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An examination of induced anxiety and its interaction with trait anxiety on executive functioning tasks

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AN EXAMINATION OF INDUCED ANXIETY AND ITS INTERACTION WITH TRAIT ANXIETY ON EXECUTIVE FUNCTIONING TASKS

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ABSTRACT

Anxiety is a common human experience which has been shown to have detrimental effects on cognitive abilities, particularly the executive abilities of inhibition, shifting and updating. Previous studies in this area have been highly specific in their focus, leaving gaps in the literature. As a result, the general nature of anxiety's effect on executive functioning has yet to be fully defined. The current study attempted to establish such a definition by exploring the effects of state anxiety and trait anxiety on each of the executive functions, both in terms of task performance and efficiency. In addition, because working memory has been shown to be closely related to higher order cognitive abilities such as general fluid intelligence (Shelton, Elliott, Matthews, Hill, & Gouvier, 2010), the influence of working memory capacity (WMC) was also explored. In the current study, it was found that the manipulation designed to increase or decrease state anxiety was ineffective. Additionally, no effects of trait anxiety or WMC were found for any of the executive function tasks, either in terms of accuracy or reaction time (RT). Implications and future directions are discussed.

INTRODUCTION

Anxiety is an aversive emotional state experienced as a result of perceived threatening circumstances. Anxious individuals tend to worry about threats to achieving some current goal and try to develop strategies to overcome these threats. Within the field of cognition, anxiety is of prime importance because it is most often associated with detrimental effects on task performance. The current proposal will examine the effects of state and trait anxiety, along with individual differences in working memory capacity, on executive functioning.

Anxiety can be categorized into two types: state and trait anxiety. Johnson and Spielberger (1968) defined state anxiety as an organismic condition, which is characterized by subjective consciously perceived feelings of apprehension and tension, that interacts with the activation of the autonomic nervous system. State anxiety is experienced as a result of one's environment and fluctuates in reaction to changes in the environment. For example, state anxiety occurs when a person experiences an increase in heart rate upon hearing a loud and unexpected noise. On the other hand, trait anxiety refers to the degree to which individuals manifest state anxiety in response to various forms of stress. For instance, two individuals may require exposure to two different levels of a given stressor in order to elicit the same physiological response to that stressor. The more highly trait-anxious a given person is, the less of a particular stressor is needed to elicit the physiological response. This type of anxiety is a fixture of one's personality and, therefore, remains relatively constant over time and across situations (Johnson & Spielberger, 1968). Both state (Bichsel & Roskos-Ewoldsen, 1999; Eysenck, 1982) and trait (Elliman, Green, Rogers & Finch, 1997; MacLeod & Donnellan, 1993) anxiety have been associated with decreased academic performance as well as decreased performance on various cognitive tests.

Anxiety as a whole can be conceptualized as consisting of two primary components: worry and emotionality (Leibert & Morris, 1967). Worry is the main component that contributes most to the experience of anxiety. Worry encompasses the cognitive aspects of anxiety, such as negative self-evaluation, expectations of one's performance, and comparing one's own performance to the perceived performance of others (Deffenbacher, 1986). Emotionality refers to the affective response engendered by the interpretation of the physiological reactions to a stressful situation, such as an increase in heart rate or perspiration (Deffenbacher, 1986). In particular, it is the worry component of anxiety that is thought to be most responsible for the decreased cognitive performance of anxious individuals by compromising the working memory system (Coy, O'Brien, Tabaczynski, Northern, & Carels, 2012). In addition, the effect on cognitive performance is greater for worry than it is for emotionality, as measured with the TAI (Harris & Elliott, 2013). In all, once worry is controlled for, emotionality ceases to share any relationship with task performance (Cassady, 2004).

Working memory is a cognitive structure that includes temporary stores for holding domain specific task-related information, such as the phonological loop and the visuospatial sketchpad, and a domain general executive function system for processing that information (Baddeley, 2007). It is this executive that is responsible for carrying out particular functions such as directing attention and maintaining task goals. Working memory has been studied and characterized in different ways by different types of researchers. Experimental psychologists administer tasks which allow a quantification of an individual's working memory capacity (WMC). WMC can be conceptualized as how able the executive is to coordinate with the other domains of the working memory in order to process task-relevant information while inhibiting task-irrelevant information. The ability to perform cognitive tasks which require maintenance and manipulation of information signifies an individual to be higher in WMC, or lower in WMC. The assessment of an individual's WMC is typically done through the administration of complex span tasks, which will be discussed in greater detail below. WMC has been shown to predict an individual's abilities on a wide variety of cognitive tasks, including complex problem solving abilities, in addition to general intellectual ability, and so is an important individual differences variable (e.g., Conway, Kane, & Engle, 2003). However, neuropsychologists tend to be concerned with an individual's executive functioning abilities. These are so called because they are the functions specifically carried out by the executive and refer to the one's ability to perform tasks such as inhibition of prepotent responses and mental set shifting, tasks which will be discussed in greater detail below. It has been demonstrated that tasks designed by experimental psychologists to assess an individual's WMC share a significant correlation with tasks developed by neuropsychologists to assess one's executive functioning (e.g., McCabe, Roediger, McDaniel, Balota, & Hambrick, 2010). This suggests that there is a common underlying executive attention system that is being assessed by both types of tasks. In other words, both types of tasks are accessing a common executive attention facility.

With regard to anxiety, it has been found that WMC offers protective effects against anxiety (Tse & Pu, 2012). It was found that participants high in WMC demonstrated consistent performance on a list-learning task regardless of their trait anxiety levels. However for those low in WMC, trait anxiety had a detrimental effect on performance. In other words, if participants were low in WMC, the higher their trait anxiety score, the less accurate they were on the list learning task. It is thought that the reason for why WMC should have a protective effect against anxiety is due to how anxious individuals approach a given task. An anxious individual will tend to worry more about how they are performing than their non-anxious fellows will. As a result, more cognitive resources are being spent on worrying, which would have otherwise gone towards task performance (e.g., Klein & Boals, 2001). The protective effect of being high in WMC can be thought of in terms of a fixed cost associated with worrying. If an individual is low in WMC, the cost of worrying alone may be sufficient to exhaust their capacity. However, if another individual is high in WMC and also worrying, he is still incurring that same cost associated with the process of worrying, but has additional cognitive resources to spare. Hence, a protective effect of WMC can be found in the WMC/anxiety relationship.

