6-2017

Radio Dispatch Cognitive Abilities and Working Memory

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RADIO DISPATCH COGNITIVE ABILITIES AND WORKING MEMORY

A Thesis

Presented to the

Faculty of

California State University,

San Bernardino

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

in

Psychology:

General/Experimental

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by

David Alejandro Buitron

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ABSTRACT

Public safety radio dispatchers incontrovertibly have to manage multiple tasks at any given time, from relaying lifesaving information to field units, to simultaneously overseeing several monitors and keeping up with the radio transmissions in a timely manner. Interestingly, however, the underlying cognitive abilities necessitated for performing such tasks have not been thoroughly investigated. To begin understanding the cognitive faculties that underlie dispatching tasks, we gauged cognitive ability measures relevant to dispatcher duties and introduced Working Memory Capacity (WMC) as underlying the differentiation on performance. The four general dispatcher cognitive factors identified by Peace Officer Standards and Training (POST) literature, were Reasoning, Perceptual, Memory, and Verbal. This study substantiated the relationship that higher WMC had on increased performance of the four factors; WMC was a strong predictor of overall cognitive task accuracy. This study also measured dispatcher abilities detached from any dispatcher-like duties, to better explore the cognitive underpinnings without the confound of dispatcher-like tasks within the measures. High and low WMC group comparisons also revealed accuracy differences in cognitive abilities, task switching costs, and dual-task interference. Overall, this study provides support for WMC's executive functioning as a key underlying mechanism determining dispatcher cognitive ability level.

ACKNOWLEDGEMENTS

It was with the concern of possible overburdening of radio dispatchers that San Bernardino County Sheriff's Department Desert Control Center (DCC) communications manager Ronald Dunn and communications supervisor James Bare devised a plan to establish a cognitive saturation point for their radio dispatchers, that from below such point, optimal radio dispatcher performance would be preserved. Soliciting the collaboration of California State University, San Bernardino's Cognitive Psychology branch, DCC overseers aimed to establish an empirical basis to their predicament. Subsequently, we have initiated exploration into the cognitive faculties relevant to dispatching duties, to provide a foundation that can better address the cognitive overburdening concern observed by dispatcher overseers. I would like to thank my thesis advisor Hideya Koshino for investing his time into guiding me through my master's thesis project, as well as, allowing me to fine-tune my research abilities via Koshino Lab. I would also like to thank my thesis committee members John Clapper and Robert Ricco for taking the time from their busy schedules and accepting to participate in my thesis committee. As well, I thank Yecica Bernardo for providing me with moral support and encouragement throughout the duration of the graduate program.

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CHAPTER ONE

PEACE OFFICER STANDARDS AND TRAINING

Introduction

Public safety dispatchers are the first point of contact between the public and the law enforcement system. The dispatcher's responsibilities entail disseminating critical information to ensure the safety of citizens as well as field safety personnel, continual evaluation and implementation of incoming data, monitoring field units, and coordination with other emergency agencies, such as fire, medical emergency services, and other public safety agencies.

The demanding tasks of public safety dispatchers is sometimes divided into two branches: Intake personnel and radio dispatchers. Intake personnel are tasked with handling complaints and requests from the public. Radio dispatchers keep the public safety field units informed and must constantly govern and prioritize information; they must juggle a multitude of incoming information and employ various cognitive abilities, such as reasoning, verbal, memory, and perception, to piece-together and prioritize a rational and swift course of action. Given the amount of incoming information that can rapidly accumulate at any given time for radio dispatchers, it is not unfathomable to comprehend task overload occurring and impairing performance.

In the initial efforts to address the question of cognitive-task overload and establish a foundation for better understanding the cognitive demands of dispatcher tasks, assessing the relevant cognitive abilities and any possible underlying factors, seemed like an appropriate place to begin the investigation. Cognitive ability has demonstrated to be a key component to successful job performance across many fields (see Hunter, & Hunter, 1984). The Commission on Peace Officer Standards and Training (POST), (Weiner, & Solorio, 1991) identified the relevant cognitive abilities for dispatcher tasks. Furthermore, Working Memory Capacity (WMC), which entails the ability of keeping representations active despite distraction, and involves the control of attention (Engle, Tuholski, et al., 1999), we argue, is extremely indicative of most dispatcher job tasks. Moreover, WMC best predicted effective multitasking performance in a study by Konig, Buhner, and Muling (2005). Therefore, this study aims to demonstrate the relevance of WMC towards dispatcher-related abilities along with plotting the differences between low and high WMC across general dispatcher abilities (reasoning, memory, perception, verbal) and individual tasks. Advancing our understanding of relevant cognitive abilities and WMC will offer a new lens to explore the scantily researched cognitive domain of public safety dispatchers.

Alarmingly, there is an unsettling lack of research investigations pertaining to public safety dispatchers. POST's statewide job analysis of the public safety dispatcher occupation (Weiner, 1990; Weiner, & Solorio, 1991; Weiner, Solorio, & Pruden, 1991; Weiner, Lively, & Pruden, 1996), entail most of the background research on dispatchers. The analysis determined the job duties, knowledges, skills, traits, and abilities that were essential for California dispatchers to possess. Their results laid the groundwork for subsequent procedures in training curricula and hiring standards, which implemented a cognitive ability measurement in their selection battery.

Component 1: Job Task Analysis

Component 1's task analysis, which was the first step in the job analysis, served to identify *core* job activities, performed by the majority of dispatchers in California, as well as, to clearly outline tasks that require refresher training and entry-level training. Weiner (1990) outlined the steps involved in deriving the relevant dispatcher tasks. First, POST researchers constructed a dispatcher task inventory; then 639 incumbent dispatchers and 258 dispatcher supervisors rated the importance of dispatcher tasks, resulting in 121 core tasks. The 121 core tasks were grouped into eight major job areas: (a) Screening Complaints and Obtaining Information, (b) Providing Information to the Public and Other Agencies, (c) Monitoring Field Units and Emergency Systems, (d) Dispatching Personnel and Resources, (e) Providing Information to Field Units, (f) Reporting and Recordkeeping, (g) Facility Operations, and (h) Training.

Component 2: Analysis of Job Requirements

POST Component 2 (Weiner, & Solorio, 1991) sought out to identify the various worker requirements, including Knowledges, Skills, Abilities and Traits

(KSATs) that are quintessential for dispatchers to successfully perform the *core* task inventory outlined in Component 1's job-task analysis. Weiner (1990) defines the KSATs as follows: *Knowledges* entail the understanding of a body of information, which may be used to perform multiple functions; *skills* deal with the competency of applying experience-based knowledges and techniques while performing a given task; *ability* is an underlying capacity that drives performance on a wide variety of tasks; *traits* are enduring patterns or behavioral characteristics that reflect individual performance under varying circumstances. In this section, however, we will only focus on the pertinent abilities from the KSAT to this study (i.e., cognitive abilities). Although all of the KSATs are important for dispatcher work, cognitive abilities have demonstrated to be good indicators of job performance across various professions and were subsequently the only KSAT used in POST's selection test battery.

Fleishman, Quaintance, and Broedling (1984) define *ability* as a more general capacity of the individual related to performance in a variety of human tasks, and that an ability is a general trait of the individual that has been inferred from certain response consistencies. Both learning and genetic components underlie ability development. POST researchers (Weiner, & Solorio, 1991) adopted the Fleishman's ability taxonomy in their classification of relevant dispatching abilities for the job analysis KSATs section. Weiner and Solorio extrapolated 28 cognitive, psychomotor, and sensorimotor abilities (19 were cognitive abilities) from Fleishman's taxonomy as pertinent for dispatcher duties.

Each ability was ranked on importance by 267 supervisors to determine dispatcher core abilities, which resulted in 13 core cognitive abilities.

The 13 cognitive abilities were grouped into four respective general ability factors (i.e., verbal, reasoning, memory, and perception) outlined by Nunnally (1978). Nunnally described these major factors as some of the most important to human ability: (a) *Verbal*: The ability to read and listen to information and identify facts and draw conclusions and the ability to write clearly, including Oral Comprehension, Written Comprehension, Oral Expression, and Fluency of Ideas. (b) *Reasoning*: The ability to apply general rules to specific problems to attain logical answers, and the ability to correctly follow rules to arrange things or actions in a certain order, including Deductive Reasoning, Inductive Reasoning, and Information Ordering. (c) *Memory*: The ability to store and retrieve facts, details, and other information, including Memorization. (d) *Perceptual*: The ability to quickly and accurately compare letters and numbers presented orally and in written form, and the ability to shift back and forth between two or more sources of information, both written and orally, when performing a task, including, Perceptual Speed, Time Sharing, Selective Attention, and Speed of Closure (see APPENDIX A: CORE COGNITIVE ABILITIES for a list of the 13 core cognitive abilities with a working example)

Component 3: Linkage Analysis

Component 3's linkage analysis (Weiner, Solorio, & Lively, 1991) served to associate Component 2's KSATs needed for the completion of Component 1's job tasks. 54 dispatchers, dispatcher managers, and supervisors [Subject Matter Experts (SME)] conducted the linkage analysis in a POST workshop. Regarding the 13 core cognitive abilities, 558 linkages were established between cognitive abilities and core-tasks. The results of the linkage analysis further confirmed the relevance of abilities towards job task completion and set the foundation for POST's Entry Level Selection Test Battery.

Entry Level Selection Test Battery

POST researchers employed the findings from the job analysis (Component's 1 – 3) to form a selection test battery for job screening purposes (Weiner, Lively, & Pruden, 1996). More specifically, the battery revolved around gauging the core cognitive abilities. Nine of the 13 core abilities were selected to measure individual aptitude in POST's entry level selection battery based on practicality of measurement: Oral Comprehension, Written Comprehension, Written Expression, Deductive Reasoning, Inductive Reasoning, Information Ordering, Memorization, Perceptual Speed, and Time Sharing. Oral Expression, Fluency of Ideas, Selective Attention, and Speed of Closure were excluded. POST researchers, with the help of dispatcher supervisors and managers with selection experience formulated an 11-item scenario-like test (see APPENDIX B:

SELECTION TESTS for an outline of each test). The 11 selection measures were administered on 1,442 job applicant academy students, non-academy students, and students with entry-level dispatching experience. The test battery scores were norm-referenced from the scores of job applicants and students that were applying for public safety dispatcher positions.

To validate the tests on performance, researchers used academy instructor ratings, job performance supervisor ratings, probation success/failure, and self-ratings. Total battery test scores were significantly predictive of dispatcher academy performance (Basic Academy Total Perf), future job performance (Supervisor Ratings and Self-Ratings), and the passing/failing of probation periods (Probation Pass/Fail), (see APPENDIX C: TEST VALIDITY). The validation data reinforced the assuredness that the task measures based on the cognitive abilities served to predict future performance.

CHAPTER TWO

COGNITIVE APPLICABLE RESEARCH

Cognitive Ability Performance Research

Overall, the validity of cognitive abilities predicting job performance is consistent with performance research. In meta-analysis research, Hunter and Hunter (1984) found that cognitive complexity performance increased in validity as job complexity increased. That is, the more cognitively complex the job was, the better cognitive ability predicted successful job performance. Hunter and Schmidt (1996) outlined that high General Cognitive Ability (GCA) individuals are "faster at cognitive operations on the job, are better able to prioritize between conflicting rules, are better able to adapt old procedures to altered situations, are better able to innovate to meet unexpected problems, and are better able to learn new procedures quickly as the job changes over time" (p. 465). In sum, GCA deals with the adequacy and speed of learning. GCA scores are usually extracted by having participants perform a battery of various cognitive tasks, dealing with reasoning, verbal, spatial, quantitative, and more, and averaging an overall composite score of their performance, or via factor analyses (Jensen & Weng, 1994). Some of the most common batteries are: Wonderlic Personnel Test (WPT), (Wonderlic, 2007), or the General Aptitude Test Battery (GATB), (Hunter, 1980). The Wonderlic Personnel Test, for example, allots 12 minutes to solving a series of 50-item questions from, verbal analogies, word comparisons, numerical, and spatial matrix problems.

Cognitive abilities seem to underlie job performance across a myriad of job elements. Gottfredson (1997) also explains how complex jobs require more complex information processing and that cognitive ability is a good predictor of work performance and training outcomes. Hunter and Schmidt (1986) reported that GCA directly affects job performance in civilian jobs (r = .75, n = 1,790), and military jobs (r = .53, n = 1,474). Their results demonstrate support for the predictive validity of cognitive abilities on job performance. Moreover, Ghiselli (1973) presented the results of many studies regarding the predictive capacity of cognitive abilities on job performance. Measuring abilities as indicators of job performance and training success is supported by cognitive ability research, and thus should prove an advantageous direction to assessing the underlying mechanisms required by dispatchers.

Working Memory

There is an underlying component that may also be crucial for the successful performance of dispatcher work; that is, the working memory component of cognitive tasks. Working Memory (WM), (Baddeley, & Hitch 1974) is a memory system required for the temporary storage, processing, and manipulation of information. Complex working memory span tasks (e.g., symmetry span, operation span, reading span, etc.) have demonstrated to be good measures of individuals' overall Working Memory Capacity (WMC), which entails the ability of keeping representations active despite distraction involving the control of attention (Engle, Tuholski, et al., 1999). WM span tasks typically involve remembering a word or digit, while processing a series of attentively demanding tasks (e.g., comprehending a sentence or assessing if a math equation is correct). To manage any interference involved in the performing of WM span tasks, executive control is required (Conway, Kane, & Engle, 2004). WMC has been linked to the performance of many cognitive faculties, such as, reasoning, problem solving, and reading/listening comprehension (Daneman & Carpenter, 1980; Adams & Hitch, 1997; Engle, 2002). Individual WMC also accounts for a large portion of a person's overall intellectual ability (Conway, Kane, & Engle, 2004; Conway, Cowan, Bunting; Kane et al., 2004). As well, although there are various measures of WMC, they should all share a commonality in executive attention.

Barret, Tugade, and Engle (2004) argue that any individual differences observed in WMC measures result from differences in the central executive, which is responsible for the ability to control attention. Their research supports a general resource view of controlled processes involved in WMC (Daily, Lovett, & Reder, 2001). Moreover, although there are minor influences in performances across separate complex working memory span tasks (e.g., reading comprehension, mathematical aptitude, or spatial ability), their commonality in measuring control of attention, carries most of the performance weight.

Barret, Tugade, and Engle (2004) also emphasize control of attention as necessary for the activation and maintenance of memory representations in WM, and found that those who scored high in WMC also retrieved goal-relevant information faster and more accurately than lower scoring WMC individuals. Moreover, low WMC individuals were more susceptible to distracting information (i.e., negative priming, fan interference, proactive interference, and retroactive interference; Conway & Engle, 1994; Conway, Tuholski, Shisler, & Engle, 1999; Rosen & Engle, 1997). The suppression effects also differ between low and high WMC groups, and goal incongruent representations are better suppressed by high WMC groups (Rosen & Engle, 1997). As well, suppressing orienting cues (Conway, Cowan, & Bunting, 2001) and attention capturing visual cues (Kane, Bleckley, Conway, & Engle, 2001) are better responded to by high WMC individuals.

