processing. In a typical Simon task, subjects might press a left- or right-hand key, depending on the color of a stimulus light which appears on the left or right side of a display panel. In this case, the location of the light provides an irrelevant spacial cue that interferes with processing the relevant symbolic cue which is the color of the light. In other words, reaction times are faster on trials in which the location of the stimulus and response correspond than on trials in
which they do not correspond. The speed of reaction time is known to depend on the spatial relationship between stimulus and response.

There have been numerous attempts to locate the Simon effect within a hypothetical series of processing stages (e.g., serial information processing model) by applying the Additive Factors Method suggested by Sternberg (1969). The logic of this method is that if two given task variables affect different stages, their statistical effects combine additively, while a statistical interaction of their effects is taken to indicate that they both affect a common stage in information processing. Simon effects have shown to combine additively with variables that are assumed to influence early stages in information processing, namely stimulus identification (Acosta & Simon, 1976; Simon, 1982; Simon & Berbaum, 1990; Simon & Pouraghabagher, 1978; Stoffels, Van der Molen & Keuss, 1985). Correspondence effects, on the other hand, combine additively with the effects of variables that presumably affect motor programming or later stages, such as response specificity, movement amplitude, and relative stimulus-response frequency (Stoffels, Van der Molen & Keuss, 1989), as well as time uncertainty and accessory intensity (Stoffels et al., 1985). Clear interactions between correspondence effects and S-R mapping have been found, in that, some variable (e.g. accessory location) is related to response selection (Simon, Mewalt, Acosta, & Hu, 1976; Stoffels et al., 1985). If these results are taken together the locus of the Simon effect points to the response selection stage. It seems relatively fair to assume that the effects of the irrelevant location cues are thought to arise independently of processes located at rather early or rather late stages in information processing.

The Stroop and Simon effects are similar on a superficial level and there is some evidence that both the effects might involve the same processing stage. Therefore, it is of
great interest to determine the relationship between the two interference effects.

Sternberg's additive factors method (1969) provides a powerful tool for examining the stages of processing and defining the stages of processing which occurs in each stage.

**Inspection Time**

Human cognition has been mentioned previously by referring to specific measures of cognition. Researchers as well as clinicians are interested in mental abilities and are searching for underlying causes of individual differences, mainly in fluid intelligence. Fluid intelligence has been highly correlated with IQ tests, therefore its potential for understanding individual differences in cognitive functioning has been expunged via IT tasks. Figure 2.1 shows an IT stimulus known as a pi figure. It has two parallel, vertical lines, with one being longer than the other. The two lines are adjoined at the top by a vertical line. There are two forms of this figure, one with the longer line being on the right side, and one on the left. Subjects are asked to determine which line appears to be longer after the stimulus has been presented for a given amount of time. The discrimination is so easy that the range of scores varies across a wide range of ages and mental ability levels. However, the performance can be made more difficult. The exposure time can be limited by allowing the subject to view the stimulus for a limited amount of time. As the exposure time decreases, the amount of correct answers also decreases. In order to prevent the subjects from processing information in ionic storage after the figure has been removed, the presentation of the stimulus may be followed by a visual backward mask (see Figure 2.2). On each trial the subject is asked to respond to which line appears to be longer. There are no requirements to respond quickly, and the subjects are encouraged to respond at their leisure. This is an important feature of the IT task in which only the correctness of the subjects judgment is taken, no RT measure is
Again, IT has been used to assess individual differences in intelligence but is has been referred to as the speed of intake of information. The idea that the quickness of intake of visual information might be related to more fluid mental ability differences occurred to Cattell in the 1880's while he was working in Wundt's laboratory (Deary, 1986). This hypothesis was never tested. Certain correlates were developed between IT and mental test performance into a mental speed theory of intelligence (Brand, 1981, 1984; Brand & Deary, 1982). Nettlebeck semiquantitative review (1987) concluded that IT account for approximately 25% of IQ variance. The lack of correlation with IT and many tests including intelligence, has promoted researchers to investigate certain other cognitive pathways.