The relationship between anxiety and cognitive task performance has been studied extensively in the past, but has only recently been formally described by Eysenck and colleagues in terms of the Attentional Control Theory (ACT; Eysenck, Derakshan, Santos, & Calvo, 2007; Eysenck & Derakshan, 2011). Under ACT, worry directs attention to threatening stimuli, either internal or external, at the expense of the current task. External threatening stimuli include task-irrelevant distractors such as unexpected sounds or movements from others in a testing situation. Internal threatening stimuli include worrisome thoughts such as rumination on the consequences of failure and comparison of one's own performance to the perceived performance of others. When an individual recognizes that his/her attention is being directed away from the current task towards these task-irrelevant stimuli, auxiliary processing resources are required to compensate for this divided attention. However, using these auxiliary resources is an effortful process, and therefore time-consuming. The individual is able to maintain task performance, but at the expense of efficiency (e.g., RT slowing). On tests of working memory, anxious participants typically display normal accuracy but increased RTs (Eysenck & Calvo, 1992).

Because this diverting of cognitive resources is effortful, and resource allocation has been considered by some to be an important executive functioning task (Miyake, Friedman, Emerson, Witzki, Howerter, & Wager, 2000), it follows that executive functioning plays a significant role in this process. Furthermore, it would be expected that tasks specifically requiring executive functions would be compromised, primarily in terms of processing efficiency (Berggren & Derakshan, 2012). Accuracy would only be expected to suffer once RT had been drastically increased. It is generally recognized that the executive attention system is responsible for three major executive functions: inhibition, shifting, and updating (Miyake et al., 2000). Inhibition refers to the restraining of prepotent responses, such as, in the classic Stroop color-word paradigm (Stroop, 1935), inhibiting one's primary response to read the word and instead to identify the color of the ink that the word is printed in. Inhibition also refers to the ability to ignore distracting stimuli in competition with the primary task for one's attention, such as worrisome thoughts about a test's outcome (Friedman & Miyake, 2004).

Shifting refers to the ability to transition between tasks or operations or mental sets (Monsell, 1996). The Wisconsin Card Sorting Task (WCST; Berg, 1948) has long been considered to be a prime means of assessing this particular function. In this task, a series of cards are presented which show some number of some shape, all in one of various colors. The participant's task is to decide whether to sort each card into a particular pile based on number or shape or color of the objects on the card. Only the researcher knows the correct rule at any given time, and will advise the participant whether the rule by which they assigned the previous card was "correct" or "incorrect". After a given number of trials, the researcher will change the rule, perhaps from "color" to "shape". After a process of trial and error, the participant will ideally discover the new rule and proceed from there through several more rule changes. The WCST assesses how well a participant is able to abandon a previously successful method of problem solving and adapt to new conditions; how well they were able to "shift" between sorting rules.

Updating refers to the process of monitoring incoming information in working memory relevant to the task at hand and discarding older, less-relevant information (Morris & Jones, 1990). A common means of assessing one's updating abilities is with the Keep Track task (Yntema, 1963). In this task, participants are randomly presented with verbal examples of several categories (animals, metals, fruits, etc.) in sequence and are prompted to report the most recently presented example of each category at random intervals. The participant must, in effect, keep a running tally of the most recent members of each category, accessible at a moment's notice.

Of the three executive functions, the function presumed to be the most strongly affected by anxiety, and consequently the most heavily researched in this context, is inhibition. The prime method for interference of anxiety on working memory is the generation of task-relevant worry and task-irrelevant thought. In addition to reallocating additional cognitive resources, one must inhibit this largely involuntary negative off-task self-dialogue in order to maintain task performance. Indeed it has been repeatedly shown that participants high in trait anxiety perform poorly on assessments of inhibition relative to those lower in trait anxiety (Spence, Farber, & McFann, 1956; Spence, Taylor, & Ketchel, 1956; Standish & Champion, 1960; Pallak, Pittman, Heller, & Munson, 1975; Nottelman & Hill, 1977; Alting & Markham, 1993). However, it has recently been proposed that there is no impact of state anxiety on the inhibition function (Coy et al., 2012). When participants were induced into states of high and low anxiety through a relatively common means (information that the following task would be very difficult or very easy) Coy et al. (2012)found no relation between state anxiety and accuracy on the Stroop color-word task, a standard measure of inhibition. At first, this finding seems slightly incongruous with the previous literature. It may either be the case that their version of the Stroop task was not sensitive enough to detect differences between groups, or that state anxiety acts on a different mechanism where inhibition is concerned than does trait anxiety. This latter alternative is unlikely as both types of anxiety have been shown to result in negative off-task self-dialogue. What is a more likely explanation is that the dependent variable itself was not ideal. Coy et al. (2012) assessed the effect that state anxiety had on individuals' performance (i.e., accuracy) on the Stroop color-word task as a measure of inhibition. According to the ACT, anxiety would have its greatest effect on the efficiency with which inhibition-related tasks were performed (i.e., participants' RTs; Eysenck et al., 2007). Although Coy assessed the amount of correctly identified ink colors in a given period of time, a more sensitive assessment of efficiency would be to measure participants' RTs to each color word individually.

Past literature on the effects of anxiety on the remaining executive functions, updating and shifting, is not nearly as extensive as on inhibition. However, previous studies have found evidence for a detrimental effect of anxiety on shifting and updating. Johnson (2009) found significant effects of trait anxiety on participants RTs while performing a set shifting task. As yet, the effects of both state and trait anxiety on the accuracy and RT of the shifting function have not been assessed within the same study.

Likewise, anxiety has also been shown to have an effect on the updating function. Darke (1988) found a significant effect of trait anxiety and state anxiety on Reading Span (R-Span) task performance. The R-Span task is one of several complex span tasks used to assess updating ability (e.g., Daneman & Merikle, 1996). The R-Span task will be discussed in greater detail below. Trait anxiety was assessed with the Test Anxiety Scale (TAS; Sarason, 1972). The TAS is a commonly used measure of test anxiety and has been shown to correlate highly with participants' overall trait anxiety (Onyeizugbo, 2010). State anxiety was induced through a set of ego-threatening instructions, (e.g., informing participants that the following task would be difficult). It should be noted that no measures of state anxiety were taken. It was assumed that participants who received the anxiety-inducing instructions would have higher state anxiety than those who did not. Sorg and Whitney (1992) found similar effects of state and trait anxiety on R-Span accuracy: highly trait-anxious participants, based on their scores on the State-Trait Anxiety Inventory (STAI), displayed poorer accuracy under stressful conditions. The conditions involved either playing a video game (non-stressful condition) or playing a video game in competition with other participants for a large cash prize ($50; stressful condition). As in Darke (1988), no state anxiety measures were taken, nor was RT assessed. It was found that highly trait-anxious individuals performed worse on the R-Span task when they thought the task would be difficult (stressful condition) than non trait-anxious individuals in the same condition.

