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Are All Measures of Inhibition Creatively Equal? : The Differential and Interaction Effects of Inhibition Type on Creativity

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ARE ALL MEASURES OF INHIBITION CREATIVELY EQUAL? THE DIFFERENTIAL AND INTERACTION EFFECTS OF INHIBITION TYPE ON CREATIVITY

By

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To my Mom and Dad, whose unwavering faith and support made this possible

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ABSTRACT

Previous research revealed mixed findings regarding the direction of the relation of inhibition and creativity. The goal of this study was to determine if the task used to measure inhibition accounts for this variance in direction and if these various tasks would demonstrate convergent validity, despite contention that inhibition cannot be deconstructed into separate types. It was hypothesized that attention inhibition measures would correlate negatively to creativity, whereas memory inhibition measures would correlate positively. Confirmatory factor analyses showed that the inhibition measures did not demonstrate convergent validity based on the proposed two factor model of attention and memory inhibition. Also, most of the inhibition tasks were unrelated to creativity and intelligence, though the n-back task, a memory inhibition measure, positively predicted scores on the Remote Associates Test, a convergent thinking creativity test ($r(59) = .39$, $p = 0.002$).

CHAPTER ONE

INTRODUCTION

Whilst there still remains some variability in the definition of creativity, the two aspects that appear in most prominent theories of creativity are originality and appropriateness. Piffer (2012) states, "A product which is useful but not novel (a car might be judged novel in an ancient civilization but not in the contemporary one), or novel but not useful (e.g. bizarre or schizophrenic ideas) cannot be considered creative." Thus, while many would classify a life-like oil painting of a bowl of fruit to be creative, most creativity researchers would not. They would likely deem Pete Fecteau's mural of Martin Luther King Jr. a creative work of art, however, as it is comprised of over 4,200 Rubik's cubes, a novel material in the art world that is appropriate for creating portraits as the faces of the cubes resemble pixels. What abilities are necessary to produce a work such as this? Some argue that the cognitive abilities that comprise intelligence are all that is necessary for creative production, but measures of creativity are significantly more predictive of creative achievement than IQ (Kim, 2008) and intelligence has been shown to be a nonsignificant predictor of creativity at high levels of intelligence (Jauk, Benedek, Dunst & Neubauer, 2013). How exactly are intelligence and creativity related? Despite decades of research dedicated to the endeavor, the relation between creativity and intelligence is still nebulous. Several possible conceptualizations of the relation between the two higher order cognitive abilities have been postulated (Sternberg & O'hara, 1999).

Divergent thinking is a construct Guilford (1957) developed to elucidate the processes of basic problem solving. Divergent thinking tasks have become the predominant measure of creativity in the field, and are often used synonymously. Divergent thinking is a top down approach that combines previous information to generate several possible solutions. Its counterpart, convergent thinking, in contrast, is a bottom up approach to problem solving that uses knowledge to narrow down to a single, correct answer. Guilford conceptualized both as subservient to intelligence in his structure of intellect model. Wallach and Kogan (1965) proposed that convergent and divergent thinking utilized different types of cognitive functioning. Whereas convergent thinking was reliant on executive functioning, divergent thinking was associationistic in nature. This is in line with Mednick (1962), which theorized that the individual differences in creative ability were the result of variance in the gradient of associative hierarchies. He posited that highly creative individuals have flatter associative hierarchies; thus, while unoriginal responses remain prepotent, less typical responses were closer in associative strength than those with steeper hierarchies. Since the introduction of this theory, researchers have viewed creativity as associational and intuitive, in contrast to intelligence, which is usually related to executive functioning. Recent meta-analyses, however, report weak to moderate mean correlations between intelligence and creativity; Kim (2005) found a weak correlation of 0.17, and Silvia (2007), with the usage of structure equation modeling, which attenuates measurement error and allows for a more comprehensive representation of the construct of intelligence (and creativity) via latent variables, increased the strength to a weak moderate correlation of 0.43. These findings lend credence to the position that intelligence and creativity are separate, but related constructs. Researchers have explored various factors that might account for this relation, such as openness to experience (Batey, M., Furnham, A., & Safiullina, X., 2010). Some have begun to argue that the shared variance indicates that the creative process requires executive functioning after all (Benedek, Franz, Heene, & Neubauer, 2012; Nusbaum & Silvia, 2011; Storm and Angello, 2010; Storm, Angello, and Bjork, 2011). .

Some researchers postulate that convergent thinking is necessary for creative production even during divergent thinking tasks, such as the alternate uses task. During the alternate uses task (Guilford, 1967), participants given the name of a common object (e.g. brick, knife, etc.) and are instructed to generate as many creative ways to use it as possible within a time limit (usually anywhere from 3-10 minutes). Although divergent thinking is the process of generating several possible responses, the creativity scores are usually operationalized as a Likert scale rating of creativity based on the originality and appropriateness of the idea (Beaty & Silvia, 2012). Thus, it is not enough to make distant associations; an adherence to parameters of originality and appropriateness is ostensibly necessary for the production of creative ideas. This is representative of real life creative ideation; typically creative ideas are formed in response to specific needs or desires, such as developing an advertising campaign for a product. The campaign must represent the product as well as appeal to interests and needs of the target audience.

Of the currently delineated executive functions, inhibition has been the most thoroughly studied in relation to creativity. A review of the extant research reveals mixed findings (Ansburg & Hill, 2003; Benedek, Franz, Heene, & Neubauer, 2012; Chirilaa & Feldman, 2012; Fink, Slamar-Halbedlas, Unterrainer, &Weiss, 2012; Gilhooley, et al, 2007; Memmert, 2007; Storm & Angello, 2010). Whereas the significance of the relation between inhibition and creativity has been relatively invariant (albeit the published studies), the direction has been less consistent. Inconsistency is also apparent in both the conceptualization and operationalization of inhibition within these studies as well.

Studies that conceptualized inhibition as the prevention of intrusive thoughts from entering or remaining in working memory have found a positive relation between inhibition and creativity. As previously stated, in order for low frequency associations to result in a creative ideas, they must meet the parameters of originality and appropriateness. Thus, the recall and fixation of unoriginal or inappropriate thoughts would impede creative ideation. Gupta, Jang, Mednick, and Huber (2012) administered a fast paced Remote Associates Task (RAT), a test where participants are given three words and instructed to provide a fourth word that is associated with each. As the test progresses, individuals are required to make increasingly lower frequency, distant associations. They found that those who performed better on the RAT produced both correct and incorrect responses that were lower frequency associations, which might suggest that they inhibit the recall of unoriginal responses, whereas less creative individuals do not. Other studies have incorporated published measures of inhibition to determine if they are indeed associated with the recall and/or fixation of previously generated ideas during creative ideation. Storm and Angello (2010) showed that those who exhibited less retrieval-induced forgetting (as measured by a task very similar to a known cognitive inhibition task) showed a greater fixation effect during problem solving, which increased over time. Storm, Angello, and Bjork (2011) replicated this effect using a direct measure of inhibition engendered by a problem solving task (RAT). Not only did problem solving result in inhibition of high frequency associates of the three cue words, individual differences in inhibition were positively related to performance on a second RAT. Gupta et al. (2012)'s statistical models also revealed that those who scored higher on the RAT were more likely to avoid answering with strong associates of the cue words. Greater performance on a random number generation task, which is posited to require the inhibition of previously responded numbers in the created sequence, has been found to positively correlate with creative fluency (the quantity of ideas constructed), which is also highly correlated with creative originality, arguably because inhibition of unoriginal or previously considered ideas allows for the cognitive faculties that would be dedicated to them to instead be used to generate more novel ideas (Benedek et al. 2012). Beaty and Silvia (2012) examined the influence of intelligence on the serial order effect, the phenomenon of ideas becoming increasingly original over time. They implemented the alternate uses task, a divergent thinking task where participants are instructed to generate as many uses for an everyday object as they can. They found that the serial order effect was moderated by intelligence; as intelligence increased the serial order effect diminished. Further probing showed that these more intelligent individuals began the task with more original responses than their less intelligent peers. Beaty and Silvia (2012) contested that inhibition of unoriginal responses was a possible, but unlikely explanation for this effect, however, since no variance in the latency period between the beginning of the task and the first answer was accounted for by intelligence. However, this may have been due to a difference in processing speed. Participants with higher intelligence may have been able to inhibit a high frequency response and generate a more original idea within the same timeframe as it took less intelligent participants to produce an unoriginal answer. Vartanian, Martindale, and Matthews (2009) seems to support this; they found that those who performed better on divergent thinking tasks were faster at judging relatedness of two concepts. Thus, highly creative individuals appear to not only be better at generating several possible solutions to a problem, but also suppressing recall and/or fixation of unoriginal solutions.