Conclusion

Inspection time assesses the processing of information in an indirect method as do Simon and Stroop tasks. In the past researchers have postulated that Simon and Stroop tasks measure independent components of human cognition that may be similar. Inspection time is said to test fluid intelligence, which is a global measure of human cognition. It seems reasonable to attempt to determine the relationship between all of the tests to further try to explain any common cognitive mechanisms.
Inspection Time Task

Response Keys
Pattern Mask

Response Keys
CHAPTER THREE

METHODS

Participants

Eighteen undergraduate student volunteers from UNLV served as participants in the experiment. The students were naive of the theoretical implications of the study. Prior to participation, each participant read a brief description of the study and signed an informed consent form.

Design

The design of the study is a one-way within subjects design having four levels (tasks). The independent measures were the four tests that were administered; Inspection Time, Simon, Stroop (automated), and Stroop (manual). The dependent measure was reaction time for the Simon and the Stroop (automated) task. For Inspection Time and the Stroop (manual) task, the dependent measure was the number of correct responses.

Apparatus

The first version of the Stroop task (manual) was administered manually by a laboratory experimenter which was experienced at administering the Stroop task. The participant was shown a page with colors of words written in different colors of ink (e.g. BLUE written in green or red ink), and then asked to name the color of the ink in which the word is written. For all tasks except the Stroop (manual) task the apparatus consisted of a Gateway 2000 microcomputer that measured the RT as well as accurate answers. The participants responded to the color of the ink in which the word appeared by
pressing a red or green colored key, “f” or “j” respectively.

Procedure

Prior to participation in any of the tasks, the participant was seated away from the testing area and was asked to read a set of instructions for that task. After completing a task the participant would be asked to read the next set of instructions. Each participant performed all four tests in one 40 minute session. The order of the tests was counterbalanced across participants.

In the Stroop (manual) color word test, the apparatus consisted of three separate sheets of colors and words. Participants were given 45 seconds to read aloud as many colors, or words (depending on the instructions) as possible. The first page of the test consisted of colors written in black ink (e.g. RED, GREEN, & BLUE). The participant was instructed to name the word. The second page consisted of ‘xxxx’ figures appearing in different colors (e.g. RED, GREEN, & BLUE). The participant was instructed to name the color of the ink of each symbol. The last page consisted of Stroop color words that were written in contrasting ink colors (e.g. BLUE written in red or green ink). The number of words and/or colors were recorded by the laboratory experimenter on a separate sheet of paper.

The Stroop (automated) color word test was administered via a computer. A blank screen appeared prior to a ‘beep’ sound which prompted the participant as to the Stroop color word that was about to appear in the center of the screen. The foreperiod was counterbalanced. The words ‘RED’ or ‘GREEN’ appeared on a color monitor in either red or green ink. The participants were instructed to respond as quickly as possible to the color in which the Stroop color word appeared. The ‘f’ key was covered with the color red, and the ‘j’ key was covered with the color green. A total of 128 trials were given.
with the first 16 being practice.

For the Simon task a blank screen appeared with a 'beep' sound in addition to an 'X' in the center of the screen that prompt the participant as to the stimulus that was about to appear. The stimulus consisted of a 'RED' or 'GREEN' circle that appeared on either the left or right-hand side of the computer screen. The participant was instructed to respond as quickly as possible to the color of the circle that appeared. Again the 'f' key was covered with the color red, and the 'j' key was covered with the color green. A total of 128 trials were given with the first 16 being practice.