Of particular relevance to the current study, both Darke (1988) and Sorg and Whitney (1992) also found that state and trait anxiety had an additive effect on R-Span accuracy such that highly trait-anxious participants demonstrated poorer accuracy in the stressful condition than high trait participants in the non-stressful condition. These findings support the assertions of the ACT that accuracy becomes compromised in highly trait-anxious individuals only under stressful conditions (Eysenck et al., 2007). Based on the ACT, it is reasonable to assume that these individuals also demonstrated significantly increased RTs, though, as stated above, RTs were not assessed.

The Current Study

Because previous studies have tended to explore the effects of worry on only one executive function at a time, and typically its effect on task accuracy rather than RT, the current study explored anxiety's effects on all three executive functions: inhibition, shifting and updating. Given the typical lack of assessment of both state and trait anxiety in the same participants within the previous literature, trait and state anxiety were both assessed. Based on the work of Coy et al. (2012) who used a design similar to that employed in the current study, and used a test-specific anxiety inventory as their anxiety measure, a test anxiety measure was also used here. Test anxiety is a situation-specific trait, and is a finer expression of trait anxiety. In keeping with the assertions of the ACT, task RTs were also assessed as a measure of efficiency, as efficiency is more likely than task performance to be affected by higher levels of anxiety, whether inherent or induced. Additionally, this is the first known study to examine the effects of anxiety on task RT in the context of the distinct domains of executive function. This study contributes to the literature by clarifying the effects of varying conditions and dispositions of anxiety on the executive functions.

Thus, in the current study, participants performed four tasks, in addition to survey measures of anxiety. One of these tasks was a complex span task, in which the participant must hold one type of information in memory while manipulating a separate piece of information and is frequently used in individual differences research in order to obtain a general score of WMC (i.e., R-Span; Daneman & Merikle, 1996).

Participants then performed three additional tasks assessing the three dimensions of executive function: updating, shifting or inhibition. The updating task was the Shape N-Back task (Hautzel, Mottaghy, Specht, Muller, & Krause, 2008). An advantage of the Shape N-Back task is that it is not verbally mediated, meaning that it represented a more sensitive task of executive ability without the opportunity for verbal rehearsal. If participants were able to verbally maintain information until it was needed, this would denote the use of covert rehearsal techniques in addition to relying on executive abilities. In order for a task to most heavily rely on executive function, the possibility for the use of rehearsal techniques to maintain information must be ruled out methodologically. The shifting task was the Letter-Number task (Rogers & Monsell, 1995) and was chosen because it too has been demonstrated to be an effective task for assessing the shifting function (Miyake et al., 2000) in addition to not being verbally mediated. The inhibition task was the Go/No Go task, which was chosen as an effective task for assessing inhibition (e.g., Thorell, Lindqvist, Nutley, Bohlin, & Klingberg, 2009; Redick, Calvo, Gay, & Engle, 2011; Rush, Barch, & Braver, 2006).

It was hypothesized that WMC would offer a protective effect such that high WMC participants would demonstrate comparable RTs and accuracies on the three executive function tasks regardless of their levels of state or trait anxiety (Tse & Pu, 2012). However, for participants who are lower in WMC, it was hypothesized that either type of anxiety would have a greater effect on task RT than on task accuracy, and that these detrimental effects would be increased when participants are high in both state and trait anxiety (Darke, 1988; Sorg & Whitney, 1992).

METHOD

Participants

The participants for this study consisted of 180 undergraduate students recruited from Louisiana State University. Participants received either course or extra credit for their participation. Participants were excluded on the basis of self-reported hearing loss, not being a native English speaker, reporting symptoms of an anxiety disorder or failing to maintain at least 85% accuracy on the processing portion of the R-Span task. This was necessary because one could easily score well on one dimension of a complex span task if they used rehearsal techniques at the expense of the other concurrent dimension of the task. Maintaining a minimum level of processing performance ensures that participants are not devoting too much attention to the recall portion of the task at the expense of processing. One hundred and sixty-four of the original 180 were able to meet all of these criteria.

Materials

Test Anxiety Inventory. The Test Anxiety Inventory (TAI; Spielberger et al., 1980) is a 20-item inventory designed to assess the extent to which an individual experiences anxiety related to test taking (e.g., "I feel confident and relaxed while taking tests"). The TAI has demonstrated high internal consistency, $\alpha = .93$ (Spielberger et al., 1980). Test anxiety is a situation-specific personality trait (Spielberger, 1972) and is considered a finer expression of trait anxiety. The TAI contains two subsections which measure worry and emotionality. Because worry is the component of anxiety which has the most impact on cognitive performance, according to ACT, our main focus was on scores from this subsection, though the emotionality subscore and total score were also assessed.

In order to obtain test-anxiety specific state scores, the text of each of the 20 items was modified to change it from a trait item to a state item. This practice has been used by Coy et al. (2012) and has been shown not to unduly alter the psychometric properties of the measure. The result was 20 state specific test-anxiety items (e.g., "I feel confident and relaxed about these tests").

Reading Span Task. The Reading Span (R-Span; Conway et al., 2005) task involves a series of sentences presented to the participant. It is the participant's task to determine whether a given sentence makes sense. Between sentences, the participant is also shown a letter of the alphabet. After judging a number of sentences, the participant is then presented with a grid of letters and selects the letters that they have seen, in the correct order. This process is repeated for 15 trials with set sizes ranging from 3-7 sentence/letter pairings. The range of possible scores is from zero to seventy-five. Scores on the R-Span task have been shown to significantly correlate with academic achievement (e.g., Hitch, Towse, & Hutton, 2001). R-Span performance has also been shown to be strongly correlated with domain-general WMC (.70; Kane, Hambrick, Tuholski, Wilhelm, Payne & Engle, 2004), and so is an appropriate analog for that variable in the current study.

Number-Letter Task. In the Number-Letter Task (Rogers & Monsell, 1995) a Number-Letter combination (e.g., 3U) is presented in one of four quadrants of a computer screen. The participants were instructed that their task is to identify whether the letter is a vowel (A, E, I or U) or a consonant (G, K, M or R) when the combination is in one of the bottom two quadrants, and to identify whether the number was even (2, 4, 6 or 8) or odd (3, 5, 7 or 9) when the combination was in one of the top two quadrants.