In contrast, studies that used a selective attention paradigm for inhibition have found a negative relation between inhibition and creativity. Selective attention is predicated on the limited capacity paradigm that humans have finite processing capabilities, and thus attention must be focused to relevant stimuli and irrelevant stimuli inhibited (Armstrong & Olatunji, 2012). Eysenck (1995) theorized that lower inhibition during perception of the environment allows for more associations to be made, and likely, more uncommon, low frequency associations, which results in a flatter associational hierarchy, which Mednick (1962) postulated accounted for individual differences in creative ability. While unoriginal responses remain prepotent, less typical responses were closer in associative strength than those with steeper hierarchies, and thus more likely to be recalled during creative ideation. Memmert (2007) introduced teen athletes to two attention training programs. Those who participated in the attention broadening program exhibited greater creative athletic performance than those given attention narrowing training and the control group. The attention broadening group also showed indications of greater improvement (although not significant) from the simple creativity task (hands) to the complex (feet) that the attention narrowing and control groups did not exhibit. Creative individuals, determined by a self-report of creativity, were shown to have significantly slower reaction times during the flanker task than those who rated themselves less creative (although thus only occurred when distractor quantity was increased or a secondary task added, which might indicate a floor effect occurred with the unaltered task). Ansburg and Hill (2003) found that different types of thinkers (determined by survey methods) performed differently on a distractor task. Unlike the other types of thinkers, when creative thinkers were measured, a positive relation was found between creativity and a peripherally cued anagram task; no relation was found between analytic thinking and scores on the same anagram task when analytical thinkers were tested.

Another attention inhibition measure, negative priming, has also been used to test the relation between inhibition and creativity. A negative priming effect occurs when reaction time to a stimulus is increased because it was previously perceived as distractor. Negative priming should relate to creativity in a way analogous to selective attention tasks because greater inhibition of interference from distracting or irrelevant stimuli should result in more inhibition to overcome when they become targets. Vartanian, Martindale, and Kwiatkowski (2007) found that creative individuals did indeed demonstrate stronger negative priming effects, and Vartanian, Martindale, and Matthews (2009) replicated these findings. Dorfman, Martindale, Gassimova, and Vartanian, (2008) found that creative participants had faster reaction times on simple tasks with no interference, but slower reaction times on the same Stroop negative priming task, distinguishing increased inhibition from decreased processing speed. Latent inhibition is an inhibitory construct that originated in conditioning studies, and was later adapted to studies of schizophrenia and other forms of psychoticism. Latent inhibition, similar to negative priming, is the delayed response to a target stimulus that was previously perceived, the distinction being that the stimulus in this case is not a distractor, but irrelevant. Fink, Slamar-Halbedlas, Unterrainer, &Weiss (2012) found that a borderline personality group had significantly lower latent inhibition scores and significantly higher originality scores than control groups. Smaller latent inhibition effects have also predicted greater real-life creative accomplishment (Chirilaa & Feldman, 2012). Carson, Peterson, Higgins (2003), using a sample of high intelligent individuals (IQ over 120), found that non-creative participants showed a latent inhibition effect, higher scores in the pre-exposed condition than the non-exposed, whereas creative participants showed no significant difference in scores.

Contention exists on whether the aforementioned inhibition tasks actually measure distinct kinds of inhibition. Friedman and Miyake (2004) conducted a factor analysis to test the divergent validity of putatively different types of inhibition, including resistance to distractor interference and resistance to proactive interference. Resistance to distractor interference is the executive process where extraneous, competing stimuli in the field of perception are ignored in favor of a focal stimulus. Resistance to proactive interference suppresses internal distractors; resistance to distractor interference is the inhibitory ability to suppress memory intrusions sparked by external stimuli from entering working memory. The confirmatory factor analysis showed that resistance to distractor interference was only modestly related to proactive interference. Bissett, Nee,and Jonide (2009) also found that resistance to proactive interference was related, but separate from resistance to distractor interference. Thus, the mixed findings may be due to a lack of convergent validity of the various inhibition tests used. If so, each inhibitory process might be responsible for a different aspect of creativity. Thus, inhibition of attention (resistance to distractor interference) might function as a filter during perception that indirectly effects creative thinking by influencing the slope of the associative gradient, whereas inhibition of unoriginal and inappropriate ideas (resistance to proactive interference) allow for more distant associations to be recalled to working memory during creative ideation. Separate inhibition types could also account for mixed findings regarding the significance of relation between inhibition and intelligence. Whereas studies that use resistance to proactive interference (memory inhibition) measures to operationalize inhibition typically find a significant positive association between inhibition and intelligence, studies that utilize resistance to distractor interference (attention inhibition) tasks seldom report significant correlations between the two factors (Benedek, Franz, Heene, & Neubauer, 2012; Carson, Peterson, Higgins, 2003; Friedman, Miyake, Corley, Young, DeFries, Hewitt, 2005). Not all executive functions have been found to underlie intelligence (Friedman et al., 2005). It may be that not only is creativity more executive in nature than previously conceptualized, but that it is underpinned by certain executive abilities that are distinct from intelligence.