In sum, WMC should arguably play a large role in the effective performance of dispatcher duties. Dispatchers have to recruit WM while performing the majority of their tasks. Moreover, WMC span scores are predictive of real world cognitive abilities that are extremely relevant to dispatcher tasks, such as, reading comprehension (Daneman & Carpenter, 1980), listening comprehension, problem solving (Adams & Hitch, 1997), and reasoning (Kyllonen & Crystal, 1990). Measuring dispatchers' WMC is sure to prove insightful towards understanding relevant cognitive abilities and differentiating performance across WM span ability.

Working Memory and Reasoning

WM and reasoning arose from two different areas in psychological research. WM arose from an information processing approach while reasoning has its roots in psychometric measurements. However, research into higher level cognitive mechanisms has led to the research investigating WM and reasoning abilities alongside each other, and the results support an intricate link between the two. Kyllonen and Christal (1990), for example, used four separate studies (*n* = 723, 412, 415, and 594) to correlate working memory capacity and general reasoning ability. The Pearson *r* coefficients for the four studies were .82, .88, .80, and .82 and thus concluded that reasoning is little more than WMC. The small difference between the two factors, however, they argued resides in WMC correlating highly with processing speed, while reasoning correlated highly with general knowledge.

Multitasking's Predictive Factors

It seems evident that the dispatching profession, particularly public safety radio dispatchers, requires multitasking abilities for effective job performance. Multitasking is described by Delbridge (2000) as the ability to juggle and work through multiple tasks/goals within the same temporal period while having to engage in periodic switching of tasks. Some studies have attempted to determine the cognitive faculties behind multitasking. Burgess and Shallice (2000) for example, identified the neural correlates of multitasking as the left anterior and posterior cingulate, as well as the right dorsolateral prefrontal cortex. These areas seem to imply decision-making, executive functioning, working memory, and cognitive flexibility as constituents of multitasking.

Konig, Buhner, and Murling (2005) sought to explore likely predictors of individual differences on multitasking performance. The predictors in their study were working memory, attention, fluid intelligence, polychronicity, and extraversion. Attention was chosen as a predictor of multitasking because the ease of refocusing attention between tasks has been linked to improved multitasking performance (Kahneman, 1973). Working memory capacity was chosen because of its relevance to keeping track of and effectively switching between the tasks in multitasking environments (Meyer & Kieras, 1997). Fluid intelligence was chosen because of its reason-orientedness and underlying ability to facilitate novel problem solving, which should also extend towards multitasking performance. Polychronicity, which encompasses a cultural/individual preference to perform and enjoy multitasking, was predicted to contribute to multitasking performance (see also Ben-Shakhar & Sheffer, 2001). The final predictor of multitasking used was extraversion, in that extraverts may be more efficient multitaskers due to their more stable arousal levels, while introverts have a harder time dealing with the arousal induced by multitasking (Lieberman, & Rosenthal, 2001).

For the criterion, the study implemented a complex multitasking computer program. Because Konig, Buhner, and Murling (2005) wanted to gauge multitasking on a wider timeframe, instead of the usual focus of millisecond timeframe, they employed a complex multitasking scenario-oriented test that entailed multiple components. They used SCHUHFRIED's standardized and commercially available Simultaneous Capacity/Multi-Tasking test (SIMKAP), (Bratfisch & Hagman, 2003), which is advertised as a selection instrument for jobs that require heavy multitasking.

Konig, Buhner, and Murling (2005) found that WM was the best predictor of multitasking performance, followed by attention and fluid intelligence, whereas polychronicity and extraversion failed to predict multitasking. WM best predicted multitasking performance, which was not surprising because WM helps keep track of a task while one switches back and forth between tasks. In light of their findings, the researchers proposed that WM tests could be used in the selection process for jobs that require high multitasking (see also Maschke & Goeters, 1999). WM was a key component towards effective multitasking. Taking into account that radio dispatching work involves the ability to multitask, and in light of Konig, Buhner, and Murling (2005) findings that WM predicted most of the variance in multitasking performance, it would make sense to measure WMC and expect those measures to predict multitasking performance.

Task Switching

Because multitasking was defined as the ability to juggle and work through multiple tasks/goals within the same temporal period while having to engage in periodic switching of tasks (Delbridge, 2000), it would be advantageous to investigate the task switch process and its ramifications on performance. One task switching observable measure that has been substantiated across various experiments is the switch cost, which results in higher error rates and longer response latencies upon immediate switching between tasks in a dual-task paradigm (Allport, Styles, & Hsieh, 1994; Rogers & Monsell, 1995).

Monsell (2003) purported that the process of changing tasks solicits a sort of mental gear change which he termed Task Set Reconfiguration (TSR). TSR can include switch elements such as, attentional shifts between stimulus attributes, retrieval of goal states, action states, adjusting response criteria, and re-ordering conceptual criteria. The recruitment of the central executive is argued as necessitated for effective task switching (Allport & Wylie, 1999), and has been supported in a series of experiments (Baddeley, Chincotta, & Adlam, 2001). Furthermore, D'Esposito, Detre, Alsop, Shin, Atlas, and Grossman (1995) found activation of the dorsolateral pre-frontal cortex (i.e., an area relating to executive functioning) only when task switching occurred and not when each task was performed alone.

Task Switching and Working Memory

Research has demonstrated conflicting reports on the requisites of task switching measures linking to Working Memory (WM), (Liefooghe, Barrouillet, Vandierendonck, & Camos, 2008). Kane, Conway, Hambrick, and Engle (2007) failed to demonstrate a *High* and *Low* WMC group difference in switch costs. In their cue prime-probed experiments (Kane, Poole, Tuholski, & Engle, 2003), participants had to either enumerate or identify the presented digit per trial. For example, if 2222 was presented, the answer could either be four or two, depending on the task. Half of the trials switched tasks after each trial, while the other half repeated tasks. In their fourth experiment, participants had to distinguish if a digit was odd or even or whether a letter was a vowel or a consonant based on an underlined cue. Both a number and a letter were paired per trial; they implemented pure-trial blocks and AABB-trial sequence blocks. They concluded that task switching measures should eliminate cue encoding and cue-based retrieval methods in order to tap into executive attention.

Furthermore, Liefooghe, Barrouillet, Vandierendonck, and Camos (2008) offer evidence that task switching impairs maintenance of WM items thus confirming the involvement of WM in task switching. In their four experiments, they used preloading and continuous span tasks (Barrouillet, Bernardin, & Camos, 2004). It involved remembering 3 - 6 consonants, followed by a series of eight digits of a blue or red hue. Participants were presented with a series of increasing-length operations starting at one operation and increasing up to six. Red hue corresponded to identifying if the number was larger or smaller than five, while blue hue corresponded to odd even discrimination. They found that recall performance decreased as task switches increased (i.e., as operations increased). In conclusion, they argue that selective interference procedures and narrow temporal windows for response selection, such as those in several dual-task studies involving disrupting inner speech via articulation suppression (Baddeley, Chincotta, & Adlam, 2001; Emerson & Miyake, 2003; Liefooghe, Vandierendonck, Muyllaert, Verbruggen, & Vanneste, 2005), may be the conditions required to elicit executive control in task switching measures. Overall, both Kane et al. (2007) and Liefooghe et al. (2008) argue that task switching measures must tap executive, volitional control mechanisms in order for them to associate with WM span scores; therefore, incorporation of task switching measures that recruit executive functioning are necessary for observe working memory differences.

Psychological Refractory Period

Dual-task interference results when the two tasks are presented in short succession to one another and the processing of the second task is postponed until the first task processing is complete. Similar to task switching capabilities, dual-task interference abilities are also quite relevant towards navigating multiple tasks in close proximity to one another. However, dual-task interference measurement is concerned more with manipulating the temporal gap between two tasks and generating greater task processing interference as the gap is narrowed. The paradigm that measure this dual-task interference is known as Psychological Refractory Period (PRP), (Smith, 1967). The more the Stimulus Onset Asynchrony (SOA) is decreased between the two tasks, the greater the interference of the first task processing on the second task processing (Pashler, 1994). That is, 50 ms SOA between task one and task two will cause a greater amount of dual-task interference as compared to 650 ms SOA between the two tasks. This processing interference is robust and is attributed to an attentional bottleneck effect (Pashler & Johnston, 1989).

CHAPTER THREE

RATIONALE AND HYPOTHESES

Individual Ability Assessment Approach

Although there are other components to the successful performance of public safety dispatchers, such as traits, knowledges, skills, and even the psychomotor and sensorimotor abilities, we focused on the cognitive abilities outlined by Weiner and Solorio (1991) because of the large role that cognitive abilities play in determining work performance. Focusing on the pertinent abilities and exploring the pattern of results—would allow for a more extensive exploration of the underlying components of dispatcher-relevant abilities.

The 11-test items in the POST selection test battery integrated many of the abilities together in their measurements of the test items. The overall test, however, seems quite representative of dispatcher work because it incorporates tasks that mirror the types of tasks that dispatchers will have to perform while on the job. Moreover, the test battery predicted trainee pass/fail retention rates and future work performance quite well as shown in APPENDIX C: TEST VALIDITY.

However, the tasks representing the abilities were coupled with plenty of dispatcher content, which may convolute the gauging of the specific general abilities such as, Reasoning, Perceptual, Memory, and Verbal. Although the selection test emphasized that it was not designed to measure job-specific knowledge and skills, many of the ability measures incorporated dispatcher-like duties, such as, recording field unit status on a radio-log, listening to simulated radio calls from patrol officers to dispatchers, recalling facts from law enforcement audio transmissions, assigning priority codes to possible emergency incidents, assigning field units based on geographic regions, etc (see APPENDIX B: SELECTION TESTS for task descriptions). To assess the contribution on performance and attribute them towards abilities, it would be advantageous to measure the underlying abilities using measures that are detached from any dispatcher duty-like rendition. This investigation will explore ability measures that are free from any dispatcher-like duties.

Working Memory and Relevant Cognitive Abilities

Cognitive ability measurement has provided a reliable indication of future job performance (Ghiselli, 1973; Hunter, 1986). As well, the more complex the job-tasks are, the greater the reliability of cognitive ability predicting job aptitude (Hunter and Hunter, 1984). There is a likely underlying contributor towards the successful performance of dispatcher-related tasks, and by extension, the cognitive abilities required to carry out those tasks. That underlying contributor, we argue, is WMC. Keeping mental representations in an active state despite distraction while exercising reasoning faculties, while subsequently shifting between tasks is something that dispatchers have to routinely manage.

Overall, WMC has demonstrated links to the four major cognitive factors of Verbal, Reasoning, Perceptual, and Memory. In Verbal ability, for instance, Daneman and Carpenter (1980) found WMC to predict reading comprehension, while Adams and Hitch (1997) also linked WMC to listening comprehension, and Baddeley and Hitch (1974) support WM's link to verbal ability. In relation to Reasoning ability, Kyllonen and Christal (1990), demonstrated high correlation between WMC and general reasoning ability and concluded that reasoning was little more than WM. Regarding Memory ability, Engle, Tuholski, Laughlin, and Conway (1999) supported short-term memory as sharing a separate but highly related construct to WM and Conway, Kane, and Engle (2003) supported that WMC relates to speed and accuracy of responses from long-term memory when there is response competition or proactive interference. As well, regarding Perceptual ability, Konig, Buhner, and Murling (2005) supported WM as their best predictor of multitasking, while selective attention (Barrett, Tugade, & Engle, 2004) and task switching (Liefooghe, Barrouillet, Vandierendonck, & Camos, 2008) have also been tied to WM.

Closely related to relevant cognitive abilities and WM are task switching and dual-task interference. Task switching effects are usually associated with higher error rates and longer response latencies for switch trials than for repeat trials. Task switching is argued by Monsel (2003) to undergo Task Set Reconfiguration, which can include switch elements such as, attentional shifts between stimulus attributes, retrieval of goal states, adjusting response criteria, and re-ordering conceptual criteria. Task switching is supported as a key process of working memory functioning (Barrouillet, Bernardin, & Camos, 2004; Cowan, Elliot, Saults, Morey, Mattox, Hismjatullina, & Conway, 2005).

Dual-task interference measured by PRP tasks results when two tasks are presented in short succession to one another, and the processing of the second task is postponed until the first task processing is complete. The link to PRP and working memory seems quite relevant in regards to recruiting attentional control, however, not much research has been carried out examining their relationship. Performance on WM and PRP tasks would likely be associated based on attentional control mechanisms. Previous research has linked PRP performance to attentional limitations (Pashler & Johnston, 1989). Similarly, dual-task interference may also be subjected to the same attentional limitations as those in task switching, such as, adjusting response criteria and shifting between stimulus attributes (Monsel, 2003). Assessing any PRP differences across WM groups would shed more light on any underlying shared construct.

Finally, this study sought out to cover four goals. Goal one was to develop a battery that gauged performance on dispatcher relevant abilities detached from any dispatcher-like duties. Goal two was to establish the relevance on dispatcher ability performance based on WMC level and substantiate WMC as a viable indicator of dispatcher ability performance. Goal three was to assess the High WMC individuals' predicted improved performance on the four ability composites. Goal four was to investigate High WMC group's predicted increased performance on the Stroop task's switch cost and the PRP's dual-task interference.

Hypotheses

1. It is hypothesized that the High WMC group will perform better in the reasoning measurement in terms of reaction time and accuracy.
2. It is hypothesized that the High WMC group will perform better in the verbal measurements in terms of reaction time and accuracy.
3. It is hypothesized that the High WMC group will perform better in the memory measurement in terms of reaction time and accuracy.
4. For the three perceptual ability measures, the hypotheses were separated according to expectations by task.
    a. In the Stroop task switching, High WMC group will demonstrate higher accuracy, shorter reaction time, and reduced switch cost
    b. in the Psychological Refractory Period (PRP) task, High WMC group will demonstrate increased accuracy and reduced dual-task interference
    c. in the Number Comparison Task, High WMC group will demonstrate higher accuracy.

CHAPTER FOUR

METHOD

Participants

The participant pool consisted of 102 California State University, San Bernardino students that participated for extra credit towards a class of their choosing. Before initiating the study, all participants signed a consent form approved by the IRB (see Appendix D: INFORMED CONSENT FORM).

Materials

Participants tested in a CSUSB testing room (SBS 452). The testing was arranged in a group format, with up to 12 participants testing simultaneously in a silent and dimly lit environment. The 12 computers were arranged with three rows of four computers per row. The computer monitors were positioned approximately 60 cm from the viewer’s seating position, and each computer monitor had a .61-meter tall styrofoam divider on three sides (i.e., one behind the monitor, and two connecting to the rear board at the left and right ends at 90-degree angles extending toward the viewer) which served to minimize visual distraction. Consent, self-report measures, and demographic information forms were administered at the beginning of each session. The tests were formatted and measured in E-prime 2.0 software (Schneider & Zuccoloto, 2007). The nine tasks in the battery are listed as follows according to ability:

Reasoning

Reasoning entails the ability to apply general rules to specific problems in the aims of reaching a logical conclusion, as well as the ability to arrange and manipulate subject matter in a specified order (Ekstrom, French, Harman, & Dermen, 1976). The Inference Test (Ekstrom et al., 1976) was used to assess reasoning. In this task, participants had to consider the nature of the conclusions drawn from provided statements, without the assumption of outside information; that is, a series of statements with five possible conclusions each were presented, with only one of the conclusions serving as a viable answer (see APPENDIX E: INFERENCE TEST for example).