The number-letter pairs were presented only in the top quadrants during the first 32 target trials, only in the bottom two quadrants for the following 32 target trials, and clockwise around the screen for the next 128 trials. Participants responded by computer key press, and the following stimulus was presented 150 ms after the preceding response.

It should be noted that for this task, efficiency was not assessed with a simple analysis of RTs, but through RT difference scores. Due to the design of the procedure, two out of every four trials involved shifting and two did not. The shift cost was calculated by subtracting the median RT of non-shifting trials from the median RT of the shifting trials for each subject. The difference between these RTs is the difference score used for efficiency analysis.

Go/No Go Task. The Go/No Go Task (Redick et al., 2011) consists of a sequence of letters presented to the participant who was instructed to press the space bar as quickly as possible whenever the letter “X” was presented (Go) and to not press the spacebar whenever a letter that was not “X” is presented (No Go). The stimuli were presented for 300 ms, followed by a blank screen for 700 ms, giving the participant a total of 1000 ms to respond by pressing the spacebar. “Go” stimuli were randomly presented 160 times during this sequence, while “No Go” stimuli were presented 40 times, for a total of 200 presentations.

Shape N-Back Task. The Shape N-Back Task (Hautzel et al., 2008) consists of a series of non-nameable shapes (Attneave & Arnoult, 1956) presented in series. After every six shapes, the participant was prompted to decide whether a particular shape had been presented within one of the three items back from their current position in the sequence. The participant then responded “yes” or “no” with a key press.

Design and Procedure

The dependent variables for the current study were accuracy scores on the inhibition (Go/No Go) shifting (Number-Letter) and updating (Shape N-Back) tasks, as well as task RTs.

The independent variables for the current study were trait anxiety group, treatment condition, state anxiety and performance on the complex span screening task (i.e., the R-Span).

Participants were tested in groups (ranging in size from 1 – 6) and were seated in front of individual computer workstations, separated by dividers. They were presented with the informed consent document. The participants first completed the trait anxiety measure of the TAI. Following the TAI, participants performed the R-Span task. The group of participants were then randomly assigned to one of two treatment conditions designed to either increase or decrease state anxiety. The technique that was used to alter the participants’ state anxiety levels was to present them with instructions prior to beginning the experimental tasks which explain that the tasks would either be very difficult, or that the tasks would be easy. This general technique has been used in several studies and has been shown to be a reliable means of raising or lowering state anxiety (e.g., Coy et al., 2012; see Appendix for the specific instructions). Following the instructions, participants completed the State subtest of the TAI. The participants then completed the cognitive tasks (Number-Letter, Go/No Go and Shape N-Back). Between tasks, participants received instructions similar in tone to the instructions presented earlier which described the current task as difficult or easy in order to maintain the induced mood state over time. Following completion of the tasks, the participants were again given the state subsection of the TAI in order to assess mood. This measurement allowed a comparison with mood states from the start of the procedure to completion.

RESULTS

The following analyses report significance at the $p < .05$ level, unless otherwise stated. The data set of one participant was removed due to missing data. If a participant's data contained an outlying median RT or accuracy score in any one of the three Executive Function tasks, the participant was removed from the data set. A total of 17 participants were removed on the basis of outlying values, defined here as at least one median RT value more than three standard deviations from the mean. Data from a further nine participants were removed because their accuracy scores on the Letter-Number shifting task were more than three standard deviations from the mean. These participants had approximately average RTs and their accuracy scores were not at floor. The range of accuracy for these nine participants is 24.44% - 53.57% (Mean = 43.99%). The likely explanation for these low accuracy scores is that those participants failed to employ the alternate decision-making criteria once the letter-number location had been switched, or else they simply did not understand the instructions and responded randomly. In all, this comes to data from 43 participants removed, resulting in 137 which were used for the following analyses.

For the accuracy analyses, trials which were completed in less than 200 ms were excluded. Responses made under 200 ms are likely anticipatory responses. These trials are not representative of a participant's abilities under the experimental conditions. Four such trials were removed from the Shape N-Back task; 2 (0.26%) from target trials at lag 1, and 2 (0.09%) from lure trials. One hundred and eight (0.47%) trials were removed from the Letter Number task. Seven hundred and seventy-seven target trials were removed from the Go No Go task (2.39%), and 178 (2.47%) lure trials were removed.

For the RT analyses, the median RTs of each participant for each task were used. Only accurate trials were used to create these median RT values. For the Shape N-Back task analyses, 36 inaccurate trials (4.74%) were removed from lag 0, 234 inaccurate trials (30.87%) from lag 1, 279 inaccurate trials (38.22%) from lag 2, and 1120 (49.82%) inaccurate lure trials. For the Letter-Number task, 3301 (14.43%) inaccurate trials were removed. For the Go No Go task, 3676 (12.76%) inaccurate target trials and 1347 (19.18%) inaccurate lure trials were removed.

Descriptive statistics and correlational analyses were computed by condition for TAI trait and state worry scores as well as R-Span total score and the relevant RT and accuracy scores for the EF tasks (See Tables 1A, 1B, 2A and 2B). There were no significant differences between the mean trait worry, state worry, state worry at time two, or R-Span total scores of the two conditions (all ts <1.15, *ns*). State worry at times one and two were significantly different from one another such that time two state worry scores were significantly higher than at time one in both conditions (Easy: $t(67) = -6.93$, $p < .01$. Difficult: $t(68) = -5.93$, $p < .01$). The state worry scores at time one in both conditions were also found to be significantly different from baseline trait scores, both lower (Easy: $t(67) = 12.31$, $p < .01$. Difficult: $t(68) = -10.35$, $p < .01$). It should be noted that the range of state values at time one is not normally distributed, particularly in the easy condition. On this basis it could be said that the easy manipulation was highly effective, as state scores have moved closer to floor than participants' corresponding trait scores. The difficult manipulation, however, was not as effective.

To document the psychometric properties of the TAI in the current sample, reliability analyses were performed on the total trait and state scales, with state assessed both by condition and combined. It was found that trait was highly reliable ($\alpha = .95$) as was state in both the easy and difficult conditions ($\alpha = .94$ and $.95$ respectively). When combined, state was still highly reliable ($\alpha = .94$). The current study was concerned with the effects of the cognitive aspect of anxiety; worry. Therefore, only the totals from the worry subsection of the TAI were used in the preceding analyses, which were also found to be highly reliable. It should be noted however that previous analyses of the factor structure of the TAI have found some items to load comparably on both dimensions (Zeidner, 1998). It is for this reason that both the emotionality subscore of the TAI as well as the total score obtained from the complete measure were also assessed against the measures of efficiency and accuracy of the EF tasks (See appendices B, C, D and E for further information).