The last test was an Inspection Time task which was also administered on a computer. A blank screen appeared in addition to a 'beep' sound prior to the Inspection Time figure appearing. The figure consisted of two vertical lines, one 30mm in length, and the other 35mm, adjoined at the top by a horizontal line that was 10mm in length. This pi figure was followed immediately by a backwards mask that consisted of two vertical lines, each 45mm in length adjoined at the top by horizontal line that is 10mm in length. The duration of the stimulus lasted for a period varying from 10 to 100 msec which was counterbalanced. The participant was instructed to respond to the line that was the longest (either right or left) by pressing either the 'f' or the 'j' key for the left or right side respectively. In this task, the participant was encouraged to respond at his/her leisure, RT is of no concern. A total of 80 trials were given with the first 16 being practice.

Analysis

A Pearson’s Product Moment Correlation was used to determine the relationship between the four tasks. The tasks were broken up into two separate components in the
Stroop (automated) and Simon tasks being compatible and incompatible. Compatible assignments in the Stroop (automated) tasks consisted of color words appearing in the same color on a computer monitor (e.g., GREEN appearing in green). Incompatible assignments consisted of the same words appearing in different colors (e.g., RED appearing in green). Compatible and incompatible assignments were in terms of spacial compatibility in the Simon task, in that colored circles appeared on either the left or right side of the screen. The analysis provided insight on the amount of shared variability among the tasks.
## Manual Stroop Task - Color Word Sheet

<table>
<thead>
<tr>
<th>RED</th>
<th>BLUE</th>
<th>GREEN</th>
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Automated Stroop Task

RED

= RED

= GREEN
Simon Task

Stimulus Lights

Response Keys

= RED

= GREEN

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Simon Task - Conditions

Slow

Fast

= RED

= GREEN
CHAPTER 4

RESULTS

Data were analyzed using a Pearson’s Product Moment Correlation. The correlational analysis was used to determine the relationship between tests of hypothetical cognitive mechanisms.

The first test analyzed was a Stroop task administered via computer. The second test analyzed was a Simon task. Again, the tasks were broken up into two separate components being compatible and incompatible. The third test was an Inspection Time task, and the last test to be examined was a Stroop task administered manually. The task was broken up into three separate components. The first was a sheet consisting of color words written in black ink. The second was a sheet of ‘XXXX’ symbols appearing in different colors. The last component of the Stroop manual task consisted of the same color words on the first sheet appearing in different colors of ink (e.g. GREEN written in blue ink). Reaction times were the dependent measures for Stroop (automated) and Simon tasks. The dependent measure for IT was the percent of correct answers. As for the Stroop (manual) the dependent measure was the amount of correct answers elicited verbally in 45 seconds. Figure 4.1 is a summary table of the results.
### RESULTS

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The purpose of the present study was to determine the relationship between paradigms proposed to test cognitive mechanisms. Specifically, paradigms thought to test response selection and interference (Stroop and Simon), and fluid intelligence (Inspection Time) were tested. Although some degree of correlation between tests was noted, the specific correlations strained the idea that these paradigms test like mechanisms. As mentioned in the introduction, there were certain predictions that could be formulated from previous literature regarding each of the tests. A recap of those predictions would prove useful for the purpose of this discussion. These are not predictions from the author, but merely predictions that can be formulated from past research regarding the tests in question.

The Simon task and both of the Stroop tasks (manual & traditional) are said to test response selection as well as selective attention. If this is accurate, when the three tests are correlated with one another, the relationship should be very strong. Inspection Time is said to test fluid intelligence. Fluid intelligence is a global measure of overall cognition, whereas response selection and selective attention are more specific measures of cognition. If Inspection Time is truly a global measure then the specific measures in each test should be strongly correlated with Inspection Time. With regard to the predictions made early on, the tests used in this study must first be considered reliable in order to be considered valid. In order for the tests to be reliable, the relationships must be strong (e.g., r > 0.70 ) as predicted. The following is a discussion regarding the strong
and weak correlations were found.