Memory

The memory ability entails one's capacity to retrieve facts, details and other information accurately (Nunnally, 1978). To measure the memory component of cognitive abilities, we used the First and Last Names Test derived from Ekstrom, French, Harman, and Dermen (1976), (see APPENDIX F: FIRST AND LAST NAMES TEST for example). The test measures the storage and retrieval of information from intermediate-term memory (ITM). ITM relates to the temporary memory structures regarding the ongoing task. ITM provides knowledge structures necessitated by WM, and if dealing with long-term memory, ITM knowledge structures begin to encounter temporal interference (Chase & Ericsson, 1982), which may recruit executive functioning. This test followed a pair-association format. Participants were presented with 15 first and last name pairs. Soon after (three minutes later), the last names were presented in a scrambled order, and the participants were tasked with typing the original corresponding first name for each last name.

Perceptual Ability

Perceptual ability encompasses one's ability to accurately and hastily compare letters, numbers or information that are presented orally or in a written format, as well as one's ability to switch between two or more sources of information (Weiner, & Solorio, 1991). The perceptual factor subcomponents are Perceptual Speed/Accuracy, Time Sharing, and Selective Attention.

The Perceptual Speed/Accuracy factor is concerned with how fast and accurately one can compare letters, numbers, objects, pictures or patterns. This factor outlines three contributors that can vary in the individual differences component of perceptual speed; they are, (a) perceptual fluency, (b) decision speed, and (c) immediate perceptual memory (Kunnapas, 1969). The Number Comparison test assessed the ability of differentiating between two numbers that were paired side by side. The test determined how quickly and accurately participants compared two numbers that look similar but were not always identical (see APPENDIX G: NUMBER COMPARISON TEST for example).

The second subcomponent of perceptual ability was Time Sharing, which assessed the ability to shift back and forth between multiple sources of information. Time Sharing was measured using the Psychological Refractory Period paradigm (PRP), (Welford, 1952; Pashler, 1994). PRP deals with the difficulty that arises when a secondary task is presented in close temporal proximity to the initial task, and that processing interference demonstrates attentional limitations. In the task, an auditory tone was presented (low or high frequency), the participant had to press a prescribed key for each of the two tones. The tones were transmitted via headphones. The secondary task encompassed highest digit identification (6,7,8,9) by which the participant had to press the corresponding key for the highest digit presented in an array of eight digits (i.e., four digits in the top row and four digits in the bottom row). The array consisted of a random assortment of digits ranging from two to the highest digit. Although digits were allowed to repeat in the array, there was only one highest digit per trial. The stimulus onset-asynchrony (SOA) between the two tasks was manipulated to randomly vary from 50, 150, or 650 milliseconds. The first task processing sometimes overlapped with the processing of the secondary task, and in effect, the shorter the interval between the two tasks, the slower the overall response rate for the secondary task (see APPENDIX H: PSYCHOLOGICAL REFRACTORY PERIOD).

The third subcomponent of perceptual ability was Selective Attention, which deals with the ability of concentrating on a task while avoiding distraction (Weiner, & Solorio, 1991). We used a Stroop Task (Stroop, 1935) in which participants were presented with a series of colors displayed in a different color from the name (incongruent). The task was either to identify the ink color (Color Naming: CN) or the word color name (Word Reading: WR). The incongruent trials tend to subject participants to more errors and slower reaction times, and only incongruent trials were used in our task. In our version of the task, selection of colors corresponded to four keys: (z) for blue, (x) for green, (n) for yellow, and (m) for red, for the color identification as well as for the word color naming trials (see APPENDIX I: STROOP TASK for an illustration). Only those four color options ever appeared. The task switching element was added to the standard Stroop task, in which WR and CN were switched and then repeated. Participants were cued via the location of the color word. If the word appeared above the central fixation, reading the word was the task, whereas if the color word appeared below the fixation, identifying the ink color of the word was the task. The trials were set to repeat and then alternate within the main blocks. That is, a WR trail was followed by a WR trial (repeat), and then followed by a CN trial (switch), or a CN trial was followed by a CN trial (repeat), and then followed by a WR trial (switch) in an alternating-run format.

Verbal

Verbal ability entails the capacity to draw conclusions, facts, and write clearly by reading and or listening to information (Weiner, & Solorio, 1991). The verbal factor subcomponents measured were Reading Comprehension and Written Expression. Rewriting and Incomplete Words (Ekstrom, French, Harman, & Dermen, 1976) were used to measure verbal ability. The task of Rewriting represented Written Expression, whereas Incomplete Words represented Reading Comprehension. Rewriting assessed one’s ability to rephrase an original sentence using sentence construction in two separate ways while reproducing the same meaning(s). This test measured the capacity of “producing connecting discourse that will fit restrictions imposed in term of letters, words, or ideas” (Ekstrom et al., 1976, p. 51), (see APPENDIX J: REWRITING for an example). In the other verbal task of Incomplete Words, participants were presented with a series of incomplete words with some missing letters, ranging from 1-4, and participants had to decide which letter(s) best completed the word. The words were common English words. The amount of missing letters per word ranged from problem to problem, but on average two to three letters were missing per word (see APPENDIX K: INCOMPLETE WORDS for example).

Working Memory Independent Measures

A composite score between two WM measures was used to calculate participant’s overall WMC level, as recommended by Conway et al. (2005), that a composite from two WM measures instead of a single measure will help minimize WMC misclassification. Reading Span (RSPAN) and Operation Span (OSPAN) partial scores were equally weighted and averaged to calculate participant’s WMC score. For RSPAN, we used the automated version (Unsworth, Heitz, Schrock, & Engle, 2005), (see APPENDIX L: READING SPAN). The test incorporated solving reading statements and assessing logicality. Subsequently, the participant had to mentally rehearse a series from 2 - 7 memory item letters, with a single letter presented after each statement, which were to be later recalled and input in the same order as presented. The OSPAN task followed the same procedure as RSPAN, but instead of having participants read logical statements, OSPAN generated a simple arithmetic equation and inquired participants to assess equation accuracy (Turner & Engle, 1989). We used the automated OSPAN (Unsworth, Heitz, Schrock, & Engle, 2005), (see APPENDIX M: OPERATION SPAN). The 2-7 memory item letters that must be recalled followed the same procedures as those for RSPAN.

Procedure

Participants began by acknowledging the consent form followed by demographic information along with self-report measures. Each of the nine measures in the test battery outlined in Table 1 were imparted on all participants, with two of the tasks, RSPAN and OSPAN serving as the measures for WMC. Furthermore, because of previous findings with our student population testing moderate/high in depression and state/trait anxiety in our lab, we also administered self-report measures of depression and anxiety to assess any contribution to overall task performance between groups. For the measures, we used the State-Trait Anxiety (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983), along with the Beck Depression Inventory (Beck, Steer, & Carbin, 1988). The measures were grouped into two 75-minute sessions that were administered at least 48 hours apart. The task order was randomized per session.

Table 1. Task and Ability Grouping

General	Ability	Task	Time (min)
Reasoning	Deductive	Inference	12
Perceptual	Speed/Accuracy	Number Comparison	5
	Selective Attention	Stroop Task Switch	20
	Time-Sharing	Psychological Refractory	25
Memory	Memory	First Last Names	12
Verbal	Written Comprehension	Incomplete Words	7
	Written Expression	Rewriting	10
Working Memory		Reading Span	15
		Operation Span	20
TOTAL			126

Note. The measurement tasks are grouped corresponding to their abilities.

CHAPTER FIVE

RESULTS

General Findings

The analysis consisted of assessing overall performance patterns [i.e., accuracy and reaction time (RT)] via correlations and regressions as well as the dissection of performance between Low and High working memory span across each task and ability factor comparisons. Furthermore, for performance on tasks that had multiple conditions (i.e., Stroop and PRP), comparisons between conditions were also investigated.

Demographics

The analysis entailed a total of 86 participants. 16 initial participants were eliminated from the analysis because they failed to show up to one of the test sessions and thus were missing half their data. Furthermore, task outliers beyond 2.5 standard deviations on task RT or task accuracy were removed from the overall analysis and group comparison analysis. Only two tasks had outliers that met this condition [i.e., Stroop and Psychological Refractory Period (PRP)]. Five participant scores from the Stroop task were excluded from all analyses (n = 81), and three participant scores from the PRP task were excluded from all analyses (n = 83). All exclusions were based off of accuracy: For the Stroop task, 2.5 standard deviations set the cutoff at 48 percent accuracy, and the PRP task cutoff was set at 68 percent accuracy. Note, however, these participants' performance on all other tasks were kept in the analysis. Overall means for age, GPA, State Anxiety, Trait Anxiety, and Depression, are listed in Table 2. Regarding the self-report measures, State Anxiety was highly correlated with Trait Anxiety [*r* (84) = .73, *p* < .001], State Anxiety was highly correlated with Depression [*r* (84) = .58, *p* < .001], and Trait Anxiety was highly correlated with Depression [*r* (84) = .70, *p* <.001]. Ages ranged from the 18 – 44 years.

Table 2. Demographics and Memory Span

	Overall (*N*=86) F=75, M= 11 Mean(SD)	Low Span (*n*=23) F=21, M=2 Mean(SD)	High Span (n=23) F=17, M=6 Mean(SD)	*t*(44)	*p*
WMC	64.8(15.34)	45.9(9.80)	81.9(5.33)	15.0	<.001
Age	22.3(5.42)	22.4(5.42)	21.7(3.08)	.50	.62
GPA	3.00(.39)	3.00(.39)	2.96(.41)	.33	.74
StateAnx	39.2(13.26)	38.8(13.58)	38.1(13.04)	.18	.86
TraitAnx	43.2(11.89)	41.4(11.08)	40.8(11.86)	.18	.86
Dep	16.9(13.41)	13.7(12.21)	16.9(12.68)	-.88	.39

Note. StateAnx = State Anxiety, TraitAnx = State Anxiety, Dep = Depression.

Span Score Criteria and Grouping

The Working Memory Capacity span score for each participant was formulated by using the partial span score, which equates to the summed number of correctly recalled letters in the correct serial position (see Turner & Engle, 1989). The partial score is argued to be a good discriminator between high and low span ability participants (Conway, Kane, Bunting, Hambrick, Wilhelm, & Engle, 2005). The span composite for this study was based on an equal weighted mean score from Reading (RSPAN) and Operation Span (OSPAN) partial span scores.

The maximum RSPAN partial score was 75, whereas the maximum OSPAN partial score was 125. To weigh them equally and out of 100, the following formula was used: [(RSPAN partial score/3) + (OSPAN partial score/5)] * 2. Half of the composite span score (i.e., WMC score) was contributed to by Reading Span partial score while the other half of the span score was derived from Operation Span partial score, so that OSPAN and RSPAN each could contribute a maximum score of 50 and a maximum combined score of 100 per participant (see Table 2 for WMC means).

To choose high and low span participants, participant group membership was arranged and ordered by their performance on the span task. As recommended by Conway, Kane, Bunting, Hambrick, Wilhelm, and Engle (2005), an extreme-groups design was implemented in regards to deciding low and high span groups. In an extreme-groups design, only the top and bottom quartile are represented, corresponding to high and low span groups respectively. A *t*-test between High and Low Working Memory Span groups revealed a significant span score group difference (see Table 2), with High span group having higher scores than Low span group. The group span division was subsequently used in all of the following factor and task analyses.

Demographics of Span Groups

Between high and low span groups, average age and GPA were computed (see Table 2). The ages ranged between 18 – 44 for Low Span group and ranged between 18 – 29 for High Span group. There was not an age difference between groups, as assessed via independent samples *t*-tests, $t(44) = .50$, $p = .62$. There was no GPA group difference, $t(44) = .33$, $p = .72$. As well, a Chi-Squared Test of Independence between gender and WMC span group did not reveal a statistical relationship between span group and gender difference, $\chi^2(1, N = 46) = 2.42$, $p = 1.2$.

Differences Between High and Low Span in Anxiety and Depression

Independent samples *t*-tests were carried out to assess for any differences of anxiety or depression between the span groups (see Table 2). There was no statistical difference of State Anxiety between span groups, $t(44) = .18$, $p = .86$. There was no statistical difference of Trait Anxiety between groups, $t(44) = .18$, $p = .86$. There was also no difference of Depression between groups, $t(44) = -.88$, $p = .39$.

Factor Composites

Dispatcher abilities relevant factors (i.e., Reasoning, Perceptual, Memory, and Verbal) were also formulated from the seven cognitive tasks. To compute the factor scores, any task(s) accuracy or RT within a factor were averaged to form that factor score. The four factors and their relationship with WM span score was assessed for accuracy and RT (see Table 3). The correlations revealed that WM span scores were all positively correlated with all the accuracy factor composites. WM span was not however correlated with any RT factor composite.

Table 3. Working Memory Span and Factor Composite Correlations

Composites	1	2	3	4	5	6	7	8
1. WMC	-							
2. Reasoning ACC	.21*	-						
3. Perceptual ACC	.45***	.26*	-					
4. Memory ACC	.39***	.14	.32**	-				
5. Verbal ACC	.37***	.37**	.15	.16	-			
6. Reasoning RT	.14	.17	.01	.12	-.04	-		
7. Perceptual RT	-.17	-.25*	-.28**	-.10	-.25*	.11	-	
8. Memory RT	-.14	-.05	.11	-.00	-.11	.34**	.01	-
9. Verbal RT	.14	.03	.13	.27	.01	.49**	.24*	.52**

Note. *$p < .05$. **$p < .01$. ***$p < .001$

The seven tasks of cognitive abilities served as the dependent measures in this analysis. Averaging all seven tasks based on mean task performance, an overall average RT measure as well as an overall average accuracy score was calculated. For the seven-task accuracy composite, because all of the task accuracy measures were on the same metric of percentage correct out of 100, the composite consisted of the average accuracy across the seven tasks.

The seven-task RT composite was calculated in a similar fashion, but because each task had its specific range of RT (e.g., milliseconds, seconds, and minutes), all task RTs were converted to *z*-scores and then to *T*-scores (with the mean = 50 and SD = 10) to facilitate interpretation and comparisons across tasks. Subsequently, all of the seven task RTs were averaged and each contributed equally towards the overall RT composite.