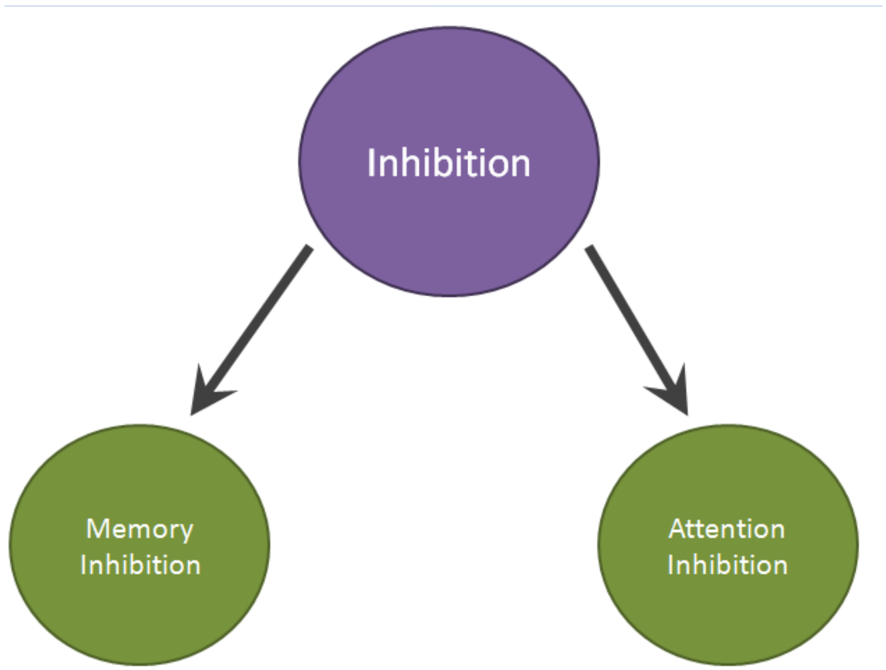

Figure 1.1: Proposed Two Factor Model of Inhibition

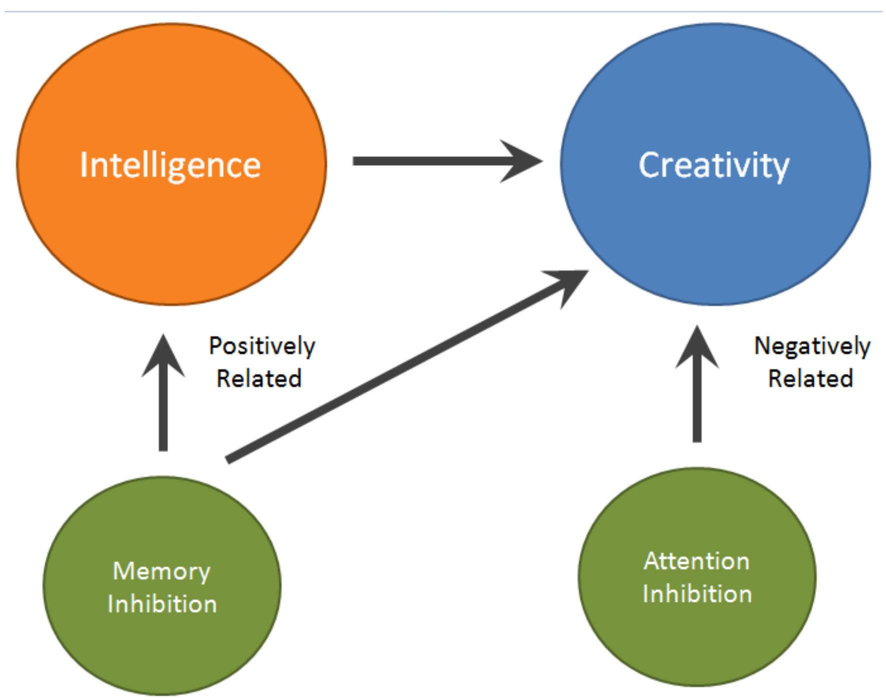

Figure 1.2: Proposed Model of the Interrelationship between Inhibition, Intelligence, and Creativity

As previously mentioned, differences in the strength of the relation between inhibition and creativity have also been found. This may be due, at least partially, to what's known as the threshold theory. Guilford (1957) discovered that the relation between intelligence and creativity varied by level of intelligence. He found a positive linear relation before 120 IQ, and thereafter no relation existed. Other factors, such as openness to experience, become more predictive of creativity beyond this intelligence threshold (Jauk, Benedek, Dunst, & Neubauer, 2013). Carson, Peterson, and Higgins, (2003) purposefully selected a highly intelligent sample for their study of latent inhibition's predictiveness of creativity because of this putative threshold; latent inhibition accounted for 19% of the variance in creativity, and highly creative individuals were 7 times more likely to have low latent inhibition scores than high scores (in contrast, less creative individuals were equally likely to have either low or high scores). Arguably more notable was the marginally significant ($p = 0.07$) interaction effect of intelligence and latent inhibition on creativity. Inhibition of attention to distractor or irrelevant stimuli in the perceptual field may only be influential to creativity if individuals have a certain degree of intelligence.

Previous studies have used either an attention or memory inhibition measure when analyzing the relation between inhibition and creativity, never both. The purpose of this study was to determine if the differences in the direction of the relation between inhibition and creativity found in previous studies can be attributed to the inhibition measure used and if the relations amongst the various measures do, in fact, indicate separate types of inhibition. If so, then the previous mixed findings are complementary rather than oppositional. Also, although it is sometimes assumed that all executive functioning underpins intelligence, previous research suggests that whereas memory inhibition is related to both intelligence and creativity attention inhibition may only underlie creativity, and not intelligence. The correlations between the various inhibition types and intelligence were also analyzed to test this fining. The study also tested whether the difference in the strength of the relation between inhibition and creativity is associated with level of intelligence, which will help elucidate the threshold theory as well as possibly assist with finding and analyzing the relation in future studies.

Research Questions and Hypotheses:

Do the various inhibition tasks measure different inhibitory types?

The attention inhibition and memory inhibition measures will each demonstrate convergent validity (see Figure 1.1).

Do the various measures of inhibition relate differently to creativity?

The memory inhibition measures will be positively related to creativity, whereas the attention inhibition measures will be negatively related (See Figure 1.2).

Do the various measures of inhibition relate differently to intelligence?

The memory inhibition measures will relate positively to intelligence, whereas the attention measures will be unrelated (See Figure 1.2).

Does inhibition better predict creativity at high levels of intelligence?

The attention inhibition measures (specifically resistance to distractor interference, latent inhibition, and negative priming) will better predict creativity at higher levels of intelligence.

CHAPTER TWO

METHOD

2.1 Participants

Ninety Florida State University undergraduate students were recruited through the FSU psychology department's online research participation system. Participants were awarded partial course credit for one of their psychology classes as compensation. No participants were excluded from the study.

2.2 Materials & Procedures

2.2.1 Creativity

Remote Associates Task (RAT)

For each trial of this task, participants were presented with three words and instructed to recall a word that is associated with each. There were 30 trials in total, six for each level of the five levels of difficulty. One item was dropped due to a typographical error. Points were awarded for accuracy; there was one correct response per item. A weighted point system was used based on difficulty: very easy items were worth 1 point, easy items were worth 2 points, medium items were worth 3 points, hard items were worth 4 points, and very hard items were worth 5 points. There was a 2 minute time limit for each item, after which a new item automatically appeared on the screen.

Alternative Uses Task (AUT)

Participants were given the name of a common object (i.e. brick) and instructed to generate as uses as possible within a 5 minute period, with the caveat that they should be original and appropriate. The dependent variables of priority are originality and fluency. Fluency was operationalized as the number of ideas generated. Raters judged the originality of each answer using a 4 point Likert scale (1 – not original, 4 very original). The inter-rater reliability was 0.91. Originality scores were calculated by averaging each participant's two highest rated uses.

Kaufmann Domains of Creativity Scale (K-DOCS)

The Kaufmann Domains of Creativity Scale (Kaufman, 2012) is a 50 item self-report questionnaire on 5 areas of creativity (Self/Everyday, Scholarly, Performance, Mechanical/Science, and Artistic). Participants were instructed to rate their perceived creative ability on various types of activities using a 5 point Likert scale (1- much less creative than the average person, 5 – much more creative than the average person). Two types of dependent measures were created from the survey: a comprehensive score formed by calculating the average of all 50 responses, and domain scores formed by calculating the average of the responses for each domain.

2.2.2 Attention Inhibition

Eriksen flanker Task

The Eriksen flanker task (Eriksen & Eriksen 1974) presents participants with a target stimulus in the center of the monitor that is flanked (hence the name flanker task) by distractor stimuli. There were two possible target stimuli {(left arrow (<) and right arrow (>)}, one of which will be presented for each trial. Participants were instructed to respond to the left arrow with the "A" key and the right arrow with the "L" key. There were four distractor conditions: congruent (arrows pointed in the same direction as the target stimulus, e.g. <<<<<<<), incongruent (arrows pointed in the opposite direction as the target stimulus, e.g. >>><>>>), neutral (equal signs, e.g. ===<===), and no distractor (e.g. <). Distractor conditions will be equally presented and displayed in random order. There was one practice block of 16 trials followed by four test blocks composed of 40 trials each. The measure was calculated by subtracting the reaction time of the no distractor trials from the reaction time of the incongruent distractor trials.

Negative Priming Task

For this task, participants were presented with strings of digits and instructed to respond (as fast as possible while still being accurate) with the number of digits within the string. Digit strings ranged from 1to 4 digits in length (e.g. "3" to "2222"). The numeric symbol was consistent throughout the digit string and could be either "1," "2," "3," or "4" (e.g. "33" or "4"). Each trial was composed of two items: a priming string and a target string. Trials began with a 500ms fixation point, after which the priming string appeared on the screen. After participants responded using the corresponding number keys, the screen went blank for 1000ms. Another 500ms fixation point appeared, and then the target string was presented. Again, participants responded using the corresponding number keys. After each trial, the screen remained blank for 2000ms. There were two trial types: negative priming (e.g. "222" then "44") and control (e.g. "1111" then "33"). For the negative priming trials, the numeric symbol (i.e. the distractor stimulus) for the priming string became the number of digits (i.e. the target stimulus) for the target string. The score was calculated by subtracting the average reaction time of the control trials from the average reaction time of the negative priming trials.

Latent Inhibition Task

This task is comprised of two segments. Participants were be seated in front of a computer screen and fitted with headphones. A sound trial was performed to individualize the volume level to ensure participants were able to detect and distinguish the auditory stimuli. Those in the pre-exposed condition were then played the audio stimuli, which consists of nonsense syllables (the original target stimulus) and white noise segments (the original distractor stimulus). A list of thirty nonsense syllables was recited and iterated five times in identical order. Thirty-one white noise segments occurred at random times and intervals over the course of the recording and last from 3 to 6 sec each. Participants were informed prior to the presentation of the recording that they will be asked the number of times a syllable occurred to guide focus to the nonsense syllable auditory stimulus. The recording was then be replayed during the test phase with a simultaneous display of yellow disks on the projector screen. The yellow disks appeared individually and coincide with one of the white noise segments. Participants were instructed to ascertain what auditory stimulus cues the appearance of the yellow disks and verbalize the answer as soon as possible. The variable was operationalized as the number of yellow disks appeared on the projector screen when the participant answered.