Strong relationships were found between compatible and incompatible Stroop (automated) tasks, incompatible Simon and compatible Stroop (automated) tasks, compatible and incompatible Simon tasks, Stroop (manual) color-word score and Stroop (manual) color score, and Stroop (manual) color score and Stroop (manual) word score. These correlations are not surprising noting the previously stated predictions.

Notably, weak relationships (e.g., \( r < 0.50 \)) occurred between IT and Stroop (manual) color-word score, Stroop (manual) color score, and Stroop (manual) word score. Additional weak relationships occurred between Stroop (manual) word score and incompatible Stroop (automated) task, IT and compatible Stroop (automated) task, as well as between compatible Simon task and IT. Interesting data was that of the three Stroop (manual) tasks. These finding were very contradictory to that of the predictions. This would lend support to the notion that the tests (Stroop manual) are not reliable hence they are not valid.

The relationship within the compatible and incompatible Stroop tasks (automated) was strong (\( r = 0.83 \)) but in all actuality, according to the assumptions from the literature, the relationship should have been even stronger. The relationship between the different Stroop tasks (manual & automated) was also weak (e.g., \( r < -0.48 \)), again refuting the assumption that they measure the same variable.

When looking at the relationship between the compatible and incompatible Simon tasks (\( r = 0.84 \)), the strength of this relationship should have been greater. If one were to predict the outcome of the relationship between the Simon and Stroop (automated) tasks, the value of the relationship would tend to be very high, as the two tasks are said to test the same cognitive mechanisms (e.g., response selection). In turn, the relationship
between the compatible assignments of the Stroop and Simon task were not strong ($r = 0.56$). Again, the relationship between the incompatible assignments of the Stroop and Simon task were not strong ($r = 0.66$). The rationale of the relationships not being strong is unknown, and rightfully so as it is not the intent of this study, although the reliability and validity is again in question.

In terms of the Inspection Time task, the correlations between all of the tasks failed to reach a value which yielded any strength. This does not say that Inspection Time is not a global measure of fluid intelligence, this only states that Inspection Time is not strongly related to Simon and Stroop tasks (manual or automated). Furthermore the test may not be a reliable measure of fluid intelligence.

Possible explanations for the value of the correlations are very speculative at this point. However, one interpretation may be a result of the way the two tests were administered. The modality of the deliverance of the tests may help explain the low correlations. The relationships that failed to reach notable strength are those in question for reliability as well as validity. Again, if any test does not render reliable results, it cannot be considered valid. Any of these explications can be considered, but the bottom line is the relationship between each of the tasks refutes the assumptions made from the literature and contradicts the possible predictions made early on in this paper.
CHAPTER 6

FUTURE DIRECTIONS AND RECOMMENDATIONS

One suggestion for future studies is in regard to predictions made early on. If the relationship turned out to be extremely high in some cases (e.g., between automated Stroop and Simon tasks), the tests under investigation could possibly be interchangeable by scientists and/or clinicians in the field.

The actual experiment was handled in like fashion as those in previous research experiments. There may have been confounding variables of interest. The first recommendation is simple. Since the power of the statistics may be in question due to the small number of participants, increasing the amount of data collection is one possible suggestion. Replication of the study with an equal sample size would allow additional implications.

Looking at the data from an individual differences standpoint is another possible recommendation. This would allow for the partitioning out of factors such as gender, age, GRE and SAT scores that could possibly impact the data. Furthermore, this would allow for more directed future studies.

The last possible recommendation for the future would be to peruse each one of the tests on an individual differences basis in order to leach out the interference effects which are accompanied therein. In general, it is the author's opinion that the areas under exploration in this study be further investigated.
APPENDIX A

INFORMED CONSENT

Motor Behavior Laboratory

Welcome to the Motor Behavior Laboratory at UNLV. The research conducted is designed to add to the body of knowledge that currently exists in a specific domain of cognitive psychology.