Seven-Task Accuracy and Reaction Time Composites
Regression on Span

To assess how well span score predicted the seven-task accuracy and RT composites, we included span score as a predictor of seven-task accuracy and RT composites (see Table 4) into two separate multiple regressions via the enter method. As well, GPA was added as a WM span comparison predictor. In the first regression analysis, we regressed the seven-task accuracy composite on WM span score and GPA. The overall model for WMC and GPA predicting accuracy accounted for 34 percent of variance explained in accuracy. WMC, however, explained the majority of the variance (i.e., about 31 percent). Lastly, GPA was not a good predictor of accuracy, explaining about 4 percent of variance in accuracy). The prediction equation for ACC was [ACC' = (.030*GPA) + (.003*WMC) +.541]. In the second regression analysis, we regressed the seven-task RT composite on WM span score and GPA. The overall model for WMC and GPA predicting RT accounted for zero percent of variance in RT. WM span only accounted for one percent of variance, and GPA also failed to predict RT well, explaining about two percent of variance in RT. The prediction equation for RT was [RT' = (-1.590*GPA) + (-.022*WMC) + 56.145].

Table 4. Seven-Task Accuracy and Reaction Time Regressions on Span

	β	*r*	$R^2_{Adjusted}$	ΔR^2	*F* (2,83)	*p*
ACC Model			.34		22.39	<.001
WMC	.56***	.57***		.31		
GPA	.17	.20		.04		
RT Model			.00		1.02	.37
WMC	-.06	-.07		.01		
GPA	-.14	-.14		.02		

Note. β = standardized regression coefficient; $R^2_{Adjusted}$ = adjusted proportion of variance explained; ΔR^2 = change in proportion of variance explained. ACC = seven-task average accuracy composite, RT = seven-task average reaction time composite. **p* < .05. ***p* < .01. ****p* < .001.

Difference Between High Span and Low Span Across the Seven Tasks

The RT and accuracy means were calculated for each of the four cognitive factors and their corresponding tasks (see Table 5). As well, when the seven-task accuracy and RT mean composites were compared between High Span and Low Span groups, there was no difference of RT between span groups; there was, however, a group difference in accuracy, in which High Span group demonstrated higher overall accuracy than Low Span group.

Table 5. Mean Accuracy and Reaction Times for High and Low Span Groups

	ACC				RT			
	High WM	Low WM			High WM	Low WM		
	M(SD)	M(SD)	*t*(44)	*p*	M(SD)	M(SD)	*t*(44)	*p*
REASON								
Inference	.52(.23)	.44(.22)	-1.47	.15	54(13)	50(9)	-1.00	.32
PERCEP	.94(.04)	.84(.10)	-.3.03	.004	50(9)	51(7)	.58	.57
NumbCo	.95(.05)	.94(.07)	-1.07	.29	50(13)	49(9)	-.34	.74
Stroop	.92(.19)	.74(.19)	*t*(41)=-3.95	<.001	49(11)	52(11)	*t*(41)=.66	.51
PRP	.95(.06)	.85(.20)	*t*(42)=-1.83	.07	50(10)	52(7)	*t*(42)=1.03	.31
MEM								
FirstLast	.46(.21)	.25(.16)	-3.77	<.001	47(6)	53(13)	1.91	.06
VERBAL	.53(.11)	.44(.11)	-2.76	.008	52(9)	49(8)	-1.15	.26
Incomp	.54(.14)	.44(.12)	-2.66	.01	52(11)	49(10)	-1.09	.28
Rewrit	.53(.19)	.45(.21)	-1.30	.20	51(9)	49(13)	-.62	.54
Total	.70(.06)	.59(.08)	-4.86	<.001	50(6)	51(6)	.15	.88

Note. REASON = Reasoning, PERCEP = Perceptual, MEM = Memory. NumbCo = Number Comparison Task, PRP = Psychological Refractory Period Task, FirstLast = First Last Names Test, Incomp = Incomplete Words Test, Rewrit = Rewriting.

Between high and low span groups, three of the accuracy composite factor scores demonstrated group differences (see Table 5). Between subjects *t*-tests were conducted to compare group means. There was no group difference between Reasoning accuracy. There was a group difference in the Perceptual factor, in which High Span group demonstrated higher accuracy than Low Span group. There was a difference between groups in the Memory factor by which High Span group had higher accuracy than Low Span group. There was also a difference in the Verbal factor, in which High Span group had higher accuracy than Low Span group.

Between High and Low Span groups, task accuracy scores had three statistically different comparisons (Stroop, First Last Names, and Incomplete Words) and four non-significant comparisons (Number Comparison, Inference, PRP, and Rewriting), (see Table 5). That is, three of the seven dependent measures demonstrated a group difference in accuracy. In all differences, High Span group demonstrated higher accuracy than Low Span group. RT comparisons, independent samples *t*-tests did not reveal any mean group differences between the seven tasks nor between the four factors (see Table 5).

Difference Between High and Low Span in Stroop Task

Apart from a single accuracy measure and a single RT measure, two of the *Perceptual* tasks (i.e., Stroop and PRP) had several within-task conditions. The Stroop task had the independent variables of Task (Word Reading and Color Naming) and *Switch* (Switch and Repeat) and a switch cost, measured as the difference between switch and repeat trials. As discussed in the beginning of the Results section, five participants were excluded from the Stroop data, and three of them were from Low Span group. 20 Low Span participants were compared to 23 High Span participants.

<u>Differences Between the High and Low Span Groups in Accuracy</u>

The combined-group mean accuracy and between-group data are shown in Table 6 and were submitted to a 2(Group) X 2(Task) X 2(Switch) mixed ANOVA. There was a significant, between-groups difference, $F(1,41) = 16.10$, p

< .001, η_p^2 = .282. Low span group had lower accuracy than High span group. There was no main effect of Switch, $F(1,41) = .24$, $p = .63$, $\eta_p^2 = .006$. There was no main effect of Task, $F(1,41) = .23$, $p = .64$, $\eta_p^2 = .005$.

Table 6. Mean Reaction Time and Accuracy for the Stroop Task

	LowSpan M(SD) *n*=20				HighSpan M(SD) *n*=23			
	WR		CN		WR		CN	
	Switch	Repeat	Switch	Repeat	Switch	Repeat	Switch	Repeat
ACC	.80 (.15)	.79 (.14)	.77 (.15)	.82 (.12)	.93 (.09)	.92 (.09)	.93 (.09)	.91 (.07)
RT	1485 (232)	1391 (247)	1506 (257)	1368 (292)	1425 (290)	1382 (299)	1425 (330)	1368 (292)

Note. WR = Word Reading, CN = Color Naming. Switch = a CN trial followed a WR trial or vice versa. Repeat = a CN trial followed a CN trial, or a WR trial followed a WR trial.

However, there was a significant interaction between Span Group and *Switch*, $F(1,41) = 5.44$, $p =.03$, $\eta_p^2 = .117$. The High Span group had a smaller switch cost than the Low Span group. As well, there was no significant interaction between Span Group and Task, $F(1,41) = .00$, $p =.97$, $\eta_p^2 = .000$. There was no significant interaction between *Switch* and Task, $F(1,41) = 3.12$, $p =.08$, $\eta_p^2 =$ .071.

There was a significant three-way interaction between Span Group, *Switch*, and *Task*, $F(1,41) = 5.65$, $p =.02$, $\eta_p^2 = .121$. As shown in Figure 1, the Low Span group showed the switch cost only for the Color Naming task, $t(19) = 2.94$, $p = .008$, but not for the word reading task, whereas, the High Span group showed no switch cost in any task.

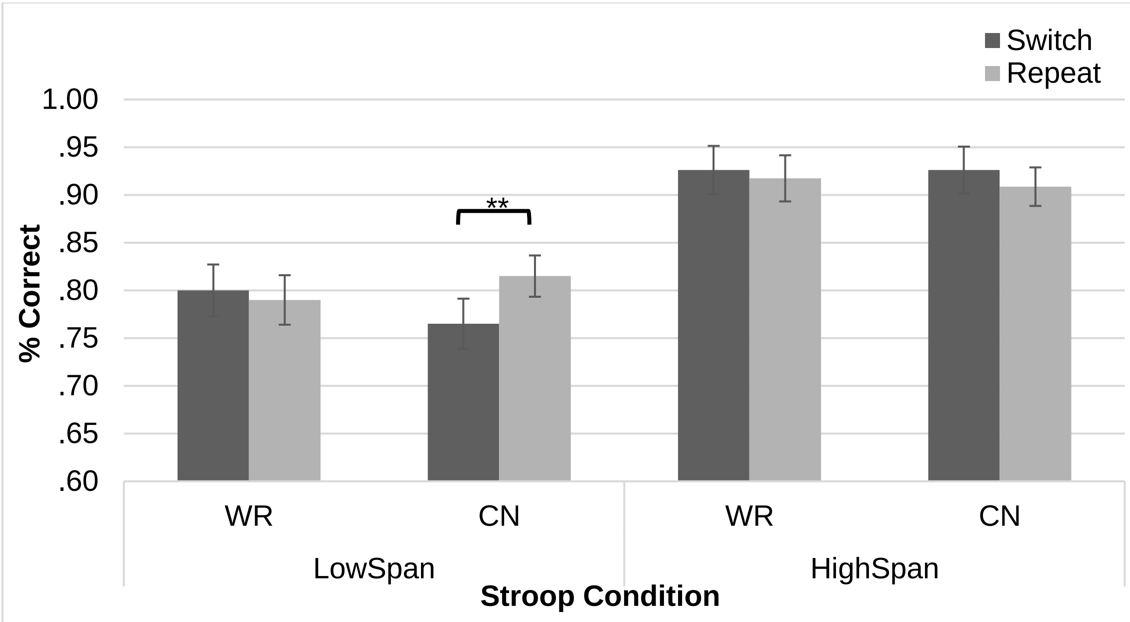

Figure 1. Mean Accuracy in the Stroop Task
Error bars represent standard error of the mean. **p* < .05. ***p* < .01. ****p* < .001.

<u>Differences Between the High and Low Span Groups in Reaction Time</u>

In the RT data, there was no overall significant difference between groups, $F(1,41) = .358$, $p = .55$, $\eta_p^2 = .009$. There was a main effect of Switch, $F(1,41) = 13.60$, $p = .001$, $\eta_p^2 = 249$, with Switch trials taking longer than Repeat trials. There was no main effect of Task, $F(1,41) = .20$, $p = .65$, $\eta_p^2 = .005$. There was no interaction between Switch and Span Group, $F(1,41) = 1.27$, $p = .27$, $\eta_p^2 = .030$. There was no interaction between Task and Span Groups, $F(1,41) = .80$, $p = .38$, $\eta_p^2 = .019$. There was no interaction between Switch and Task, $F(1,41) = .11$, $p = .74$, $\eta_p^2 = .003$. There was no three-way interaction, $F(1,41) = .01$, $p = .79$, $\eta_p^2 = .002$ (see Figure 2 for group performance across conditions).

One-way between subjects ANOVA's across each condition did not reveal any RT differences. However, within-group comparisons on switch costs were carried out and revealed switch costs resulted in all conditions except for in High Span group's WR (see Figure 2). In the Low Span group, both WR and CN demonstrated a RT switch cost: RTs were longer for the Switch trials than for the Repeat trials for the Word Reading task, $t(19) = 2.73$, $p = .01$, and RTs were longer for the Switch than for the Repeat trials for the Color Naming task, $t(19) = 2.23$, $p = .04$. In the High Span group, RTs were longer for the Switch than for the Repeat trials for the Color Naming task, $t(22) = 2.27$, $p = .03$, whereas RTs were the same between the Switch and Repeat trials for the Word Reading task, $t(22) = 2.52$, $p = .14$.

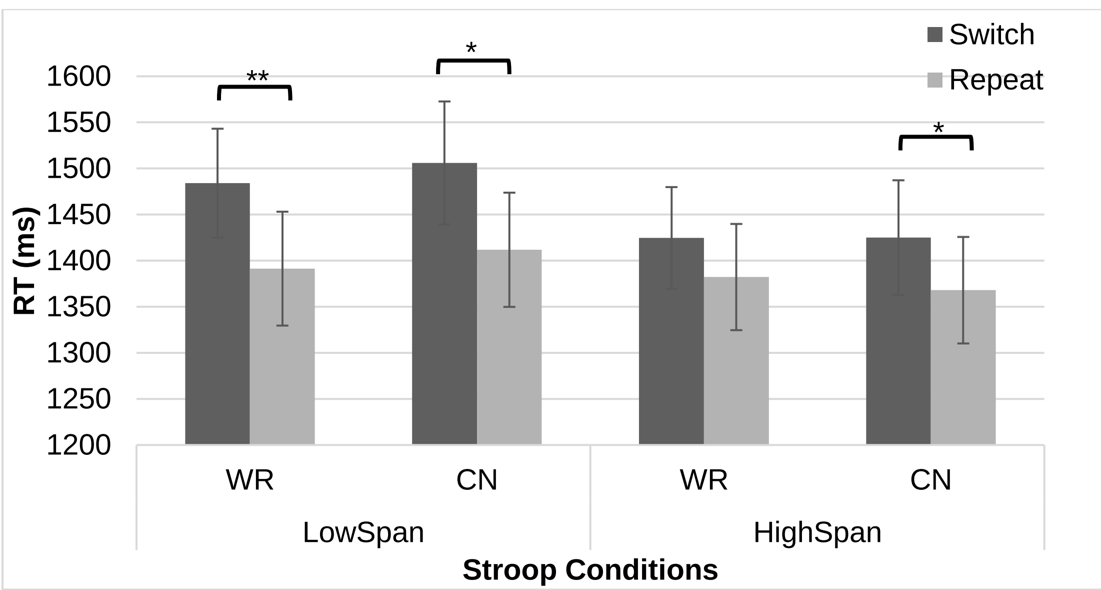

Figure 2. Mean Reaction Time Performance in the Stroop Task
Error bars represent standard error of the mean. *$p < .05$. **$p < .01$. ***$p < .001$.

Difference Between High and Low Span in the Psychological Refractory Period

Psychological Refractory Period (PRP) had the independent variables of Stimulus Onset Asynchrony (SOA), (50 ms, 150 ms, and 650 ms) and Task (High/Low Pitch discrimination and Highest Digit identification). The following section analyzes group differences between and within these within-subject conditions. As discussed in the beginning of the Results section, three participants were excluded from the PRP analysis and two of them were from Low Span group, resulting in 21 in Low Span group and 23 in High Span group for the subsequent analyses.

Psychological Refractory Period Span Group Accuracy Analysis

The mean accuracy data are shown in Table 7, and were submitted to a 2(Group) X 2(Task) X 3(SOA) mixed ANOVA. There was no significant difference between the two Span groups, $F(1,42) = 3.39$, $p = .07$, $\eta_p^2 = .073$. There was, however, a main effect of Task, $F(1,42) = 17.85$, $p < .001$, $\eta_p^2 = 298$, with Tone trials having higher accuracy than Digit trials. There was also a main effect of SOA, $F(2,84) = 4.71$, $p = .01$, $\eta_p^2 = .10$. Paired samples *t*-tests revealed that accuracy was higher for the 50 ms SOA than for the 150 ms SOA condition, t(22)=3.40, p =.003, but there were no differences between the 50 ms SOA and 650 ms SOA conditions, $t(22) = 1.00$, $p = .33$ nor between 150 ms SOA and 650 ms SOA conditions, $t(22) = -1.64$, $p = .115$. There were no significant two-way interactions (i.e., between Group X Task, Group X SOA, or Task X SOA). As well, there was no three-way interaction, $F(2,84) = .54$, $p = .58$, $\eta_p^2 = .01$.