Stroop Task

Participants were presented with a word stimulus and instructed to orally name the color the word's text. Each word was displayed after a 500 ms fixation point centrally located on the screen. There were three types of printed stimuli: color words (e.g. red, blue, green) and neutral words (e.g. cross, intent, ship), and strings of asterisks (e.g. ******). Words were presented in one of four colors (i.e. red, blue green, and purple). Based on these two variables, there were four trial types: congruent (e.g. "RED" printed in red), incongruent (e.g. "RED" printed in blue), neutral words (e.g. "SHIP" printed in blue), and asterisks (e.g. "*****" printed in green). There were 160 trials total: 16 practice trials followed by three blocks of 48 trials. There will be an equal number of trials by word type randomly ordered throughout both blocks. Participants will be instructed to answer as fast as possible. Once they recited the word, the screen went black for 1,000 ms before the next trial will begin. The measure was calculated by subtracting the reaction time for the neutral word trials from the reaction time of the incongruent (printed color and color word differ) color word trials.

2.2.3 Memory Inhibition

Brown-Peterson task

The task was comprised of four blocks: one practice block and three test blocks. The practice block had two lists instead of four. The lists contained exemplars from different categories, and thus no proactive interference occurred. For each test block, participants were presented three word lists, each composed of eight exemplars of a specific category. Exemplars were selected from Battig and Montague's (1969) category norms. All words chosen met two criteria: (1) less than 10 letters in length and (2) weaker in associative strength than the 12th strongest normed associate of its category. The first three lists belonged to the same category; the last list contained words associated with a different category. The inclusion of the last, unrelated list was not intended for measurement of PI, but to allow release from PI before the introduction of a new block.

Each block began with a 1500 ms fixation point, after which the eight exemplars appeared one at a time for 2,000 ms each. Participants were instructed to read aloud during the presentation of the exemplars. To prevent rehearsal, a simple task, known as the Trails task, was introduced during the interim between the completion of the list presentation and recall. A digit letter pair was displayed (e.g. B-63), and participants were instructed to recite the successive digit letter pairs (C-64, D-65, E-66, etc.) for a duration of 16 sec. Participants were then given 20 sec to recall the exemplars; no particular order was required. This sequence of events repeated until all four lists had been read and recalled. The variable was calculated by subtracting the number of words recalled from list 2 from the number recalled from list 1.

Cued Recall

For this task, participants were presented with word lists comprised of four words each. They were told that at any point in time, they were only to remember the words from the most recent list. There were two conditions for this task: one list and two list trials. For the one list trials, participants were instructed to read the words aloud as they appeared consecutively on the screen for 1000 ms each. For the two word lists trials, the participants would again be instructed to read the first word list aloud. After all four words from the first list were presented participants were instructed to read the second word list silently. Words appeared for 1000 ms each for both lists. After all four words were displayed a distracting task was given to prevent rehearsal. Eight two digit numbers were presented individually on the screen for 1000 ms each; participants were to state aloud whether the number was larger or smaller than a given value (e.g. 50). After this separate task, participants were instructed to recall a word from the last word list that fit a specific category (e.g. toy). They were allotted 15 seconds to recall the word before the instructions for the next trial would automatically appear.   There were 24 trials total, 12 trials for each condition, which appeared on random order. The score for the measure was calculated by subtracting the mean accuracy of the one list trials from the mean accuracy of the two list trials.

N-back Task

For this adaptation of the n-back task, letters appeared consecutively in the center of the screen. Participants had to determine whether the letter *n* presentations prior was identical to the letter currently presented: they were instructed to respond “1” for yes and “2” for no. There were 3 conditions: the 0-back, the 1-back, and the 2-back. For the 0-back, participants were instructed to press “1” when the letter X appeared and “2” for the presentation of all additional letters. There were 9 blocks in total: a practice block and two test blocks for each of the three n-back conditions. The measure was calculated by subtracting the number of accurate responses for the 0-back condition subtracted from the number of accurate responses for the 2-back condition.

2.2.4 Intelligence

Raven’s Advanced Progressive Matrices

Raven’s Progressive Matrices is an intelligence test developed to extricate and measure fluid intelligence apart from crystallized and/or verbal intelligence. This form of Raven’s Progressive Matrices was designed for adults of normal intelligence. A short version of the test was given, composed of two sets: a practice set of 4 items proceeded by a test set of 12 items. Each item was a 3x3 matrix with one component missing: participants were provided with eight possible components and instructed to select the one that completes the matrix.

CHAPTER THREE
RESULTS

To determine whether the inhibition tasks functioned as anticipated, paired sample t-tests were performed for the two conditions used to calculate the difference score. For the Eriksen flanker task, reactions times were longer for noise response incompatible trials (M = 465.08. SD = 59.25) than no noise trials (M = 599.41, SD = 100.73; $t(78) = 17.25$, $p < 0.001$). For negative priming, negatively primed trials (M = 897.11, SD = 174.61) were longer than non-primed trials (M=797.58, SD=158.49; $t(81) = 6.80$, $p < 0.001$). For the cued recall task, accuracy was greater for one list trials (M = 8.57, SD = 2.01) than two list trials (M = 7.34, SD = 2.07; $t(78) = 4.69$, $p < 0.001$). For the n-back task, the accuracy was greater for 0-back trials (M = 78.84, SD = 2.78) than 2-back trials (M = 72.41, SD = 9.40; $t(63) = 5.92$, $p < 0.001$). For the Stroop task, reactions times were longer for the incongruent color trials (M = 1202.73, SD = 118.02) than the non-color word trials (M = 1040.49, SD = 93.99; $t(72) = -24.09$, $p < 0.001$). For the Brown-Peterson variant, the number of words recalled was greater for list one (M = 5.69, SD = 1.17) than list two (M = 4.78, SD = 1.10; $t(50) = -5.76$, $p < 0.001$).

Do the various inhibition tasks measure different inhibitory types?

To test the divergent validity of the various inhibition measures, two confirmatory factor analyses were run using Mplus. First, a one factor model was conducted that included resistance to distractor interference (Eriksen flanker task), prepotent response inhibition (Stroop task), negative priming, and two of the resistance to proactive interference tasks (cued recall and n-back). The latent inhibition measure and the Brown Peterson Variant were excluded. A floor effect on the latent inhibition measure was found with this sample (28.9% of participants failed to identify the link between the appearance of the circles and the white noise), making it an unfit individual differences measure. The Brown-Peterson variant was excluded due to notable missing data. The chi squared test indicates a good model fit for the one factor model [X^2 (5, N = 90) = 3.03, p =.70; see Figure 3.2]. This may be due to small sample size, which is known to notably influence the chi squared test. Other relevant indices of fit further suggest a good fitting model, [RMSEA = 0.001 (below 0.08), CFI = 1.00 (above 0.95), TLI = 3.46 (well above 0.95)], however, although the upper limit of the 95% CI [0.00, 0.11] does extend above 0.08.

Regardless, none of the measures loaded significantly onto the factor, and negative priming loaded negatively onto the factor.

For the two factor model, resistance to distractor interference (Erikson flanker task), prepotent response inhibition (Stroop task), negative priming were loaded onto the first factor and the two resistance to proactive interference measures (cued recall and n-back) were loaded on the second factor. The chi squared test indicates a fair model fit for this model as well [X^2 (4, N = 90) = 4.18, p < 0.38], but indices not prone to the influence of sample size indicate a poorly fitting model [RMSEA = 0.023 95% CI [0.00, 0.16] (upper limit above 0.08), CFI = 0.93(below 0.95), TLI = 0.82(below 0.95). Chi squared difference test indicated that the two factor model was not a significantly better fit than the one factor model [X^2 = (1, N = 90) = -1.15, p = 0.99; see Figure 3.3]. This was somewhat anticipated: the originally intended model would have included a third factor for negative priming and latent inhibition. Because of the distribution issues with the latent inhibition measure, however, negative priming was moved to the same factor as the Erikson flanker task and the Stroop task. None of the factor loadings for either factor were significant, and as it did with the inhibition factor of the one factor model, negative priming loaded negatively onto the attention inhibition factor.