The research you are being asked to participate in consists of engaging in a series of activities which measure attention and reaction time. By signing this consent form, you are also giving the researcher permission to access your UNLV records in order to obtain your ACT or SAT scores. Your participation will include one half hour session. You will receive course credit for your participation. You are free to withdraw from the research at any time without jeopardy to current or future relationships with the researcher(s), the Department of Kinesiology, and/or the University.

The benefits of this research are that it will help add to the existing body of knowledge in cognitive psychology. There are no known risks involved in any part of this research and your anonymity will be protected. Subject codes will be used throughout and your name will not appear on any response records. Your name and social security number will be needed in order for us to obtain your ACT or SAT scores. Once the scores are obtained, the record consisting of your name, social security number, and subject code will be destroyed.

If you have any questions about the research, you may contact the Motor Behavior Laboratory (895-1241). If you have any questions about the rights of research subjects, you may contact the UNLV Office of Sponsored Programs (895-1357).

YOUR SIGNATURE BELOW INDICATES THAT:

1. YOU HAVE DECIDED TO VOLUNTEER AS A RESEARCH SUBJECT AND THAT YOU HAVE READ AND UNDERSTOOD THE INFORMATION PROVIDED ABOVE AND

2. YOU GIVE THE RESEARCHER(S) PERMISSION TO ACCESS YOUR UNLV RECORDS IN ORDER TO OBTAIN YOUR ACT OR SAT SCORES.

(date) (signature of participant)
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APPENDIX C

PARTICIPANT INSTRUCTIONS

Stroop Instructions (manual)
The study which you are about to undertake will require you to read aloud various words and colors for a duration of 45 seconds. On the first page your goal is to read as many words as possible for the time allowed. Start at the top and proceed downward until you have finished that column then move on to the next column to the right. At the end of 45 seconds the lab assistant will say “stop” at which time you will stop reading. On the second page your goal is to name as many colors as possible for the time allowed. At the end of 45 seconds the lab assistant will say “stop” at which time you will stop reading. On the last page your goal is to name the color of the ink the words are written in for the given amount of time. At the end of 45 seconds the lab assistant will say “stop” at which time you will stop reading. A recap of the instructions will be given by the lab assistant prior to your involvement in the experiment. If you have any questions, please ask the experimenter before you begin. Thank you for your participation.
Stroop Instruction (automated)

The study which you are about to undertake will require you to respond to words that appear in different colors of ink, by pressing colored keys upon a keyboard. There will be words that written in different colored ink (RED written in red ink or RED written in green ink) on a computer screen. Your goal will be to respond to the color of the ink that the word is be written by pressing the appropriate colored keys. Please respond as quickly as possible. Further instructions will be given by the lab assistant prior to your involvement in the experiment. If you have any questions, please ask the experimenter before you begin. Thank you for your participation.
Simon Instructions

The study which you are about to undertake will require you to respond to a light, that will appear directly in front of you on a computer screen. Your goal will be to respond to the color of the light that appears, either RED or GREEN, by pressing the corresponding key that is colored (press the red key if a red circle appears). Please respond as quickly as possible. Further instructions will be given by the lab assistant prior to your involvement in the experiment. If you have any questions, please ask the experimenter before you begin. Thank you for your participation.

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**Inspection Time Instructions**

The study which you are about to undertake will require you to respond to a stimulus that appears by pressing one or two keys upon a keyboard. A $\pi$ figure will appear with two vertical lines, one being longer than the other. Your goal is to determine which one of two lines is longer, and answer accordingly by pressing a left- or right-hand key for which side the longer line appears. Immediately after the $\pi$ figure appears a mask will appear which will consist of two vertical lines that are of equal length. Please wait until the mask appears to make your response. You are encouraged to take your time, and answer at your leisure. Further instructions will be given by the lab assistant prior to your involvement in the experiment. If you have any questions, please ask the experimenter before you begin. Thank you for your participation.
REFERENCES


Cattell, J.M. (1886). The time it takes to see and name objects. Mind, 11, 63-65.