Trait worry was assessed prior to the manipulation, as was R-Span performance. However, a key tenet of the current study was the active manipulation of state worry with instructions that gave the impression that the EF tasks would be easy or difficult. The instruction manipulation was not comparably effective in both conditions, thus, state worry scores at times one and two will be excluded from all further analyses.

It was also an expectation of the current study that WMC, as assessed with the R-Span task, would moderate worry's effects on task performance. Given that a significant correlation is required if one variable can be said to moderate another, and that R-Span total score shared no correlation with any measure of worry, state or trait, the proposition of R-Span score as a moderating variable has been rejected. In the following analyses, R-Span total score and trait worry only were used as independent variables.

Executive Function RT

Two multiple linear regressions were performed to determine whether trait worry or R-Span Total had an influence on updating task RT for the average of the three target lags and for lure trials of the Shape N-Back task. There were no significant effects of trait worry or R-Span total on updating task RT for target trials. There were no significant effects of trait worry or R-Span total on lure trial RT.

An additional multiple linear regression was performed to determine whether trait worry or R-Span total affected shifting task RT. As mentioned above, this variable was the difference between the average of the switched trial RTs and the average of the non-switched trial RTs. No main effects or interactions were found.

Two further regressions were performed to determine whether trait worry or R-Span total score had an effect on inhibition task RT. No main effects or interactions were found for target or lure trials in the Go-No-Go task.

Executive Function Accuracy

Several multiple linear regressions were conducted to determine whether trait worry or R-Span total affected accuracy on the switched and non-switched trials of the Letter-Number task, accuracy for targets or lures in the Go No Go task, and for accuracy on targets, as well as lure trials, in the Shape N-Back task. No significant effects were found.

Table 1. Descriptive Statistics, Easy Condition (N = 68)

	Mean	SD	Range	Skewness	Kurtosis
TAI Trait-W	15.87	5.10	8.00-31.00	1.05	0.85
TAI State-W	9.93	3.32	7.00-26.00	2.44	8.00
TAI State 2-W	13.25	4.41	8.00-27.00	1.01	0.70
R-Span Total	54.18	12.96	16.00-75.00	-0.78	0.14
SNB Target RT	1611.41	406.35	926.83-2465.23	0.28	-0.64
SNB Lure RT	1878.13	676.98	774.50-3855.00	0.64	0.21
SNB Target Acc	0.77	0.11	0.47-1.00	-0.42	0.00
SNB Lure Acc	0.53	0.17	0.07-0.93	-0.47	-0.01
GNG Target Acc	0.87	0.05	0.73-0.97	-0.29	-0.52
GNG Lure Acc	0.79	0.14	0.23-0.98	-1.49	3.11
GNG Target RT	319.40	31.48	265.50-431.00	1.09	1.76
GNG False Alarm RT	277.37	18.93	231.00-329.00	0.27	0.88
LN No-Switch Acc	0.95	0.04	0.78-0.98	-1.94	6.06
LN Switch Acc	0.94	0.05	0.73-1.00	-1.94	4.98
LN Switch Cost	549.33	240.14	93.50-1049.00	0.41	-0.72

Note: TAI scores refer to the worry subscales. SNB refers to the Shape N-Back task. *GNG* refers to the Go-No-Go task. *LN* refers to the Letter-Number task.

Table 2. Descriptive Statistics, Difficult Condition (N = 69)

	Mean	SD	Range	Skewness	Kurtosis
TAI Trait-W	16.01	5.59	8.00-32.00	1.08	0.82
TAI State-W	10.14	3.35	7.00-23.00	1.72	3.35
TAI State 2-W	12.64	4.31	8.00-28.00	1.59	2.99
R-Span Total	56.58	11.54	29.00-75.00	-0.52	-0.38
SNB Target RT	1642.65	498.54	867.50-3834.43	1.62	4.55
SNB Lure RT	1973.26	740.52	871.50-3954.00	0.62	-0.31
SNB Target Acc	0.79	0.11	0.60-1.00	0.01	-0.86
SNB Lure Acc	0.56	0.18	0.13-0.93	-0.14	-0.49
GNG Target Acc	0.87	0.05	0.76-1.00	0.05	-0.02
GNG Lure Acc	0.80	0.12	0.45-0.98	-0.98	0.44
GNG Target RT	319.00	30.44	262.00-401.00	0.47	-0.13
GNG False Alarm RT	276.33	20.39	236.50-334.00	0.73	0.58
LN No-Switch Acc	0.94	0.05	0.74-0.98	-2.15	5.10
LN Switch Acc	0.93	0.06	0.68-1.00	-1.84	4.39
LN Switch Cost	547.56	265.52	136.00-1446.50	1.03	1.40

Note: *TAI scores refer to the worry subscales. SNB* refers to the Shape N-Back task. *GNG* refers to the Go-No-Go task. *LN* refers to the Letter-Number task.

Table 3. Correlations, Easy Condition (N = 68)

	TAI Trait	TAI State	TAI State 2	R-Span Total
TAI Trait-W				
TAI State-W	0.62**			
TAI State 2-W	0.38**	0.51**		
R-Span Total	0.15	0.09	0.17	
SNB Target RT	0.04	0.10	0.07	0.10
SNB Lure RT	0.07	0.17	0.05	0.02
SNB Target Acc	0.10	0.06	0.02	-0.20
SNB Lure Acc	-0.05	0.00	0.06	-0.14
GNG Target Acc	0.06	0.05	0.15	0.04
GNG Lure Acc	0.08	0.13	0.18	0.03
GNG Target RT	0.20	0.03	0.14	0.06
GNG False Alarm RT	-0.05	-0.16	0.04	-0.19
LN No-Switch Acc	-0.00	-0.08	0.13	0.09
LN Switch Acc	0.00	-0.05	0.08	0.15
LN Switch Cost	0.09	0.02	-0.07	-0.12

Note: ** indicates significance at the 0.01 level. *SNB* refers to the Shape N-Back task. *GNG* refers to the Go-No-Go task. *LN* refers to the Letter-Number task.