Also, contrary to the Friedman and Miyake (2004) cognitive inhibition factor analysis, the prepotent response inhibition measure, the Stroop task, did not load well with the distractor interference measure, the Erikson flanker task. A Pearson's r correlation revealed that the Stroop task and the Erikson flanker task were not correlated (r(72) = 0.03, p = 0.80). The Stroop task also did not correlate with the negative priming (r(75) = -.05, p = 0.69) nor the latent inhibition (r(76) = 0.17, p=.18) measures. It did, however correlate with BPV (r(52) = 0.34, p = .03), and marginally correlate with the cued recall task (r(63) = 0.22, p = 0.08), both of which are resistance to proactive interference tasks. However, it was far from significantly correlated with the other recall interference measure, the n-back task (r(56) = 0.01, p = 0.93).

For exploratory purposes, a second two factor model was conducted with Stroop task loaded onto the second factor with the resistance to proactive interference measures. The chi squared test revealed that this model had a good model fit [X^2 (4, N = 90) = 2.52, p = 0.64; see Figure 3.4]. [RMSEA = 0.001, CFI = 1.00 (above 0.95), TLI= 2.40=1 (above 0.95) although the upper limit of the 95% CI [0.00, 0.13] does extend above 0.08. The chi squared difference test indicated that this two factor model was also not a significantly better fit than the one factor model [X^2 = (1, N = 90) = 0.52, p = 0.47], although this model had lesser AIC AND BIC index values (AIC=3598.79, sample-size adjusted BIC=3588.29) than the two factor model with the Stroop loaded on the attention oriented inhibition factor (AIC=3600.46, sample-size adjusted BIC=3589.96). Both the AIC and sample size adjusted BIC differences were 1.67. As seen in *Figure 3.5*, however, the flanker and negative priming didn't load correctly onto the first factor because they were negatively related, clearly displaying divergent validity regardless of the fit indices. The slightly improved indices fit is likely the result of separating the other inhibition measures from negative priming.

A one factor confirmatory factor analysis was also conducted for creativity. The subscales for the K-DOCS were included, making the model multilevel. The chi squared test indicates a good model fit [X^2 (14, N = 90) = 18.78, p = 0.17; see Figure 3.5]. This is likely due to small sample size, however. Other relevant indices of fit suggest a poorly fitting model [RMSEA = 0.06; 95% CI [0.00, 0.13] (above 0.08), CFI = 0.91 (below 0.95), TLI = 0.86(well below 0.95)]. The RAT and the K-DOCS appear to covary with the AUT distinct from one another.

Do the various measures of inhibition relate differently to creativity?

Despite the inclusion of several inhibition and creativity measures, the only significant correlation found was between the RAT and n-back task (r(59) = .39, p = 0.05l; see Table 3.2). The RAT was initially found to negatively correlate to negative priming, but Bonferonni corrections for multiple correlations increased the p-value well beyond the 0.05 alpha.

Do the various measures of inhibition relate differently to intelligence?

Again, despite the inclusion of several inhibition measures, no significant correlations were found between inhibition and intelligence, although the n-back task was significantly correlated with the Raven Advanced Progressive Matrices before the Bonferroni corrections were implemented.

Does inhibition better predict creativity at high levels of intelligence?

Intelligence did not correlate with significantly with any of the attention or memory inhibition tasks. Despite this, intelligence x inhibition interaction effects were tested for both the RAT and AUT since a priori predictions were made. All analyses revealed nonsignificant findings. For the AUT: intelligence x negative priming (B = -0.11, t(74) = -0.93, p = 0.36), intelligence x flanker (B = 0.03, t(78) = 0.22, p = 0.83) intelligence x stroop (B = 0.13, t(77) = -

1.05, p = 0.30), intelligence x cued recall (B = 0.01, t(78) = -0.11, p = 0.91), intelligence x negative priming (B = -0.18, t(74) = -1.55, p = 0.13). intelligence x n-back (B = 0.10, t(63) = -0.60, p = 0.55). For the RAT: intelligence x flanker (B = 0.06, t(79) = 0.48, p = 0.63), intelligence x stroop (B = 0.16, t(73) = 1.26, p = 0.21), intelligence x cued recall (B = -0.09, t(78) = -0.76, p = 0.45), intelligence x negative priming (B = -0.18, t(73) = -1.54, p = 0.13) and intelligence x n-back (B = 0.22, t(63) = 1.51, p = 0.14).

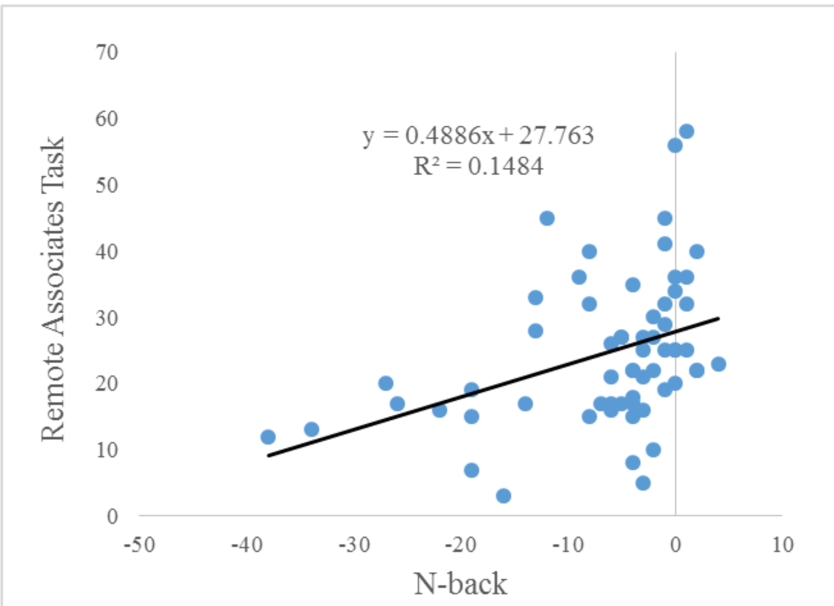

Figure 3.1: Correlation between Memory Inhibition and Creativity

Table 3.1

Split-half Reliabilities of Inhibition Measures

Inhibition Measure	rho
Eriksen Flanker	0.71
Negative Priming	0.81
Stroop	0.96
Brown-Peterson variant	0.62
Cued Recall	0.04
N-back	0.84

Table 3.2

Correlation Matrix

	APM	RAT	KDOCS	AUT-O	AUT-F	LI	NP	FL	STR	CR	BPV	NB
APM	1											
RAT	.223	1										
KDOCS	.129	-.044	1									
AUT-O	.069	.241	.297*	1								
AUT-F	-.111	-.088	.056	.357*	1							
L I	-.089	-.188	-.109	-.043	.082	1						
NP	-.128	-.242	.109	-.034	.-016	.058	1					
FL	.029	.202	.139	.061	.068	.118	.131	1				
STR	-.021	.158	.109	.059	.178	.166	-.049	.033	1			
CR	.070	.055	-.115	.124	.076	-.057	-.073	.125	.223	1		
BPV	-.076	.110	-.039	-.032	.056	-.047	.078	.002	.341	.017	1	
NB	.280*	.385*	-.271	-.133	-.031	-.083	-.063	.187	.013	.243	-.214	1

Note: Raven's Advanced Progressive Matrices (APM), the Remote Associates Task (RAT), Kaufman Domains of Creativity Scale (KDOCS), Alternate Uses Task – Originality (AUT-O), Alternate Uses Task – Fluency (AUT-F), Latent Inhibition (LI), Negative Priming (NP), Erikson Flanker Task (FL), Stroop Task (STR), Cued Recall (CR), Brown-Peterson Variant (BPV), N-back Task (NB)

Table 3.3

Means and Standard Deviations

Measure	M	SD
Remote Associate's Task	27.38	14.19
Alternate Uses Task - Org	1.97	0.62
Alternate Uses Task - Flu	10.48	4.87
K-DOCS	3.17	0.43
Raven's APM	5.45	2.45
Erikson Flanker Task	-128.36	58.93
Negative Priming	99.54	132.57
Latent Inhibition	15.61	11.44
Stroop Task	-159.56	53.14
Cued Recall	-1.23	2.33
Brown-Peterson Variant	-0.90	1.12
N-back task	-6.44	8.70