Table 7. Mean Reaction Times and Accuracy for the Psychological Refractory Period Task

		LowSpan (*n*=21)		HighSpan (*n*=23)	
		ACC	RT	ACC	RT
Task	SOA (ms)	M(SD)	M(SD)	M(SD)	M(SD)
Tone	50	.93(.10)	1253(266)	.97(.05)	1247(336)
	150	.92(.11)	1139(239)	.95(.07)	1149(330)
	650	.93(.10)	951(199)	.96(.07)	1010(256)
Digit	50	.88(.13)	814(353)	.94(.07)	653(487)
	150	.85(.15)	836(376)	.92(.09)	698(520)
	650	.87(.15)	844(394)	.93(.09)	639(493)
Total AVG		.90(.12)	973(304)	.95(.07)	899(404)

One-way between subjects ANOVA comparing each condition between groups demonstrated that the High Span group had significantly higher accuracy than the Low Span group for the 50 ms SOA condition in the Digit task, $F(1,42) = 4.22$, $p = .05$ (see Figure 3). There were no differences between groups in each Tone SOA comparisons.

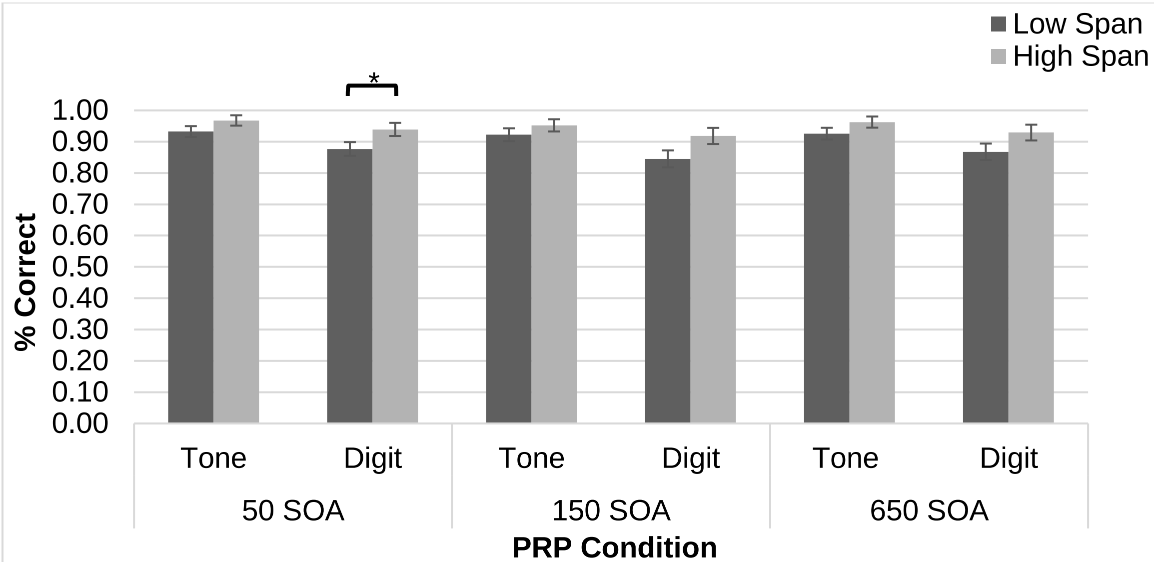

Figure 3. Mean Accuracy for Psychological Refractory Period Task
Error bars represent standard error of the mean. *p < .05. **p < .01. ***p < .001.

<u>Psychological Refractory Period Span Group</u>
<u>Reaction Time Comparisons</u>

The mean RT data are shown in Table 7, and were submitted to a 2(Group) X 2(Task) X 3(SOA) mixed ANOVA. There was no significant main effect of Group, $F(1,42) = .722$, $p = 4.0$, $\eta_p^2 = .017$. There was, however, a main effect of Task, $F(1,42) = 35.06$, $p < .001$, $\eta_p^2 = .455$, with Tone trials having longer RTs than Digit trials. There was also a main effect of SOA, $F(2,84) = 36.62$, $p < .001$, $\eta_p^2 = .466$. Paired samples *t*-tests revealed that the RTs were longer for the 50 ms than for the 150 ms SOA condition, $t(22) = 3.71$, $p = .001$, longer for the 150 ms than for the 650 ms SOA condition, $t(22) = 6.25$, $p < .001$, and longer for the 50 ms than for the 650 ms SOA condition, $t(22) = 4.71$, $p < .001$.

There was no Group by SOA two-way interaction, $F(2,84) = .18$, $p = .84$, $\eta_p^2 = .004$. As well, there was no Group by Task two-way interaction, $F(1,42) = 2.12$, $p = .15$, $\eta_p^2 = .050$. However, there was a Task by SOA two-way interaction, $F(2,84) = 19.73$, $p < .001$, $\eta_p^2 = .320$ (see Figure 4). Within-subjects *t*-tests revealed that RTs were different across all of the Tone SOAs, whereas, for the Digit SOAs, RTs were different between the 50 ms and 150 ms SOA only. The RTs were shorter for the 50 ms than for the 150 ms SOA for the Digit task, $t(43) = 2.64$, $p = .012$. The RTs were the same for the 50 ms and the 650 ms SOA for the Digit task, $t(43) = .39$, $p = .67$. The RTs were the same for the 150 ms and the 650 ms SOA for the Digit task, $t(43) = 1.33$, $p = .19$. The RTs were longer for the 50 ms than for the 150 ms SOA for the Tone task, $t(43) = 5.77$, $p < .001$. The RTs were longer for the 50 ms and the 650 ms SOA for the Tone task, $t(43) = 6.81$, $p < .001$. The RTs were longer for the 150 ms than the 650 ms SOA for the Tone task, $t(43) = 4.03$, $p < .001$. The three-way interaction was not significant, $F(2,84) = 1.01$, $p = .34$, $\eta_p^2 = .025$.

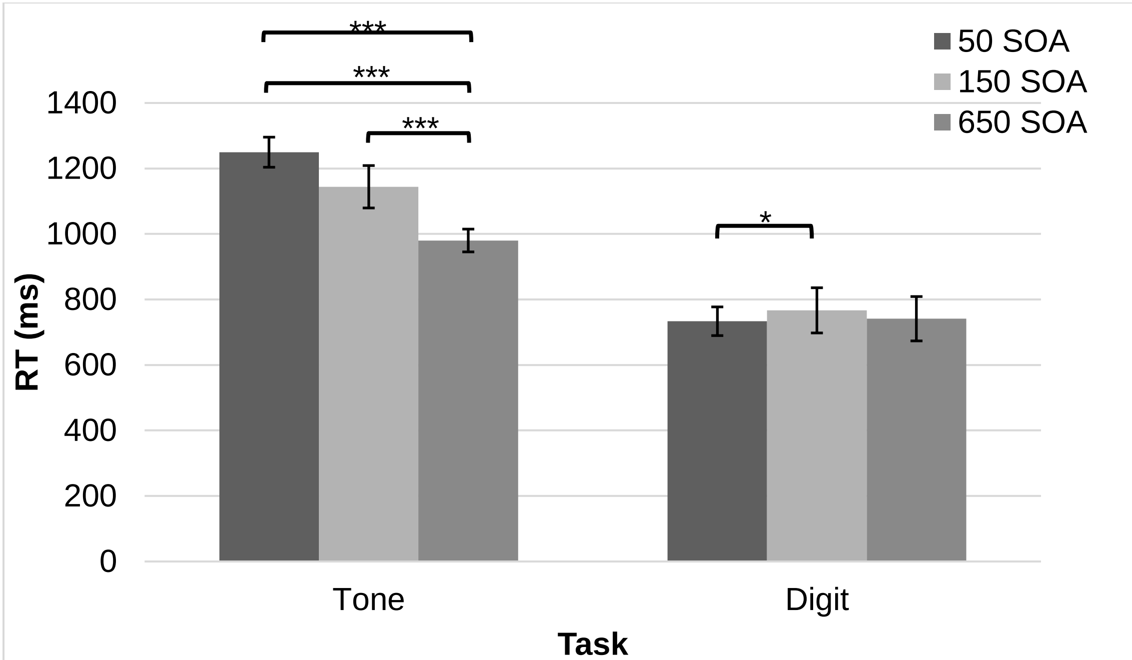

Figure 4. Mean Reaction Times for the Psychological Refractory Period Task
Error bars represent standard error of the mean. **p* < .05. ***p* < .01. ****p* < .001.

<u>Psychological Refractory Period Reaction Time Cost Comparisons</u>

RTs for the first task (Tone) and second task (Digit) for each SOA condition for the two groups are shown in Figure 5. Post-hoc t-tests were performed to compare whether the difference between the two tasks was different across SOA conditions for each group. For Low Span group, the difference between the two tasks was greater for 50 ms than for 150 ms SOA, $t(22) = 3.56$, p = .002, and greater for 50 ms than for 650 ms SOA, $t(22) = 6.89$, $p < .001$, and greater for the 150 ms than for the 650 ms SOA, $t(22) = 3.63$, $p = .002$. For High Span group, the difference between the two tasks was greater for 50 ms than for 150 ms SOA, $t(22) = 4.26$, $p < .001$, and greater for 50 ms than for 650 ms SOA, $t(22) = 2.73$, $p = .01$, but not different between 150 ms and 650 ms SOA, $t(22) = .90$, $p = .38$.

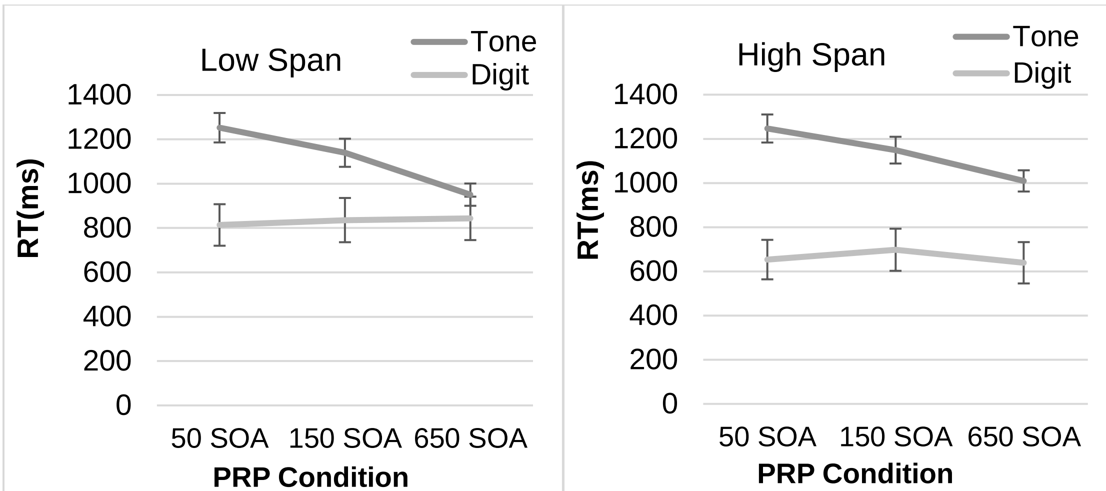

Figure 5. Mean Reaction Times Plotted Against Stimulus Onset Asynchrony for Two Task Conditions for Each Group in the Psychological Refractory Period Task

Error bars represent standard error of the mean.

CHAPTER SIX
DISCUSSION

Main Findings Overview

This study sought out to shed light on the cognitive abilities necessitated for dispatcher duties that were identified by POST (Weiner, & Solorio, 1991) on several dimensions. The first goal was to develop a battery that would measure general cognitive abilities determined as essential for dispatchers, without any job-knowledge biases in the task measures. POST's measurement of dispatcher abilities also entailed dispatcher duties in their selection test battery, such as, recording field unit statuses on a radio-log, listening to simulated radio calls from patrol officers to dispatchers, recalling facts from law enforcement audio transmissions, assigning priority codes to possible emergency incidents, etc. Therefore, exploring these abilities without any possible dispatcher duty confounds would advance our understanding of the underlying mechanisms necessitated by these cognitive abilities. The second goal was to establish the relevance of dispatcher ability performance based on WMC level and substantiate WMC as a viable indicator of dispatcher ability performance. This relevance on ability was founded upon executive functioning's keeping representations active despite distractions (Engle, Tuholski, Laughlin, & Conway, 1999). The following two goals specifically deal with High and Low Span group differences. The third goal was to assess the prediction of improved performance of High WMC group on the four ability composites. The fourth goal of this study was to investigate the prediction of improved performance of High WMC group across the Stroop task's switch cost and the PRP's dual-task interference. Overall, all of the goals of this study were mostly supported; that is, WMC was strongly tied to the accuracy measures of abilities but was not indicative of RT performance.

Accuracy measures indicated towards a strong, underlying relationship with WMC, whereas average speed of response failed to establish any meaningful links to WMC. WMC strongly predicted the seven-task accuracy composite, even better than college GPA. WMC explained about 30% of variance in the seven-task accuracy composite, whereas GPA only accounted for 4% of variance. WMC did not predict the seven-task RT composite well.

Furthermore, each of the accuracy composites of Reasoning, Perceptual, Memory, and Verbal factors were positively correlated with WMC, in that those who demonstrated higher accuracy throughout four-ability composites were also those that had higher WMC scores. Reasoning ability linked to WMC, as indicated by Kyllonen and Christal (1990) was supported in this analysis. Our Verbal ability composite score based on accuracy demonstrated an association to WM performance. This finding is in line with Daneman and Carpernter (1980) and Baddeley and Hitch (1974) assertions of WM being linked to Verbal ability. The findings of Memory ability scores demonstrating a strong association to WM performance is also in line with research by Conway, Kane, and Engle (2003) that argued and supported WMC relating to long-term memory. The Perceptual composite score was also highly associated with WMC performance, providing support for the association of WMC to attentional control (Barrett, Tugade, & Engle, 2004), as well as, the linkage of WMC to task switching effects argued by Barrouillet, Bernardin, and Camos, (2004).

Differences Between High and Low Working Memory Span Groups

The self-report measures of State Anxiety, Trait Anxiety and Depression did not differ between the two groups; therefore, the difference in performance in the cognitive tasks between High and Low WMC groups was not attributed to by anxiety nor depression. Overall, our hypotheses that WMC would differentiate performance on dispatcher relevant abilities were confirmed based on differences found between WMC groups in accuracy data.