Table 4. Correlations, Difficult Condition (N = 69)

	TAI Trait	TAI State	TAI State 2	R-Span Total
TAI Trait-W				
TAI State-W	0.54**			
TAI State 2-W	0.58**	0.61**		
R-Span Total	-0.10	-0.04	-0.76	
SNB Target RT	-0.19	0.10	-0.20	0.21
SNB Lure RT	-0.09	-0.23	0.08	0.15
SNB Target Acc	0.08	0.02	-0.02	-0.20
SNB Lure Acc	0.05	-0.01	0.00	0.00
GNG Target Acc	-0.06	0.04	-0.04	0.19
GNG Lure Acc	0.19	0.11	0.19	0.02
GNG Target RT	0.05	0.17	0.09	0.05
GNG False Alarm RT	0.28*	0.35**	0.11	-0.04
LN No-Switch Acc	-0.06	-0.15	-0.12	0.19
LN Switch Acc	-0.09	-0.13	-0.17	0.24*
LN Switch Cost	-0.02	0.01	-0.14	0.08

Note: * indicates significance at the 0.05 level. ** indicates significance at the 0.01 level.

DISCUSSION

The current study was conducted to test the predictions of ACT for how state and trait worry would influence performance of the three main executive functions. Additionally, the current study sought to determine whether WMC, as assessed with the R-Span task, would also moderate the relationship between worry and task performance. Within the current sample, it appears that worry has very little effect on EF task performance, and that the relationship between worry and performance is not moderated by WMC. However, before discounting the previous work on which these hypotheses have been based, the limitations of the current study must be addressed. Most importantly, state anxiety was not successfully manipulated in the current study. Although the easy/difficult instructions used in the current study were exactly those used by Coy et al. (2012) a different measure of test anxiety was used. The worry subsection of the Test Anxiety Inventory was used in the current study, while Coy et al. (2012) used the whole of the Revised Test Anxiety Scale (RTA). The RTA is composed of items from the TAI and the Reactions to Tests Inventory (RTI; Sarason, 1984). The RTA contains six items from the worry dimension of the TAI which factor analysis had revealed to be the most predictive of the overall worry score. At present, no data exists comparing the statistical properties of specifically the worry subsection of the TAI and the RTA. It is possible that, though two measures of test anxiety should theoretically strongly correlate, the additional factors within the RTA (tension, bodily symptoms and test-irrelevant thinking) make the RTA different enough such that one would return significant effects and one would not, following the same instructions.

It should also be noted that in the current study, booster instructions were given prior to each EF task in order to maintain the lowered or elevated state of test anxiety. These additional prompts may have inadvertently informed the participants in both conditions that anxiety was the variable of interest, and so the instructions that they received likely did not genuinely reflect the ease or difficulty of the tasks.

When comparing the current performance on EF tasks to previously reported performance, some interesting differences arise. Specifically, in the original iteration of the Letter-Number task, Rogers and Monsell (1995) reported a switching cost which was less than half of what was observed in the current study (224 ms as opposed to approximately 548 ms). Additionally, in the study of the Go-No-Go task conducted by Redick et al. (2011), target trial accuracy is approximately at ceiling, while in the current study target accuracy is at 87% in both conditions. Similarly, for lure trials, Redick reports approximately 93% accuracy, while the accuracy rate in the current study is between 79% and 80% by condition. Target trial RTs are not significantly different between studies (Redick: 323ms, Current study 319ms). With regard to the Shape N-Back task, Hautzel et al. (2008) report 99% accuracy on lag 0 trials of the same design as used in the current study, and 87% accuracy on lag 2 trials, while the current study found a pooled accuracy of between 77% and 79% depending on condition. Hautzel also reported RTs of 471 ms and 757 ms for the respective trials, while the current study found pooled RTs of 1611.41ms for the easy condition and 1642.65ms for the difficult condition. Taken together, these differences from previous studies (lower than expected accuracy and longer than expected RTs), as well as the proportion of inaccurate lure trials which had to be cut from the Shape N-Back analyses (nearly 50%) suggest that the participants may not have been sufficiently motivated to perform to the best of their abilities. It should be noted that Coy's participants were tested one at a time and while wearing a heart rate monitor. These conditions were different from those used in the current study and may have contributed to the difference in observed results as well by adding additional anxiety-inducing elements to the environment.

Issues of state worry aside, it is puzzling why trait worry did not have any significant effects on EF task performance. One answer may lie in the distinction that test anxiety is a situation-dependent trait. In other words, when a highly test-anxious individual is in a high-stakes testing situation, they will experience increased state anxiety, relative to someone who is low in test-anxiety. It is possible that the testing environment in the current study was not perceived to be "high-stakes". Some participants may have been high in test-anxiety, but without a suitably strong situational stressor to provoke an anxious inner monologue, their tendency for test-anxiety would not have been an issue and they would have tested on an equal plane with their non-test-anxious peers. A possible modification for future research of this nature relates to the research pool from which these participants were recruited. Future studies might only allow participants from introductory courses, who are typically first or second year students. Participants from more advanced courses are likely to have participated in several previous studies and may have come to expect some amount of manipulation or deception from the experimenter. In the case of the current study, it is possible that more experienced participants were not affected by statements to the effect that their performance on the experimental tasks would predict educational success and career attainment and so on. To the contrary, it appears that such instructions caused state worry levels to decline across the board, and equally between conditions. In the case of those participants in the easy condition, they were told that the tasks did not matter and were therefore not concerned about them at all. In the case of those in the difficult condition, they knew that the experimenter was trying to manipulate their anxiety levels, but saw no relevant reason to them why the following tasks should be a cause for anxiety, and so allowed themselves to be relaxed about the following tasks. Over the course of the experimental session, it appears that state worry levels were rising back to baseline, as time 2 scores were approximately half way between time 1 state scores and trait. By the time the second state measure was taken, the participants had completed three complex tasks. It is likely that the tasks were new to them and slightly confusing, or at the very least, long and cognitively fatiguing. This explains why their state levels at time 2 would be slightly higher than at time 1. Still, cognitively taxing though the tasks were, they were still not personally relevant and so the participants remained relatively casual about them. It is possible that an experimentally-naïve participant may be more strongly influenced by such instructions.

Returning to the work of Coy et al. (2012), the current study appears to have replicated their finding that anxiety has no effect on inhibition task performance. As mentioned above, it is possible that there is genuinely no relationship between anxiety and the inhibition function. In two independent studies using two different anxiety measures and two different inhibition measures, no such effect was found. However, before discounting this relationship, it is more likely that the measures and tasks used to test anxiety's effect on inhibition were not appropriate in either case. The methodological shortcomings of both the current study and that of Coy et al. will have to be addressed and compensated for before the already well-established relationship between anxiety and inhibition can be contested.