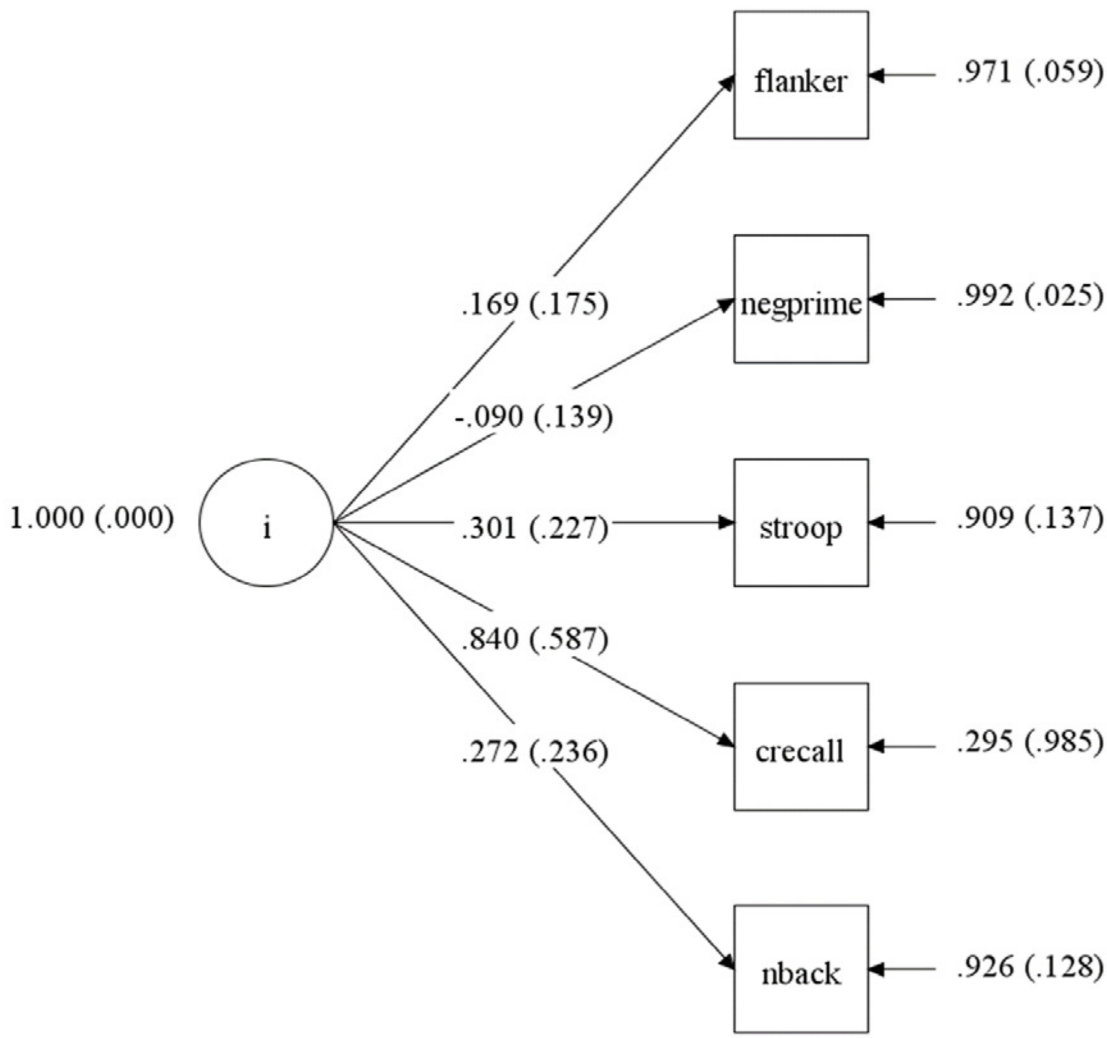

Figure 3.2: The One Factor Inhibition Model

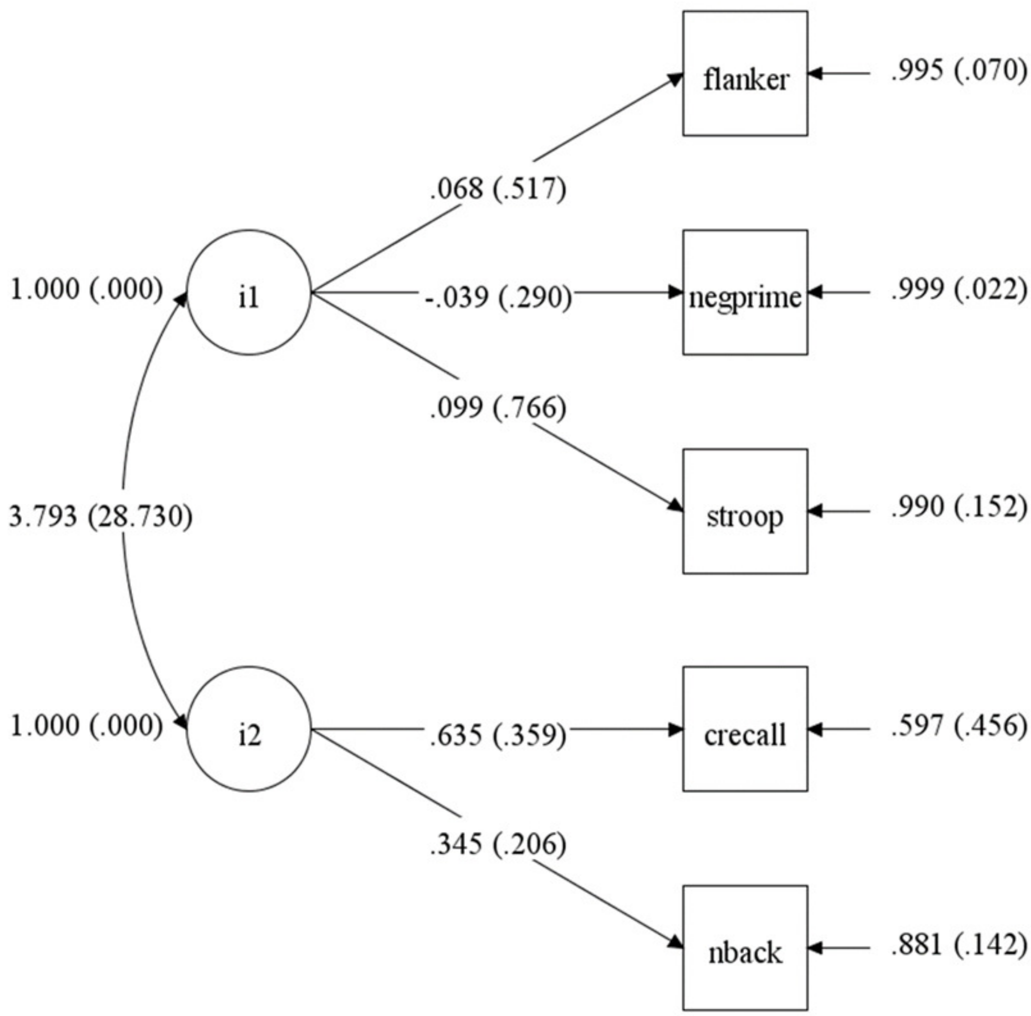

Figure 3.3: The First (Proposed) Two Factor Inhibition Model

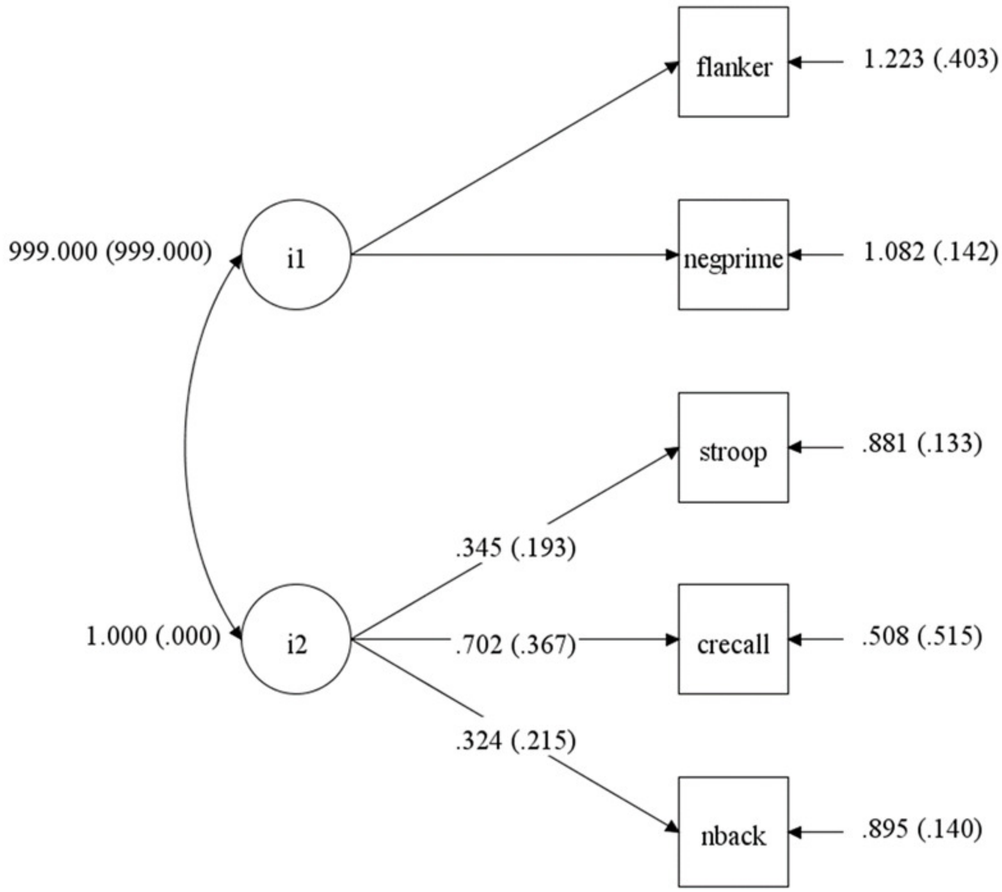

Figure 3.4: The Second Two Factor Inhibition Model

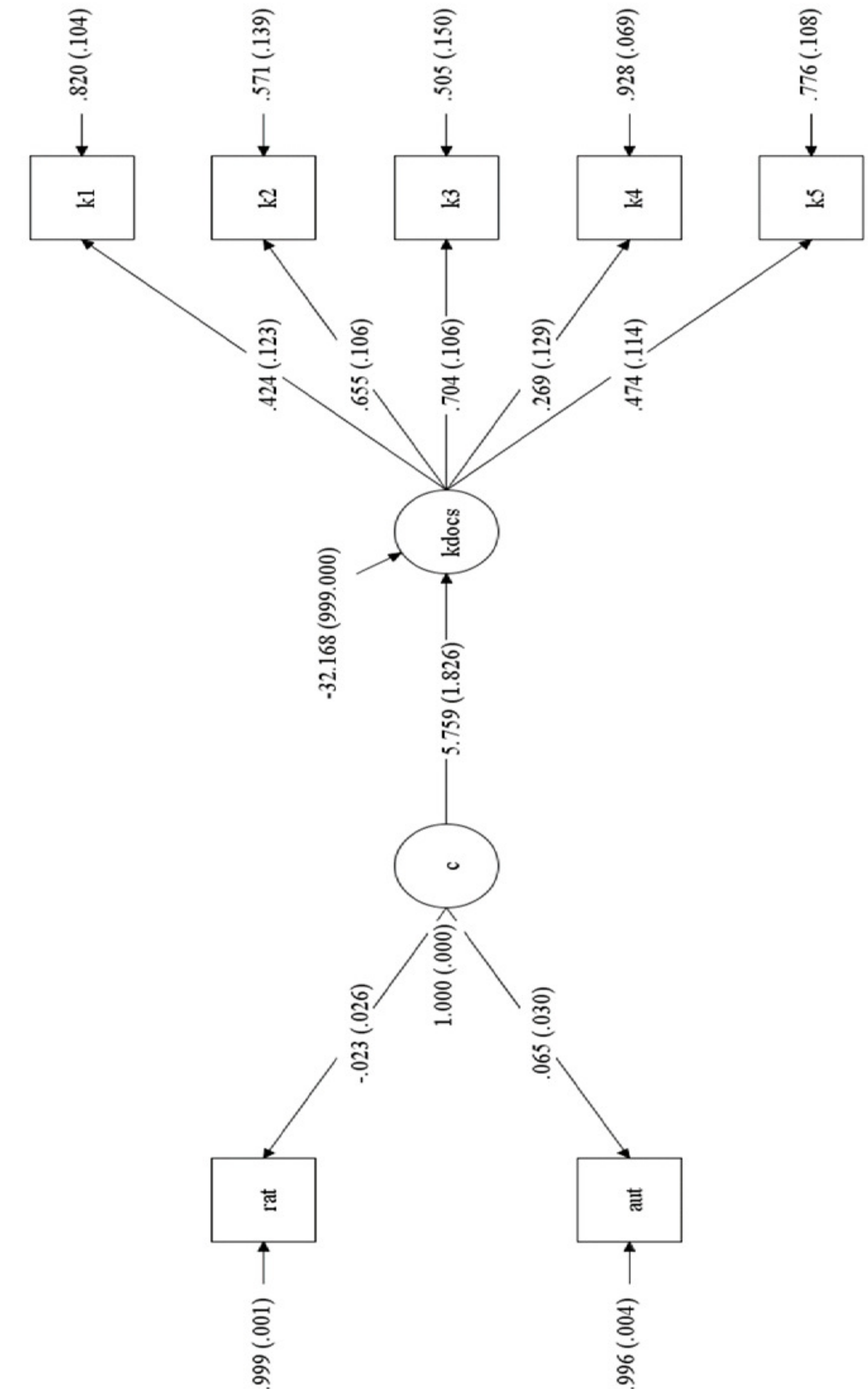

Figure 3.5: The One Factor Creativity Model

CHAPTER FOUR
DISCUSSION

Our study failed to replicate the findings of Friedman and Miyake (2004) and Bissett, Nee,and Jonide (2009); the two factor inhibition model was not a significantly better fit than the one factor model. That said, despite fair model fit indices, none of the measures significantly loaded onto the one factor model either. These findings may have been, at least in part, the result of including one particular measure: negative priming. The negative priming task used was found to negatively load (albeit not significantly) onto both the one factor and the two factor inhibition models. Friedman and Miyake (2004) note that negative priming tasks tend to have particularly low reliabilities. However, as seen in Table 3.1, with a reliability of 0.81, that does not appear to be the issue. Friedman and Miyake (2004) also state that there is contention amongst researchers regarding whether negative priming is actually a measure of attention inhibition or if the effect some other phenomena, such as episodic retrieval, feature mismatch, temporal discrimination, etc. Negative priming was not included as a measure of resistance to distractor interference by Friedman and Miyake (2004) nor Bissett, Nee,and Jonide (2009), so the issue may very well be a misconceptualization of this phenomenon. It may not be a matter of one isolated measure, but