Specifically, hypothesis 1 predicted that High WMC group will perform better in the reasoning measure in terms of RT and accuracy. Hypothesis 2 predicted that the High WMC group will perform better in the verbal measure in terms of RT and accuracy. Hypothesis 3 predicted that the High WMC group will perform better in the memory measure in terms of RT and accuracy. Lastly, hypothesis 4 outlined that for the perceptual ability measures, (a) in the Stroop task, High WMC group will demonstrate higher accuracy, a shorter RT, and reduced switch costs, (b) in the PRP task, High WMC group will demonstrate increased accuracy and reduced interference in dual-task processing, and (c) in the Number Comparison task, High WMC group will demonstrate higher accuracy.

For the Reasoning, Perceptual, Memory, and Verbal factors, High WMC group showed higher accuracy than the Low WMC group for all the factors except for the reasoning factor. There was no significant difference between the two groups for reasoning scores, and hypothesis 1 was not supported; however, that does not necessarily indicate the absence of a relationship between WMC and our reasoning measure. Although no WMC group difference was found on reasoning ability, which was likely due to low statistical power, the overall analysis with all participants supported a relationship between WMC and Reasoning: WMC and Reasoning were significantly positively correlated, thus in line with supporting research arguing for the sharing of similar constructs between reasoning and WM (see Kyllonen & Christal, 1990).

Hypothesis 2, on the other hand, was supported in terms of accuracy; High WMC group performed better on Verbal ability. Our measure of Reading Comprehension and Written Expression were in line with Baddeley and Hitch (1974) assertion of WMC being linked to Verbal ability. Verbal cognitive faculties recruit WM as verbal complexity increases, to hold and express increasingly complex information more efficiently.

Hypothesis 3 was also supported in terms of accuracy; High WMC group outperformed Low WM group in the Memory ability. The fact that this memory measure was strongly associated with WMC is likely due to the recruitment of attentional control necessitated for this task's temporal interference (Chase & Ericsson, 1982); that is, the three minutes between presentation and recall served as enough interference to solicit attentional control. Therefore, it is likely that participants had to mentally manipulate and keep the memory representations active to minimize the effects of temporal interference, and those with higher WMC had greater facility in keeping those mental representations active.

Hypothesis 4(a) entailing the Stroop task performance difference was supported in the results in that High WMC group showed increased overall accuracy compared to the Low WMC group. The RT difference of High Span group demonstrating lower RT than Low Span group was not supported by the results. In terms of the switch cost differences between the two groups, the hypothesis was supported; High WMC group did not show a switch cost in accuracy in neither color naming nor word reading, whereas Low WMC group showed a switch cost in the color naming trials thus indicating that Low WMC group was more prone to errors in switching tasks as compared to High WMC. In terms of RT switch cost, the hypothesis was partially supported: Low WMC group showed a switch cost for color naming and word reading, whereas, High WMC group only showed a switch cost for color naming.

We expected Low WMC group to demonstrate a larger switch cost than High WMC group, and our results lend support for this expectation. The lack of a switch cost in High WMC group indicate that High WMC group was less prone to errors associated with Task Set Reconfiguration (i.e., attentional shift ability, retrieval of goal states, and adjusting response criteria) upon a task switch (Monsell, 2003), whereas the presence of a task switch cost in Low WMC group indicate towards a diminished ability of executive control mechanisms.

The result of color naming eliciting a RT switch cost for both High and Low WMC groups may be due to word reading being the more automated task and color naming the more effortful task; therefore, the task switching measure had a processing asymmetry between the two tasks in which switching from word reading to color naming was costlier, even for High WMC group.

Overall, the Stroop task switching analysis provided support for High WMC group demonstrating lower switch costs than Low WMC group. This finding supports Kane, Bleckley, Conway, and Engle (2007) and Liefooghe, Barrouillet, Vandierendonk, and Camos (2008) assertions that a task switching measure must tap volitional control mechanisms in order to be linked to WMC differences. However, unlike Kane et al. (2007) study's failed attempts to support a link between WMC and switch cost, this studies' Stroop task switching measure managed to substantiate a connection between WMC and switch cost. Kane et al. (2007) concluded that task switching measures should eliminate cue encoding and cue-based retrieval methods in order for them to tap into executive functioning. The present study's Stroop task, however, also implemented a cue-based retrieval method but managed to tap into executive functioning. The link to executive functioning likely resulted from what Liefooghe, Vandierendonck, Muyllaert, Verbruggen, and Vanneste (2005) proposed, that strong selective interference procedures can solicit executive functioning in task switching. Our Stroop task only used incongruent trials, which likely increased selective interference and recruited volitional control when coupled with the task alternating run sequence.

Hypothesis 4(b), regarding PRP group difference was partially supported: In terms of accuracy, High WMC group demonstrated higher accuracy than the Low WMC group for the 50 ms SOA condition in the Digit task thus indicating less dual-task interference from the first task (Tone discrimination) on the second task (Digit processing). That is, the 50 ms SOA condition was meant to produce the greatest amount of processing overlap between the two tasks, and a diminished accuracy on task two in the Low WMC group indicates that Low WMC group performance on the second task was more affected by the processing of the first task.

The PRP task was used to assess an aspect of time-sharing in which the interval between two tasks is manipulated so that an extremely short interval (i.e., 50 ms) would push back the processing of the second task due to the individual still processing the first task. In the 50 ms interval between tasks, the Low WMC group demonstrated more errors than the High WMC group on the second task thus supporting Low WMC group's diminished capacity to accurately process the subsequent task in the most difficult SOA condition. There was no RT difference however between 50 ms SOA of first and second tasks between groups, which indicates that the PRP task was only sensitive to accuracy differences between WMC Span groups.

Hypothesis 4(c) stated that High WMC group would demonstrate higher accuracy in the Number Comparison Task; however, this prediction was not supported. Kane, and Engle (2003) supported that WMC relates to speed and accuracy of responses when there is response competition or proactive interference. However, the absence of a link to WMC likely resulted from the Number Comparison's measure not requiring executive functioning.

Future Direction and Conclusion

One of our expectations for this study was to observe a RT difference between span groups, which has been reported in previous WM literature. However, the lack of average trial RT span differences led us to question the degree of relationship between RT and WM and if their relationship is dependent upon task complexity. We propose that any RT differences that arise between span groups will likely result from more complex, within group conditions, which may not be overtly measured by simple average RT gauging. In our study, RT differences resulted only when assessing more complex RT measures, such as, the Stroop switch cost per conditions, or the PRP's two-task RT difference. Therefore, RT differences between span groups are probably best manifested via more complex conditions within tasks. Engle and Kane (2003), for instance, demonstrated mixed results in their Stroop task experiments in which accuracy or

RT independently accounted for the interference across span group, which was dependent upon the congruency level sequence. In high-congruency trial sequences (i.e., 75% and 80%), low span demonstrated lower accuracy but no RT difference in terms of Stroop interference. However, high-incongruent trial sequences (i.e., 0% or 20% congruent) led span groups to demonstrate more RT differences and no accuracy differences. The researchers concluded that performance on their Stroop manipulations were determined by two mechanisms which were sensitive to span group differences. The first mechanism was *response-competition*, which led to the RT differences between span group without showing ACC differences, while the second mechanism was *transient failure of goal maintenance*, which was reflected mostly by the accuracy differences between span groups and not so much by RT differences. Therefore, to assess any WMC group difference, investigating more complex condition-dependent constructs may shed more light on the circumstances in which WMC relates more intricately to RT measures.

The dispatcher cognitive abilities and the tasks that measure them reflect underlying cognitive faculties that are necessitated for effective public safety radio dispatching. That is, the four cognitive abilities of Reasoning, Perceptual, Memory, and Verbal and the seven dependent measures were all aimed at assessing dispatcher cognitive ability performance alone. By excluding any dispatcher-like duties in our ability measures, we were able to gauge relevant cognitive ability without the confound of familiarity with dispatcher duties thus allowing us to implement the cognitive battery on a student sample from various backgrounds.

With WMC substantiated as intricately linked to accuracy performance on ability measures, subsequent investigations should be carried out on dispatcher populations to assess how WMC differs across dispatchers in regards to expertise, supervisor ratings, time employed, etc. Furthermore, assessing dispatcher work performance in light of WMC differences can provide insight into the cognitive faculties that facilitate dispatcher tasks. As supported by Konig, Buhner, and Murling (2005), WMC can serve as a good indicator of performance on jobs that require a high degree of multitasking, and in conjunction with this study's findings of WMC's relevance towards dispatcher abilities, a WMC measure may be considered as a viable indicator of the capacity to conduct dispatcher ability tasks accurately.

As well, considering that dispatcher duties are frequently submitted to task switching demands at any given time, and that a reduced switch cost can facilitate dispatcher task performance, measuring performance on task switching, while investigating any task switching-WM interaction in current dispatchers can prove advantageous in considering an alternative, more efficient dispatcher task procedure. Finally, this battery can be further improved by incorporating all of the ability sub-factors that were not all gauged due to time constraints and practicality of administration, and thus ensuring that each major ability is adequately represented by its sub-ability constituents.

APPENDIX A

CORE COGNITIVE ABILITIES

"Core" Abilities Necessary Before Hire

COGNITIVE ABILITIES

VERBAL

ORAL COMPREHENSION is the ability to understand spoken English words and sentences.

Examples of this ability include: Understanding complaints, requests, and other information received orally from citizens, field personnel and other agencies; and understanding briefings, instructions and directions received orally from field personnel, supervisors and co-workers.

WRITTEN COMPREHENSION is the ability to understand written sentences and paragraphs.

Examples of this ability include: Reading and understanding written incident information (e.g., summaries), various reference materials, (e.g., manuals, codes, policies and procedures), and teletype information (e.g., CLETS, NCIC).

ORAL EXPRESSION is the ability to use English words or sentences in speaking so others will understand.

Examples of this ability include: Providing information and directions orally to the public, co-workers and field personnel; questioning callers; dispatching field personnel; and explaining policies and advising citizens of actions to take in various emergency and non-emergency situations.

WRITTEN EXPRESSION is the ability to use English words or sentences in writing so others will understand.

Examples of this ability include: Recording and summarizing complaint information in writing (e.g., completing incident cards and reports); maintaining various logs; preparing information to broadcast (e.g., teletype messages, APB's); writing office communications and bulletins; and dispatching field personnel via CAD system.

FLUENCY OF IDEAS is the ability to produce a number of ideas about a given topic.

Examples of this ability include: Providing alternatives to the public and field personnel (e.g., identifying alternative resources, routes of travel, etc.); coming up with alternative approaches to obtain information from a difficult caller or to keep a caller on the phone (e.g., suicide, suspect); and identifying a variety of data bases and other resources as needed to obtain requested information.

REASONING

DEDUCTIVE REASONING is the ability to apply general rules to specific problems to come up with logical answers. It involves deciding if an answer makes sense.

Examples of this ability include: Resolving complaints and requests for service; determining how many units to dispatch to a call (e.g., appropriate level of response); and recognizing that information given by a caller is not consistent.

INDUCTIVE REASONING is the ability to combine separate pieces of information, or specific answers to problems, to form general rules or conclusions. This involves the ability to think of possible reasons why things go together.

Examples of this ability include: Judging whether a complaint or request is legitimate; determining whether a complaint is a criminal or civil matter; evaluating complaint information and determining the type of crime (e.g., robbery vs. burglary); and recognizing duplicate or related calls (e.g., comparing suspect information given in separate calls).

INFORMATION ORDERING is the ability to correctly follow a given rule or set of rules to arrange things or actions in a certain order. The things or actions to be put in order can include numbers, letters, words, pictures, procedures, sentences, and mathematical or logical operations.

Examples of this ability include: Classifying and prioritizing complaints and requests; recording complaint/request information in the appropriate format; arranging information in the appropriate order for broadcasting to field personnel; and reading back a teletype message in logical order.

MEMORY

MEMORIZATION is the ability to remember information, such as words, numbers, pictures, and procedures. Pieces of information can be remembered by themselves or with other pieces of information.

Examples of this ability include: Remembering the details of a recent incident or related incidents; remembering procedures for handling various types of complaints and incidents, as well as for operating communications equipment and systems; remembering various codes and abbreviations (e.g., radio, legal); and remembering geographical boundaries and significant common locations.

"Core" Abilities Necessary Before Hire

PERCEPTUAL

SPEED OF CLOSURE ability involves the degree to which different pieces of information can be combined and organized into one meaningful pattern quickly. It is not known beforehand what the pattern will be. The material may be visual or auditory.

Examples of this ability include: Evaluating initial information and quickly determining whether an incident is an emergency; receiving multiple radio transmissions in rapid succession and determining that they pertain to the same incident; and taking several calls reporting different parts of the same incident and quickly combining the information to gain an overall picture of what happened.

PERCEPTUAL SPEED ability involves the degree to which one can compare letters, numbers, objects, pictures, or patterns, both quickly and accurately. The things to be compared may be presented at the same time or one after the other. This ability also includes comparing a presented object with a remembered object.

Examples of this ability include: Quickly comparing and verifying names, locations and descriptions received by radio, telephone, or in written form (e.g., checking a detainee's description against a wanted list or data base inquiry); and quickly comparing incident information to determine if different calls are related.

SELECTIVE ATTENTION is the ability to concentrate on a task and not be distracted. When distraction is present, it is not part of the task being done. This ability also involves concentrating while performing a boring task.

Examples of this ability include: Taking calls and dispatching field personnel from within a noisy, distracting work environment (e.g., taking a complaint from a citizen while other phone lines are ringing, other dispatchers are receiving emergency calls, teletype messages are printing, and alarm panels are sounding; or dispatching field personnel to an incident while other unrelated personnel are transmitting on the same frequency).

TIME SHARING is the ability to shift back and forth between two or more sources of information.

Examples of this ability include: Handling multiple calls for assistance at the same time; taking a complaint while monitoring radio traffic, teletypes and alarm panels; coordinating the response of multiple field units to an incident or several ongoing incidents; monitoring multiple radio channels at the same time; and tracking the status of field personnel while performing other duties (e.g., taking complaints or dispatching).

Weiner, J. Solorio, A. (1991*). Public safety dispatcher job analysis. Component 2: analysis of job requirements*. Sacramento, CA: Commission on Peace Officer Standards and Training.