With regard to testing the predictions of ACT, no valid conclusions can be drawn from the current study. It was a weakness of ACT which was noted above that so relatively few studies are cited by Eysenck et al. (2007) as support for their predictions of how anxiety would affect the various executive functions. It appears that one possible reason for the citation of so few studies is that there are few studies which report significant findings. Future studies of anxiety in the context of working memory would benefit from rigorously tested and repeatedly demonstrated state anxiety manipulations, as well as the identification of a sensitive and specific anxiety measure. Perhaps self-report measures as a whole should be supplemented with physiological assessments, as used by Sorg and Whitney (1992), and behaviorally-based tasks should be assessed in the context of neurological data.

Since the development of ACT, several studies have examined its predictions from a neurological standpoint. In the past, one common way to operationally define task efficiency has been to assess task RT. This conceptualization was particularly suited to ACT due to the assumption that anxiety would usurp cognitive resources, more would need to be summoned, and this process would take additional time. Studies which report as much have been cited as support for ACT by Eysenck et al. (2007) in their original proposal and have been discussed here as well. However, following the publication of the original ACT paper, researchers have explored ACT's predictions by conceptualizing efficiency in a different way: by comparing the amount of mental effort exerted with the quality of performance observed, assessed with functional magnetic resonance imaging (fMRI) scans or by measuring event-related potentials (ERPs). In other words, inefficient processing would be signified by a large amount of brain activation occurring, only to achieve modest accuracy ratings. The use of resources would therefore be inefficient.

By exploring the predictions of ACT neurologically, rather than simply behaviorally, effects of anxiety may be observed in experimental paradigms in which they may not otherwise be seen. For instance, Righi, Mecacci, and Viggiano (2009) found increased activation in regions known to be associated with the allocation of attentional resources for highly anxious, relative to non-anxious, individuals while performing a task similar to the Go-No-Go task used in the current study, though no behavioral differences were observed. A similar result was observed by Ansari and Derakshan (2011) in anxious participants during an anti-saccade task. The authors suggest that this finding indicates that anxious participants were utilizing greater compensatory strategies than their low-anxious peers. Contrary to these findings, Bishop (2009) found reduced activation in high-anxious participants while performing a competitive visual search task. Bishop (2009) contends that anxiety therefore results in an impoverishment in one's ability to summon cognitive resources, rather than an increase in their access and use. It is this impoverishment which then results in anxious individuals taking longer to complete EF tasks, as they have fewer resources with which to perform them. To address these presumably disparate findings, Berggren and Derakshan (2012) point out that ACT predicts that anxious individuals will indeed summon additional cognitive resources when task demands are relatively moderate, but that in high-demand situations, this process will be impaired. It is possible then that the tasks used by Bishop (2009) were too demanding for highly-anxious participants, resulting in diminished cognitive resources being available.

Regardless of the precise nature of the neural relationship between anxiety and EF task performance, the use of neuroscientific technologies has allowed researchers to explore the tenets of ACT in new ways which will ultimately spur theoretical development. In the case of the current study, and in the context of the more recent work on anxiety and EF tasks, it remains entirely possible that those participants who were anxious did utilize more cognitive resources than their non-anxious peers. The lack of any behavioral results to this effect are still in line with the results of several studies which observed neural evidence of an effect of anxiety with no corresponding behavioral differences (see Eysenck & Derakshan, 2011 for a review). The effects of anxiety on cognitive performance in general and EF performance specifically are well-supported. These effects are also fleeting, and the tools and methods used in the current study to examine them may not have been sufficient. Future research will benefit from a comprehensive approach to further understanding the relationship between anxiety and executive function.

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APPENDIX A: ANXIETY INDUCING/REDUCING INSTRUCTIONS

Anxiety-Inducing Instructions

"As was mentioned earlier, this project involves you performing tests that assess attention, concentration and memory. These tests have been shown to be highly related to intelligence and ability to do college work. They are also related to success in later life such as earned income and occupational attainment. It is likely that you have never seen these tests before so many of them may seem quite difficult. During each test, you will be timed and notes will be taken regarding your performance. It is important that you do well because at the end of the session, we will review the results with you and compare your performance with the performance of other college students. Any questions?"

Anxiety-Reducing Instructions

"As was mentioned earlier, this project involves you performing tests that assess attention, concentration and memory. Before we begin, though, we want to inform you that we are mainly interested in determining if these tests would be appropriate for a future project. Therefore, we are not that concerned about your performance, so do not worry so much about whether you are doing good or bad. Although we are not that concerned about how well you do on these tests, we do want you to try your best. We want to remind you that no one will see the results of your performance. So, just relax and follow the instructions as best you can. Before we begin you may just want to take a couple deep breaths and clear your mind. Any questions?"

APPENDIX B: MEANS, SDS, RANGES AND CORRELATIONS OF EMOTIONALITY IN THE EASY CONDITION

	TAI Trait	TAI State	TAI State 2
Mean	27.04	19.19	12.42
SD	8.14	5.90	4.66
Range	13.00-47.00	9.00-31.00	8.00-25.00
TAI Trait-E			
TAI State-E	0.97**		
TAI State 2-E	0.52**	0.53	
R-Span Total	0.02	0.03	-0.03
SNB Target RT	0.16	0.13	0.09
SNB Lure RT	-0.07	-0.03	0.12
SNB Target Acc	0.04	0.03	0.02
SNB Lure Acc	-0.15	-0.14	0.06
GNG Target Acc	-0.07	-0.01	0.04
GNG Lure Acc	0.15	0.19	0.17
GNG Target RT	0.14	0.17	0.10
GNG False Alarm RT	-0.03	0.00	-0.07
LN No-Switch Acc	-0.07	-0.08	-0.06
LN Switch Acc	0.00	0.01	0.12
LN Switch Cost	-0.01	-0.03	-0.13

APPENDIX C: MEANS, SDS, RANGES AND CORRELATIONS OF EMOTIONALITY IN THE DIFFICULT CONDITION

	TAI Trait	TAI State	TAI State 2
Mean	28.04	18.98	12.16
SD	7.83	5.35	3.71
Range	12.00-48.00	8.00-32.00	8.00-27.00
TAI Trait-E			
TAI State-E	0.98**		
TAI State 2-E	0.54**	0.49**	
R-Span Total	-0.18	-0.17	-0.07
SNB Target RT	-0.26*	-0.29*	0.04
SNB Lure RT	-0.02	-0.02	-0.02
SNB Target Acc	-0.03	-0.05	0.04
SNB Lure Acc	0.02	0.04	-0.08
GNG Target Acc	0.15	0.15	0.19
GNG Lure Acc	0.08	0.05	0.08
GNG Target RT	0.16	0.13	0.14
GNG False Alarm RT	0.09	0.09	0.01
LN No-Switch Acc	-0.01	0.00	0.06
LN Switch Acc	0.00	0.03	0.10
LN Switch Cost	-0.09	-0.12	-0.07