common characteristics of all the inhibition measures. Most, if not all, of these measures were intended to observe inhibition effects, not individual differences in inhibition. Thus, they may not be effective individual differences measures. Most of the attention inhibition measures have good internal consistency reliabilities, most likely because each measure was comprised of at least 80 trials in an attempt to bolster reliability. On the other hand, the Brown-Peterson variant and the cued recall task, memory inhibition measures whose trial length prevented the inclusion of more than 10-30 trials, both have notably lower reliabilities.

Also unlike Friedman and Miyake (2004), the Stroop task did not load well with the attention inhibition measures, but with the memory inhibition measures. This may be another possible effect of the negative priming task negatively loading onto a common factor. The Stroop task may have loaded better onto attention inhibition than the memory inhibition in a model absent of the negative priming measure. Another possible explanation is misconceptualization of the Stroop task. Although the Stroop task is typically believed to measure the inhibition of a prepotent response (i.e. reading the word) which would result from semantic interference from word encoding (i.e. the word is a name for a color), recent findings suggest that the Stroop effect occurs at the level of response selection (Kuipers et al., 2006), not perception, thus the inhibition occurring would be of intrusive thoughts (i.e. the meaning of the word) within working memory. This could also account for the previous finding of a positive correlation between the Stroop task and creativity (Benedek, Heene, & Neubauer, 2012).