APPENDIX B

SELECTION TESTS

POST Entry-Level Dispatcher Selection Tests[2]

1. Public Safety Bulletin (r M): The examinee is given 3 minutes to review a one-page simulated "shift bulletin" containing several single-paragraph descriptions, each one pertaining to a different event. After the study period, the examinee answers multiple-choice questions regarding facts and details about the events based solely upon memory. *(paper-pencil format; power test; 4 response options; 15 items; 6 min.)*

2. Assigning Field Units (v R m): The examinee reads a novel set of rules for assigning field units and then determines which of five field units should be assigned to various "incidents." The incidents occur in different geographic regions and are designated emergency or non-emergency. The examinee uses a multiple-choice response format to designate no, one, or more units to be dispatched to each incident. Each item response alternative is scored. This test was designed to measure the deductive facet of Reasoning ability, primarily. *(paper-pencil format; power test; 32 response options; 20 items; 5 min.)*

3. Evaluating Facts (V): The examinee reads a set of public safety-related facts and then determines whether statements that follow are true, false, or cannot be determined on the basis of the facts. The answer is marked on a multiple-choice response sheet. *(paper-pencil format; power test; 3 response options; 15 items; 5 min.)*

4. Setting Priorities (R): The examinee is given a novel set of rules to read and follow in order assign priority codes to events. The events are presented in sets of three. A multiple-choice response format is used to designate the priority of events in each triad as 1st, 2nd, and 3rd priority. This test was designed to measure Information Ordering ability, a facet of Reasoning ability. *(paper-pencil format; power test; 3 response options; 15 sets/45 items; 10 min.)*

5. Reading Comprehension (V r): The examinee reads a brief passage and then answers multiple-choice questions regarding facts and details contained in the passage, as well as the meaning of the information, how it may be interpreted, and conclusions that may be drawn. While primarily designed to measure Written Comprehension ability, this test also measures Reasoning ability. *(paper-pencil format; power test; 4 response options; 20 items; 15 min.)*

6. Clarity (V): The examinee compares two versions of the same sentence and identifies the one that is more clearly written. The answer is marked on a multiple-choice response sheet. This test measures Written Expression, a facet of Verbal ability. *(paper-pencil format; power test; 2 response options; 15 items; 5 min.)*

7. Recalling Facts & Details (M): The examinee listens to a tape recording of a simulated call for law enforcement service received by a public safety dispatcher. The examinee is not allowed to take notes. The examinee then answers multiple-choice questions regarding various facts and details contained in the call, based solely upon memory. *(audiotape format; hybrid speed/power test; 4 response options; 18 items; 9 min.)*

(continued)

POST Entry-Level Dispatcher Selection Tests

8. Call-Taking (v R p): The examinee listens to a tape recording of three simulated calls for law enforcement service received by a dispatcher. The examinee is allowed to take notes during the calls and is given a brief period to complete the notes after all calls have been presented. The examinee is allowed to use the notes to answer a series of multiple-choice questions regarding facts and details pertaining the calls, as well as interpretations and conclusions regarding the meaning of each call. While primarily a measure of Reasoning ability, this test was also measures Oral Comprehension (Verbal) and Perceptual Speed and Accuracy abilities. *(audiotape format; hybrid speed/ power test; 4 response options; 25 items; 17 min.)*

9. Oral Directions (v R m): The examinee listens to a tape recording of a simulated radio call from a patrol officer to a dispatcher. The examinee is allowed to take notes during the call and is given a brief period to complete the notes after the call is presented. The examinee is allowed to use the notes to answer multiple-choice questions regarding various tasks to be performed, the order in which they are to be performed, various details contained in the call such as names, times, locations, etc., and interpretations and conclusions that may be drawn. While primarily a measure of Reasoning ability (Information Ordering), this test also measures Oral Comprehension (Verbal) and Memory abilities. *(audiotape format; hybrid speed/power test; 4 response options; 17 items; 14 min.)*

10. Checking Coded Information (P): The examinee listens to a tape recording of a narrator presenting a series of random letter-number codes. The codes range from two to four alphanumeric characters. As each code is presented orally, the examinee refers to a "Code Sheet," and identifies and marks the corresponding code among 5 written alternatives. The information is presented slowly at first, increasing in speed until the task becomes very difficult. After the information is presented, the examinee the marks his/her answers onto a scan able answer sheet. This test was designed to measure Perceptual Speed and Accuracy. *(audiotape format; speeded test; 5 response options; 60 items; 9 min.)*

11. Checking & Listening (r P): The examinee performs two tasks at the same time: (1) compare a list of names, addresses, and license numbers with a "HOT SHEET" containing similar information, and identify as many matches as possible; and (2) listen to a tape recording of simulated radio broadcasts from several field units and keep track of their status. The examinee records the unit status transmissions on a "RADIO LOG." After the simulated radio broadcasts have ended, the examinee is instructed to stop the comparison task and answer a series of multiple-choice questions regarding the various status changes of each unit. This test was designed to measure Perceptual Time Sharing ability, primarily. *(audiotape format; speeded part I, hybrid speed/ power part II; 2 response options part I; 5 response options part II; 105 items; 13 min.)*

Weiner, J. A., Lively, D., & Pruden, V. (1996). *POST entry-level dispatcher selection test battery: User's manual*. Sacramento, CA. Commission on Peace Officer Standards and Training.

APPENDIX C

TEST VALIDITY

Summary of Validity Evidence for the
POST Entry-Level Dispatcher Selection Test Battery

Tests[a]			Job Performance					
	Basic Academy		Supervisor Ratings		Self-Ratings		Probation	
	Pass/ Fail[b]	Total Perf[c]	Total Perf[d]	KSAs[e]	Unable to perf[f]	Total Perf[g]	Global Rating[h]	Pass/ Fail[i]
TOTAL BATTERY	.21***	.35***	.28**	.32***	-16*	.24**	.26**	.30***
1. Public Safety Bulletin (r M)	.15***	.30***	.18*	.14*	-14*	.18*	.17*	.16**
2. Assigning Field Units (v R m)	.13**	.29***	.18*	.20**	-.06	.22**	.16*	.20**
3. Evaluating Facts (V)	.14***	.23***	.13	.22**	-.04	.07	.08	.09
4. Setting Priorities (R)	.14**	.18***	.06	.06	-.16*	.01	.02	.14*
5. Reading Comprehension (V r)	.18***	.33***	.22**	.21**	-.21**	.15*	.17*	.13*
6. Clarity (V)	.12**	.24***	.12	.18*	-.11	.15*	.17*	.08
7. Recalling Facts & Details (M)	.15***	.21***	.12	.09	-.19*	.14*	.15*	.13*
8. Call-Taking (v R p)	.16***	.30***	.21**	.20**	-.11	.09	.09	.28***
9. Oral Directions (v R m)	.15***	.28***	.15*	.16*	-.11	.15*	.18*	.25***
10. Checking Coded Information (P)	.17***	.22***	.18*	.17*	-.01	.13	.17*	.28**
11. Checking & Listening (r P)	.14**	.25***	.25**	.32***	-.10	.19*	.20**	.26***

***p<.0001; **p<.01; *p<.05 (one-tailed).

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[a]Abilities measured are shown in parentheses; V=verbal, R=reasoning, M=memory, P=perceptual; uppercase denotes major factor loading (>=.50); lower case denotes minor loading (>=.30).

[b]N=627 to 680 non-affiliated students and student/dispatchers. Completed Dispatcher's Basic Course=1; failed to complete for any reason=0.

[c]N=629 to 682 non-affiliated students and student/dispatchers. Mean of standardized mean knowledge/skill rating and standardized class rank (15% of students ranked within class on the basis of academy curriculum test scores; no ratings available).

[d]N=148 to 153 entry-level dispatchers. Mean of: (a) mean of global effectiveness and relative performance ratings; (b) mean of 20 job duty ratings; (c) mean of 18 KSA ratings; and (d) mean of 8 work behavior ratings related to conscientiousness and performance under stress.

[e]N=150 to 155 entry-level dispatchers. Mean of 18 KSA ratings.

[f]N=144 to 149 entry-level dispatchers. Note: negative correlation is desired direction: Any instances where the dispatcher was unable to perform a critical job duty due to inadequate knowledge, skills, abilities, or other characteristics, over the last month (1=yes, 0=no).

[g]N=134 to 139 entry-level dispatchers. Mean of: (a) mean of global effectiveness and relative performance ratings; (b) mean of 20 job duty ratings; (c) mean of 18 KSA ratings; and (d) mean of 8 work behavior ratings related to conscientiousness and performance under stress.

[h]N=134 to 139 entry-level dispatchers. Mean of global effectiveness and relative performance ratings.

[i]N=215 to 221 entry-level probationary dispatchers. Completed=1; Resigned or terminated while job performance was unsatisfactory due to inadequate job knowledge, skills, or abilities=0.

Weiner, J. A., Lively, D., & Pruden, V. (1996). *POST entry-level dispatcher selection test battery: User's manual*. Sacramento, CA. Commission on Peace Officer Standards and Training.

APPENDIX D

INFORMED CONSENT FORM

CALIFORNIA STATE UNIVERSITY
SAN BERNARDINO

College of Social and Behavioral Sciences
Department of Psychology

Student Informed Consent
Dispatcher Cognitive Abilities

You are invited to participate in a study being conducted by David Buitron under the guidance of Hideya Koshino of the Psychology Department of California State University, San Bernardino (CSUSB). This study is approved by the Psychology Department subcommittee of the Institutional Review Board of California State University, San Bernardino, and a copy of the official Psychology IRB stamp of approval should appear on this consent form. The University requires that you give your consent before participating in this study.

This study explores cognitive performance on a series of cognitive tasks ranging from reasoning, verbal, perception, and memory. This study aims to gauge participant performance on these cognitive tasks, as well as, assess working memory, fluid intelligence, attention, and dual-tasking. We hope to gain a better understanding of the cognitive underpinnings of police dispatchers by developing computerized tasks allowing for the extraction of millisecond-reaction time and accuracy data. During the tests, computer-based cognitive measures will provide instructions for each task. An experimenter will also guide you through the study at every step. You are involved in the pilot testing of the measures that will be used for dispatchers to ensure that the measures are reliable. Your data will be stored on password protected lab computers behind locked doors, and participant numbers will be issued to maintain a separation between your name and your individual performance.

In exchange for participating in this study, you will receive extra credit. Specifically, you will receive 5 units of extra credit for every session that you complete, for a maximum of 15 units of extra credit through three separate 75 minute sessions; that is, once you complete the first session, you will have the opportunity to earn an additional 5 SONA units more for the subsequent session, as well as 5 other additional SONA units for the third session, which you can apply to one or more psychology classes of your choice, at your instructor's discretion. Keep in mind that you will be free to withdraw from the study at any time, without penalty or loss of previously accrued SONA points.

This study involves no risks beyond those of daily life. You will also gain an introduction to psychological research, as well as SONA extra credit towards your courses as compensation for your participation. The investigator will not associate your name in any way with the research findings, and all data are anonymous. Your participation in this study is completely voluntary and you are free to withdraw at any time without negative consequences. The results of this study will shed light on the scantly researched cognitive abilities of police dispatcher identified for successful job completion. Moreover, the measures that you will participate in will be the same measures that the dispatchers will take, which I will incorporate as findings into my master's thesis project. The dispatcher data results will also be presented to dispatcher supervisors as a foundation for identifying the limits of multitasking performance of dispatchers.

The California State University
Bakersfield • Channel Islands • Chico • Dominguez Hills • East Bay • Fresno • Fullerton • Humboldt • Long Beach • Los Angeles • Maritime Academy
Monterey Bay • Northridge • Pomona • Sacramento • San Bernardino • San Diego • San Francisco • San Jose • San Luis Obispo • San Marcos • Sonoma • Stanislaus

Please feel free to ask any questions that you have. Should questions concerning the study arise at a later date, please do not hesitate to contact the principal investigators at the phone number or address below, or in the event of a research-related injury, please contact the University's Institutional Review Board at (909) 537-5027. Results of this study will be available from David Buitron or Hideya Koshino @ HKoshino@csusb.edu after the Spring quarter of 2016 upon request.

Please read the following before indicating that you are willing to participate.

1. The study has been explained to me and I understand the explanation that has been given and what my participation will involve.

2. I understand that my participation is entirely voluntary, and that I may withdraw from participation at any time, or refuse to answer any specific question, without penalty or withdrawal of benefit to which I am otherwise entitled.

3. I understand that if I have any questions or concerns regarding this study, or if I wish to receive additional explanations after my participation is completed, I can contact David Buitron at (424) 273-3486 or buitrond@csusb.coyote.edu.Please place a check or an X in the space provided below to acknowledge that you are at least 18 years old and have read and understand the statements above. By marking the space below you give consent to participate voluntarily in this study. Thank you very much.

Participant's X _______

Date: ___________

CALIFORNIA STATE UNIVERSITY PSYCHOLOGY INSTITUTIONAL REVIEW BOARD SUB-COMMITTEE			
APPROVED	4/9/16	VOID AFTER	4/9/17
IRB #	H-16SP-04	CHAIR	

APPENDIX E

INFERENCE TEST

INFERENCE TEST — RL-3

In each item on this test you will be given one or two statements such as you might see in newspapers or popular magazines. The statements are followed by various conclusions which some people might draw from them. In each case, decide which conclusion can be drawn from the statement(s) without assuming anything in addition to the information given in the statement(s). There is only one correct conclusion.

Mark your answer by putting an X through the number in front of the conclusion that you select.

Consider the following sample item:

Bill, a member of the basketball team, is 6 feet, 2 inches tall and weighs 195 pounds. To qualify for the team, a person must be at least 5 feet, 10 inches tall.

1-The larger a man is, the better basketball player he is.
2-Basketball players are often underweight.
3-Some players on the team are more than 6 feet tall.
4-Bill is larger than the average man.
5-The best basketball players come from the ranks of larger-than-average men.

Only conclusion 3 may be drawn without assuming that you have information or knowledge beyond what the statements give. The statements say nothing about how good different players are, nothing about whether they are underweight, and nothing about average or taller-than-average men.

Your score on this test will be the number marked correctly minus some fraction of the number marked incorrectly. Therefore, it will not be to your advantage to guess unless you are able to eliminate one or more of the answer choices as wrong.

You will have 6 minutes for each of the two parts of this test. Each part has three pages with 10 items. Be sure to do all the items in each part if you have time. When you have finished Part 1, STOP. Please do not go on to Part 2 until you are asked to do so.

Ekstrom, R. B., French, J. W., Harman, H. H., & Dermen, D., (1976). *Manual kit of factor-referenced cognitive tests.* Princeton, NJ: Educational Testing Service.

APPENDIX F

FIRST AND LAST NAMES TEST

FIRST AND LAST NAMES TEST — MA-3

This is a test of your ability to learn first and last names. In each part of the test you will study a page of 15 full names, first and last. After studying the page showing full names you will turn to a page showing a list of the <u>last</u> names in a different order. You will be asked to write the <u>first</u> names that go with each last name.

Here are some practice names. Study them until you are asked to turn to the next page (1 minute).

Janet Gregory

Thomas Adams

Roland Donaldson

Patricia Fletcher

Betty Bronson

Ekstrom, R. B., French, J. W., Harman, H. H., & Dermen, D., (1976). *Manual kit of factor-referenced cognitive tests.* Princeton, NJ: Educational Testing Service.

APPENDIX G

NUMBER COMPARISON TEST

NUMBER COMPARISON TEST — P-2

This is a test to find out how quickly you can compare two numbers and decide whether or not they are the same. If the numbers are the same, go on to the next pair, making no mark on the page. If the numbers are not the same, put an X on the line between them. Several examples are given below with the first few marked correctly. Practice for speed on the others.