APPENDIX D: MEANS, SDS, RANGES AND CORRELATIONS OF TAI TOTAL SCORE IN THE EASY CONDITION

	TAI Trait	TAI State	TAI State 2
Mean	42.48	29.60	31.76
SD	12.23	10.56	10.79
Range	21.00-78.00	20.00-70.00	20.00-63.00
TAI Trait-T			
TAI State-T	0.64**		
TAI State 2-T	0.58**	0.59**	
R-Span Total	-0.02	-0.05	-0.03
SNB Target RT	0.19	0.19	0.08
SNB Lure RT	-0.05	0.02	0.12
SNB Target Acc	0.08	0.11	0.04
SNB Lure Acc	-0.09	-0.05	0.10
GNG Target Acc	-0.09	0.01	0.04
GNG Lure Acc	0.15	0.10	0.18
GNG Target RT	0.11	0.04	0.08
GNG False Alarm RT	-0.06	-0.07	-0.11
LN No-Switch Acc	-0.06	-0.07	-0.05
LN Switch Acc	0.02	0.01	0.14
LN Switch Cost	0.00	-0.02	-0.10

APPENDIX E: MEANS, SDS, RANGES AND CORRELATIONS OF TAI TOTAL SCORE IN THE DIFFICULT CONDITION

	TAI Trait	TAI State	TAI State 2
Mean	44.55	30.64	31.08
SD	13.02	8.78	8.41
Range	23.00-80.00	20.00-65.00	20.00-66.00
TAI Trait-T			
TAI State-T	0.67**		
TAI State 2-T	0.59**	0.75**	
R-Span Total	-0.15	-0.06	-0.04
SNB Target RT	-0.27*	-0.02	0.03
SNB Lure RT	0.00	-0.14	-0.05
SNB Target Acc	-0.02	0.10	0.08
SNB Lure Acc	0.02	-0.05	-0.08
GNG Target Acc	0.18	0.19	0.14
GNG Lure Acc	0.09	-0.03	0.07
GNG Target RT	0.19	0.07	0.09
GNG False Alarm RT	0.16	0.14	0.05
LN No-Switch Acc	0.00	0.00	0.05
LN Switch Acc	-0.01	0.04	0.04
LN Switch Cost	-0.05	0.02	-0.04

Application for Exemption from Institutional Oversight

LSU
Institutional Review Board
Dr. Robert Mathews, Chair
131 David Boyd Hall
Baton Rouge, LA 70803
P: 225.578.8692
F: 225.578.6792
irb@lsu.edu
lsu.edu/irb

Unless qualified as meeting the specific criteria for exemption from Institutional Review Board (IRB) oversight, ALL LSU research/ projects using living humans as subjects, or samples, or data obtained from humans, directly or indirectly, with or without their consent, must be approved or exempted in advance by the LSU IRB. This Form helps the PI determine if a project may be exempted, and is used to request an exemption.

-- Applicant,Please fill out the application in its entirety and include the completed application as well as parts A-E, listed below, when submitting to the IRB. Once the application is completed, please submit two copies of the completed application to the IRB Office or to a member of the Human Subjects Screening Committee. Members of this committee can be found at http://www.lsu.edu/screeningmembers.shtml

-- A Complete Application Includes All of the Following:

(A) Two copies of this completed form and two copies of part B thru E.
(B) A brief project description (adequate to evaluate risks to subjects and to explain your responses to Parts 1&2)
(C) Copies of all instruments to be used.
*If this proposal is part of a grant proposal, include a copy of the proposal and all recruitment material.
(D) The consent form that you will use in the study (see part 3 for more information.)
(E) Certificate of Completion of Human Subjects Protection Training for all personnel involved in the project, including students who are involved with testing or handling data, unless already on file with the IRB. Training link: (http://phrp.nihtaining.com/users/login.php.)
(F) IRB Security of Data Agreement: (http://www.lsu.edu/irb/IRB%20Security%20of%20Data.pdf)

1) Principal Investigator: Emily Elliott **Rank:** Associate Professor

Dept: Psychology **Ph:** 225-578-7460 **E-mail:** eelliott@lsu.edu

2) Co Investigator(s): please include department, rank, phone and e-mail for each

Joseph W Harris, department of Psychology, Graduate Student, 817-313-1172, jhar146@tigers.lsu.edu

IRB# E5802 LSU Proposal # ______
⊗ Complete Application
⊗ Human Subjects Training

3) Project Title: Examining the combined effects of state and trait anxiety on working memory efficiency

Study Exempted By:
Dr. Robert C. Mathews, Chairman
Institutional Review Board
Louisiana State University
203 B-1 David Boyd Hall
225-578-8692 | www.lsu.edu/irb
Exemption Expires: 12-8-2014

4) Proposal? (yes or no) No **If Yes, LSU Proposal Number** ______

Also, if YES, either ◯ **This application completely matches the scope of work in the grant**
OR ◯ **More IRB Applications will be filed later**

5) Subject pool (e.g. Psychology students) LSU psychology students

*Circle any **"vulnerable populations" to be used:** (children <18; the mentally impaired, pregnant women, the ages, other). Projects with incarcerated persons cannot be exempted.

6) PI Signature Emily Elliott **Date** 12/2/11 (no per signatures)

**** I certify my responses are accurate and complete.** If the project scope or design is later changes, I will resubmit for review. I will obtain written approval from the Authorized Representative of all non-LSU institutions in which the study is conducted. I also understand that it is my responsibility to maintain copies of all consent forms at LSU for three years after completion of the study. If I leave LSU before that time the consent forms should be preserved in the Departmental Office.

Screening Committee Action: Exempted √ Not Exempted ____ Category/Paragraph 2

Reviewer Mathews **Signature** [signature] **Date** 12/9/11

VITA

Joseph Wayland Harris received his bachelor’s degree in Psychology at St. Edward’s University in Austin, Texas in 2008. He then worked at the Neuroscience Institute in Scott and White Memorial Hospital in Temple, Texas for a year prior to earning his Masters in Psychology from Stephen F. Austin State University in 2011. That same year, he entered graduate school in the Department of Psychology at Louisiana State University. He will receive his Master’s Degree in Cognitive Psychology in August of 2013, and plans to begin work on his doctorate following graduation.