As hypothesized, the n-back, a memory oriented inhibition measure, was positively correlated with the RAT. This finding supports the postulation that increased memory oriented inhibition hinders fixation on unoriginal and inappropriate thoughts during creative ideation. The relation between memory inhibition and creativity might have been found with the RAT and not the AUT due to the differing natures of the two creativity measures. It is possible to score high on the AUT by reporting a myriad of uncreative ideas as long as at least two of the generated ideas are creative. Thus, whereas inhibition of unoriginal or inappropriate ideas may facilitate performance by freeing cognitive faculties for creative ideation, it may not be as necessary as it is for a convergent thinking task, such as the RAT, where only one response is allowed. This was the only significant finding of the study; none of the other inhibition measures were found to significantly correlate with creativity or intelligence nor was intelligence correlated with creativity. As with the factor analyses, this may have been an issue of low power. When the relation has been found, it is typically weak (Ansburg & Hill, 2003; Benedek, Franz, Heene, & Neubauer, 2012; Chirilaa & Feldman, 2012; Fink, Slamar-Halbedlas, Unterrainer, &Weiss, 2012; Gilhooley, et al, 2007; Memmert, 2007; Storm & Angello, 2010). For instance, the association between negative priming and the RAT might have been found with a larger sample size.

If inhibition measures don't relate well with one another, even measures that are purportedly measuring the same type of inhibition, then selecting one inhibition measure to analyze the relation between inhibition and creativity will not clarify how inhibition assists or stymies creativity or when it transpires during the creative process. If future research is to be conducted on the relation between inhibition and creativity, researchers should attempt to measure the inhibition they posit occurs during the creative process, such as Gilhooley et al. (2007). This would avoid many of the concerns regarding construct validity as well as increase external validity. Results from studies such as these could possibly be used to design interventions that could be implemented in the schools, or at least inform teachers of the benefit of certain cognitive inhibition abilities for the creative process.

APPENDIX A

IRB APPROVAL LETTER

The Florida State University
Office of the Vice President For Research
Human Subjects Committee
Tallahassee, Florida 32306-2742
(850) 644-8673 · FAX (850) 644-4392

APPROVAL MEMORANDUM

Date: 8/15/2014

To: Ashley Rotolo

Address: [redacted]
Dept.: PSYCHOLOGY DEPARTMENT

From: Thomas L. Jacobson, Chair

Re: Use of Human Subjects in Research
Not All Cognitive Inhibition Measures are Creatively Equal: The Differential and Interaction Effects of Various Inhibition Types on Creativity

The application that you submitted to this office in regard to the use of human subjects in the proposal referenced above have been reviewed by the Secretary, the Chair, and one member of the Human Subjects Committee. Your project is determined to be Expedited per per 45 CFR § 46.110(7) and has been approved by an expedited review process.

The Human Subjects Committee has not evaluated your proposal for scientific merit, except to weigh the risk to the human participants and the aspects of the proposal related to potential risk and benefit. This approval does not replace any departmental or other approvals, which may be required.

If you submitted a proposed consent form with your application, the approved stamped consent form is attached to this approval notice. Only the stamped version of the consent form may be used in recruiting research subjects.

If the project has not been completed by 8/14/2015 you must request a renewal of approval for continuation of the project. As a courtesy, a renewal notice will be sent to you prior to your expiration date; however, it is your responsibility as the Principal Investigator to timely request renewal of your approval from the Committee.

You are advised that any change in protocol for this project must be reviewed and approved by the Committee prior to implementation of the proposed change in the protocol. A protocol change/amendment form is required to be submitted for approval by the Committee. In addition, federal regulations require that the Principal Investigator promptly report, in writing any unanticipated problems or adverse events involving risks to research subjects or others.

By copy of this memorandum, the Chair of your department and/or your major professor is reminded that he/she is responsible for being informed concerning research projects involving human subjects in the department, and should review protocols as often as needed to insure that the project is being conducted in compliance with our institution and with DHHS regulations.

This institution has an Assurance on file with the Office for Human Research Protection. The Assurance Number is FWA00000168/IRB numberIRB00000446.

Cc: Michael Kaschak, Advisor
HSC No. 2014.13258

APPENDIX B

IRB RE-APPROVAL LETTER

The Florida State University
Office of the Vice President For Research
Human Subjects Committee
Tallahassee, Florida 32306-2742
(850) 644-8673 · FAX (850) 644-4392

RE-APPROVAL MEMORANDUM

Date: 6/23/2015

To: Ashley Rotolo

Address: [redacted]
Dept.: PSYCHOLOGY DEPARTMENT

From: Thomas L. Jacobson, Chair

Re: Re-approval of Use of Human subjects in Research
Not All Cognitive Inhibition Measures are Creatively Equal: The Differential and Interaction Effects of Various Inhibition Types on Creativity

Your request to continue the research project listed above involving human subjects has been approved by the Human Subjects Committee. If your project has not been completed by 6/21/2016, you must request a renewal of approval for continuation of the project. As a courtesy, a renewal notice will be sent to you prior to your expiration date; however, it is your responsibility as the Principal Investigator to timely request renewal of your approval from the committee.

If you submitted a proposed consent form with your renewal request, the approved stamped consent form is attached to this re-approval notice. Only the stamped version of the consent form may be used in recruiting of research subjects. You are reminded that any change in protocol for this project must be reviewed and approved by the Committee prior to implementation of the proposed change in the protocol. A protocol change/amendment form is required to be submitted for approval by the Committee. In addition, federal regulations require that the Principal Investigator promptly report in writing, any unanticipated problems or adverse events involving risks to research subjects or others.

By copy of this memorandum, the Chair of your department and/or your major professor are reminded of their responsibility for being informed concerning research projects involving human subjects in their department. They are advised to review the protocols as often as necessary to insure that the project is being conducted in compliance with our institution and with DHHS regulations.

Cc: Michael Kaschak, Advisor
HSC No. 2015.15818

APPENDIX C

INFORMED CONSENT

Consent Form:

Title of Research: Not All Cognitive Inhibition Measures Are Creatively Equal: The Differential and Interaction Effects of Various Inhibition Types on Creativity

Principal Investigator: Ashley Rotolo

Purpose: The purpose of this study is to examine individual differences in certain cognitive processes and how they relate to creative performance.

Procedures:

If you agree to be in this study, you will be asked to perform a battery of cognitive measures in the lab, as well as complete a brief self-report questionnaire and two creativity tasks. Participation in all activities should take a total of approximately 90 minutes.

Risks and Benefits:

There are no foreseeable risks to participating in this study and no direct benefits apart from the compensation detailed below.

Compensation:

You will be compensated for your participation with the course credit designated on the psychology research participation website.

Confidentiality:

The records of this study will be kept private and confidential to the extent permitted by law. You will be assigned a code that will be used to keep your data together. No identifying information will be kept, separately or otherwise, that could link you to your data. Research records will be stored securely and only the researcher and her advisor will have access to the records.

Voluntary Nature of the Study:

Participation in this study is voluntary. Your decision whether or not to participate will not affect your current or future relationship with Florida State University. If you decide to participate, you are free to not answer any question or withdraw at any time without penalty.

Contacts and Questions:

You may ask any question you have now. If you have a question later, you are encouraged to contact the researcher, Ashley Rotolo, at [redacted], or her faculty supervisor, Dr. Mike Kaschak at [redacted].

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher, you are encouraged to contact the FSU IRB at 2010 Levy Street, Research Building B, Suite 276, Tallahassee, FL 32306-2742, or 850-644-8633, or by email at humansubjects@fsu.edu

You will be given a copy of this information to keep for your records.

Statement of Consent:

I have read the above information and consent to participate in the study.

____________________ ____________________

Signature Date

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BIOGRAPHICAL SKETCH

Ashley N. Rotolo

Ashley Rotolo grew up in Gulf Breeze, Florida. She attended the University of West Florida in Pensacola, Florida for her undergraduate studies, graduating with a Bachelor's degree in psychology. Ashley entered the doctoral program in Developmental Psychology in the fall of 2011.