659	___	659	7343801	___	7343801
73845	X	73855	18824	___	18824
1624	___	1624	705216831	___	795216831
438	X	436	971	___	971
4821459	___	4814259	446014721	___	446014721
658331	___	656331	5173869	___	5172869
11653	___	11652	6430017	___	6430017
617439428	___	617439428	518198045	___	518168045
1860439	___	1860439	55179	___	55097
90776105	___	90716105	63216067	___	63216057

Your score will be the number marked correctly minus the number marked incorrectly. Therefore, it will not be to your advantage to guess unless you have some idea whether or not the numbers are the same.

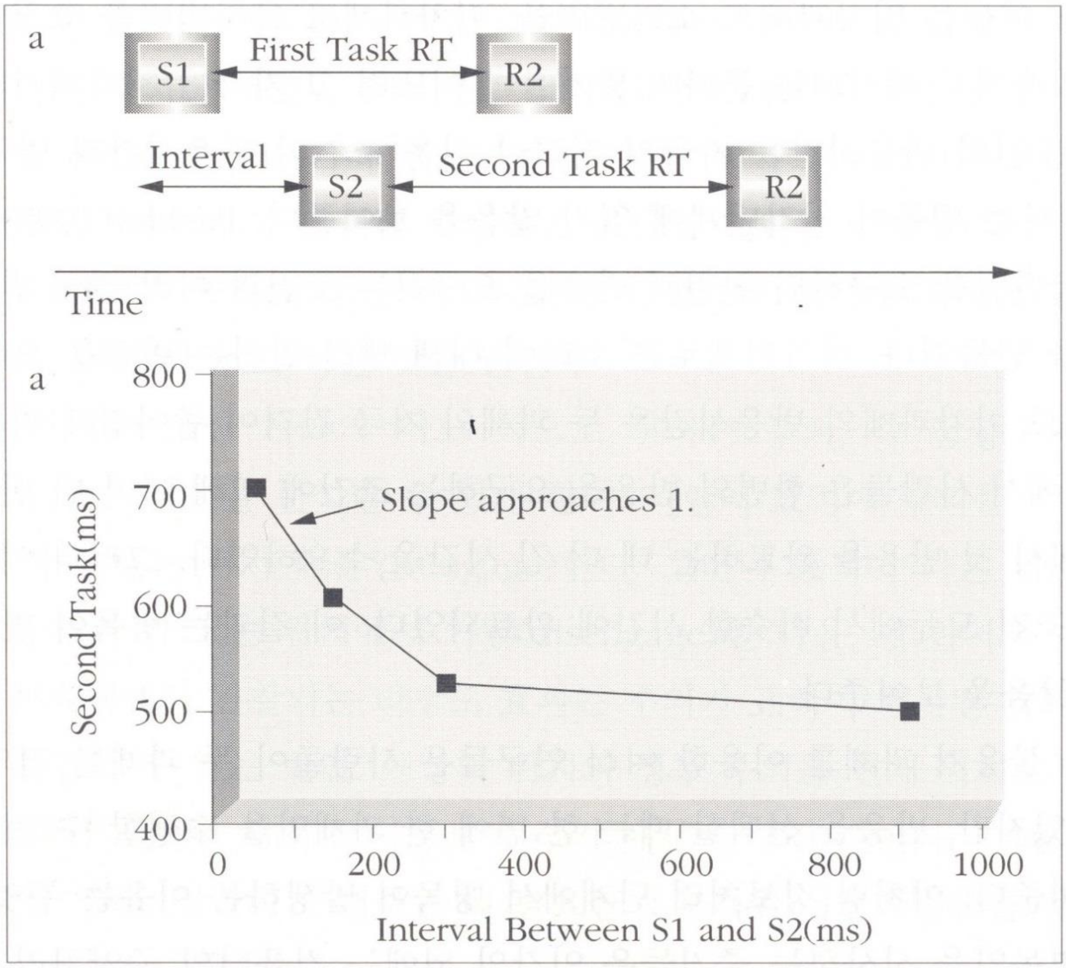
You will have 1 1/2 minutes for each of the two parts of this test. Each part has one page. When you have finished Part 1, STOP. Please do not go on to Part 2 until you are asked to do so.

DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO.

Ekstrom, R. B., French, J. W., Harman, H. H., & Dermen, D., (1976). *Manual kit of factor-referenced cognitive tests.* Princeton, NJ: Educational Testing Service.

APPENDIX H

PSYCHOLOGICAL REFRACTORY PERIOD



Welford, A. T. (1952). The ‘psychological refractory period’ and the timing of high-speed performance—a review and a theory. *British Journal of Psychology*. General Section, 43(1), 2-19.

APPENDIX I

STROOP TASK

Red	Blue
Yellow	Green
Blue	Yellow
Green	Red
Green	Green
Yellow	Blue
Blue	Red

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of experimental psychology*, *18*(6), 643-662.

APPENDIX J

REWRITING

REWRITING -- FE-3

It is often necessary when writing to say the same thing in different ways. This is done by rephrasing the original sentence. In this test you will be given sentences and asked to rewrite them so that they say the same thing in a different way.

For example:

"In response to the teacher's question, a forest of hands shot up."

might be rewritten as:

a) "When the teacher asked the question, almost every hand was raised to answer it."

Can you think of another way to say the same thing?

b) ____

____

____

Each of the items in this test will consist of a sentence which you are to rewrite. Try to write two new sentences for each sentence given. You should try to use different words and different sentence constructions, but do not change the meaning of the original sentence.

Your score will be the number of acceptable sentences which you write.

You will have 5 minutes for each of the two parts of this test. Each part has one page with three sentences. When you have finished Part 1, STOP. Please do not go on to Part 2 until you are asked to do so.

Ekstrom, R. B., French, J. W., Harman, H. H., & Dermen, D., (1976). *Manual kit of factor-referenced cognitive tests.* Princeton, NJ: Educational Testing Service.

APPENDIX K

INCOMPLETE WORDS TEST

INCOMPLETE WORDS -- CV-3

This is a test of your ability to complete words when some of the letters are missing.

Look at the example below:

sum__ary

You could put the letter "m" in the blank and make the word summary. Now look at this example which has two letters missing:

h__gh__ay

You can make the word highway by putting an "i" in the first blank and a "w" in the second blank.

Sometimes it might be possible to use any one of several different letters to complete a word. For example:

d__mp

could be completed by adding a "u" to make the word dump, or an "a" to make the word damp.

Now try these practice items. In each blank, write one letter. When a word has more than one blank, each blank has its own number.

f__ce (1)	oys__er (4)
w__th (2)	b__rge (5)
f__lder (3)	te__eph__ne (6, 7)

You could have made the following words: 1. face; 2. with; 3. folder; 4. oyster; 5. barge; and 6 and 7, telephone.

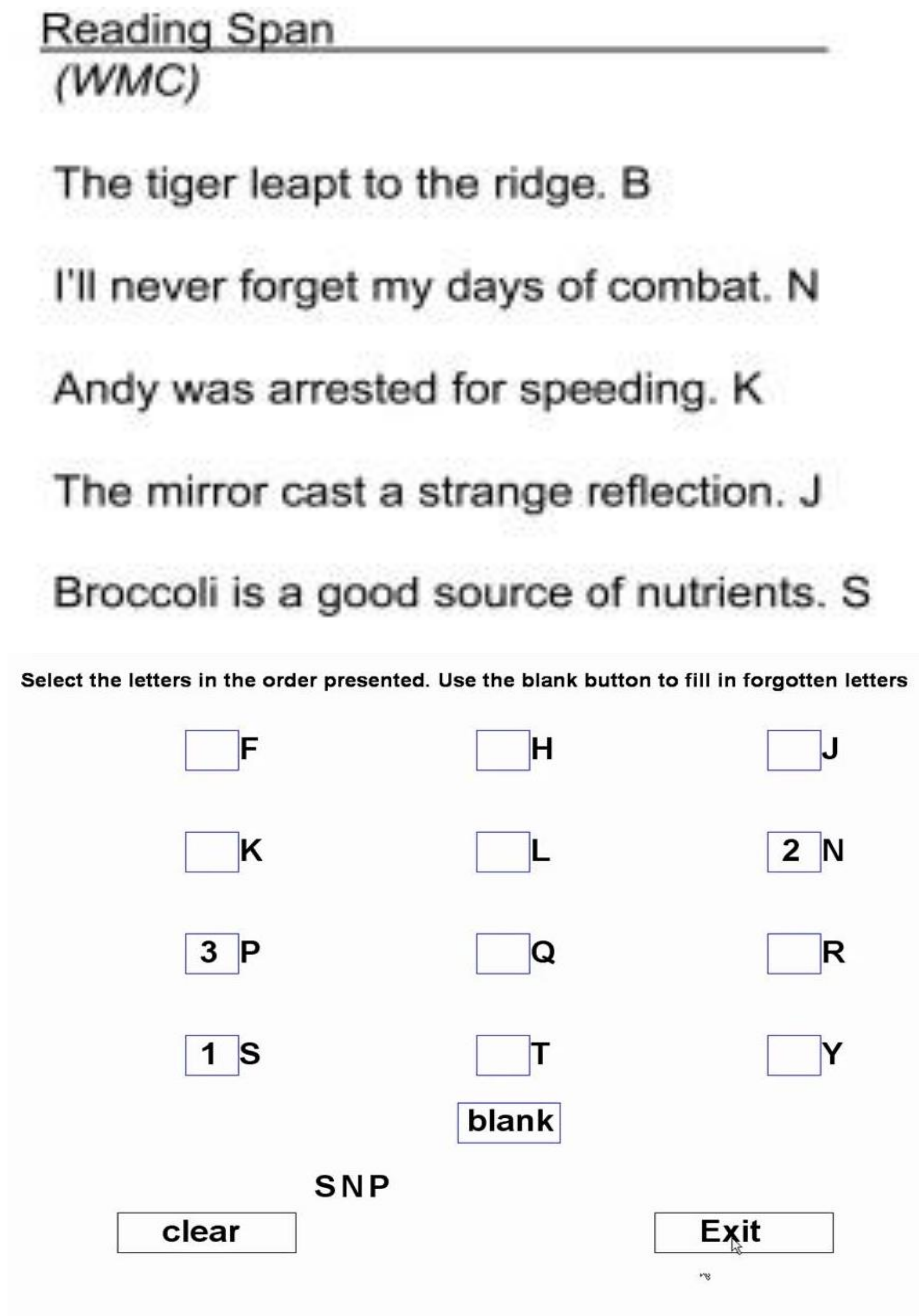
Your score on this test will be the number of words that you complete correctly.

You will have 3 minutes for each of the two parts of this test. Each part has one page with 18 words to complete. Do not spend too much time on any one word. When you have finished Part 1, STOP. Please do not go on to Part 2 until asked to do so.

Ekstrom, R. B., French, J. W., Harman, H. H., & Dermen, D., (1976). *Manual kit of factor-referenced cognitive tests.* Princeton, NJ: Educational Testing Service.

APPENDIX L

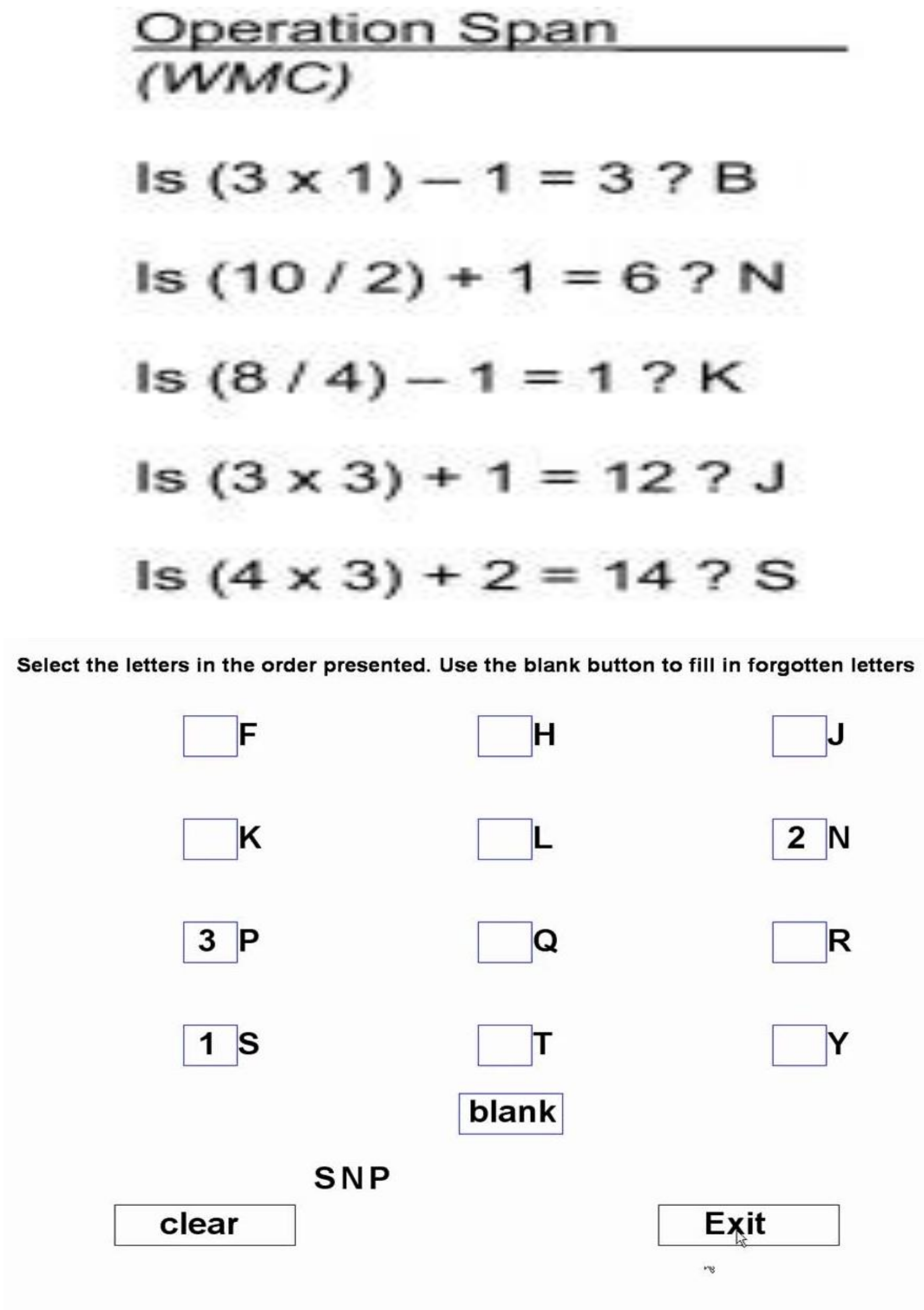
READING SPAN



Conway, A. R., Kane, M. J., & Engle, R. W. (2003). Working memory capacity and its relation to general intelligence. *Trends in cognitive sciences*, *7*(12), 547-552.

APPENDIX M

OPERATION SPAN



Unsworth, N., Heitz, R. P., Schrock, J. C., & Engle, R. W. (2005). An automated version of the operation span task. *Behavior research methods*, 37(3), 498-505.

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