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RESEARCH ARTICLE

Differential Effects of Test Anxiety & Stress on the WAIS-IV

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High-stake decisions are based on neuropsychological test data, such as diagnosis of specific learning disabilities and mental retardation. Thus, it is crucial to understand how anxiety and stress affect test scores on the most popular and current IQ measure, Wechsler Adult Intelligence Scale – Fourth Edition (WAIS-IV). Previous studies have shown negative effects of self-reported anxiety on performance on various cognitive tasks; however, these studies either used a single measure of anxiety or tested a limited number of subtests from previous versions of the WAIS. The current study sought to examine the relationship of anxiety (as determined by self-report data), stress (as determined by physiological data), and performance on the WAIS-IV. Participants (n = 25) were administered the WAIS-IV in the study that took approximately two-and-half hours. Four saliva samples approximately evenly spaced out throughout the study were collected to determine the cortisol levels. Participants' mood and anxiety levels were determined via self-reported data on PANAS, TIPI, and an anxiety questionnaire. Results indicated that only the WAIS-IV Perceptual Reasoning Index significantly correlated with self-reported test anxiety (r = -0.40, p < 0.05) and with average cortisol during testing (r = 0.41, p < 0.05). This means that the participants who reported higher test anxiety performed worse than those who reported lower test anxiety, and greater cortisol was associated with better performance on perceptual reasoning tasks. However, no significant correlations were found in regards to processing speed, verbal comprehension, and working memory. The findings demonstrated the need to interpret the WAIS-IV scores in a way to eliminate the confound effects of anxiety and stress on performance.

INTRODUCTION

Differential Effects of Test Anxiety & Stress on the WAIS-IV

Neuropsychological assessments are conducted, in part, to obtain estimates of intelligence, to understand individual differences in thinking style and personality, to detect cognitive impairment, and to aid in diagnosis of specific learning disabilities, attention deficit hyperactivity disorder, and mental retardation. The Wechsler Adult Intelligence Scale – Fourth Edition (WAIS-IV) is one of the most popular measures of Intelligence Quotient (IQ) in the U.S. and is often used in neuropsychological assessments (Wechsler Adult Intelligence Scale 2011). The WAIS-IV is composed of 10 core subtests that assess performance on four cognitive domains, including verbal comprehension, perceptual reasoning, processing speed, and working memory. Each subtest is scored and compared with age-corrected normative data. The combined IQ score, thus, provides a measure of one's competency compared to his or her peers and are predictors of academic achievement.

Given the important clinical, social, and personal implications of IQ test performance, it is important to discover and control for variables other than true cognitive capabilities that might adversely affect performance on neuropsychological assessments. The goal of the current study is to determine how stress and anxiety differentially affect performance on the four indices of the WAIS-IV, Perceptual Reasoning Index (PRI), Verbal Comprehension Index (VCI), Processing Speed Index (PSI), and Working Memory Index (WMI) in university students. This study fills an important gap in the literature because anxiety and stress are measured by self-report and physiological measures, providing a more comprehensive assessment of stress and anxiety than in most previous work, which included only self-report or only physiological measures. Further, the current WAIS-IV was administered for a more comprehensive assessment of cognition, while previous research has been conducted using the earlier editions of the WAIS (Hopko, Hunt, and Armento 2005; Hopko, Crittendon, Grant, and Wilson 2005; Moon and Lair 1970). The WAIS-IV, released in 2008, was standardized recently to a sample population in U.S.; hence, it reflects the current demographics more accurately than the WAIS-III released in 1997. Furthermore, the WAIS–IV subtests are more reliable as compared to the previous version (Wechsler 2008).

The Effects of Anxiety on Cognitive Performance

Adverse effects of anxiety have been reported in the literature on several cognitive domains, namely on working memory (Hopko, Hunt, and Armento 2005), perceptual reasoning (Hopko, Crittendon, Grant, and Wilson 2005), and processing speed (Hopko, Crittendon, Grant, and Wilson 2005; Moon and Lair 1970). Researchers at the University of Tennessee demonstrated that self-reported test anxiety adversely affects performance on WMI subtests. Specifically, anxiety was a significant predictor of the performance on WAIS-III Letter-Number Sequencing and Digit Span Backward subtests (Hopko, Hunt, and Armento 2005).

Other cognitive domains shown to be adversely impacted by anxiety are perceptual organization and processing speed. Using multiple assessments of physiological and self-

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reported stress response, Hopko, Crittendon, Grant, and Wilson (2005) reported significant adverse impact of self-reported anxiety on WAIS-III Performance Intelligence Quotient (PIQ), namely, the combined performance score on the perceptual organization and the processing speed tasks. On the contrary, heart rate was positively correlated with PIQ, suggesting that physiological arousal may benefit performance (Hopko, Crittendon, Grant, and Wilson 2005). Moon and Lair (1970) focused specifically on a measure of processing speed and demonstrated that participants experiencing higher levels of stress, induced by viewing of a disturbing film, performed significantly worse on Digit Symbol (now called Coding) than the participants in the control condition. More recently, Österberg et al. (2009) found that a group of participants with long-term work stress performed significantly worse on the WAIS-R Digit Symbol subtest than the control group. Therefore, even though the literature on the effects of anxiety and stress on cognitive performance is limited, adverse impact of anxiety on working memory, perceptual organization, and processing speed has been demonstrated in empirical research.

Many clinical psychologists and researchers have tried to understand why self-reported anxiety would adversely impact PRI, WMI, and PSI. One explanation is that along with requiring perceptual reasoning and organization, these processes tend to involve complex, sometimes abstract, thinking. Anxiety interferes greatly with such intellectually demanding tasks, making it harder to find answers to complicated questions. Conversely, anxiety may not affect the WAIS verbal comprehension subtests such as vocabulary because Verbal Comprehension (VC) measures "verbal ability, comprehension, knowledge, and crystallized intelligence" (Keith et al. 2006). Thus, retrieval of a basic theory or concept can be considered easy. The simple nature of retrieval of this kind of information may explain why anxiety does not have a profound effect on performance on these tasks. Sandstrom et al. 2011 also reported that deficits in speed and performance on novel non-verbal tests due to anxiety can be explained by the abstract nature of these tasks that require theoretical thinking.

The majority of research before Hopko, Crittendon, Grant, and Wilson (2005) exploring the relationship between stress, anxiety, and cognitive performance has been limited in methodology and assessment. Previous research has been conducted using a limited set of subtests from the previous editions of the WAIS. Furthermore, anxiety and stress were typically assessed by either self-report or physiological measures. The available data suggest that self-reported anxiety is likely to adversely impact performance on WMI and PIQ (Hopko, Hunt, and Armento 2005), whereas moderate physiological arousal may enhance PIQ (Hopko, Crittendon, Grant, and Wilson 2005).

Cortisol and Cognitive Performance

Increased levels of cortisol, a glucocorticoid, are observed in response to stress and are known to impair memory performance in healthy adults (Terfehr et al. 2011). Glucocorticoid receptors are expressed in "virtually **every** organ and **tissue** in the **body,"** (Benson et al. 2010) and thus, cortisol released in response to stress may impact performance in other areas of cognition as well. According to the "inverted-U shape" model of cortisol, cortisol levels that are too low or too high might adversely impact cognitive performance, whereas moderate levels may accentuate performance (Souza-Talarico et al. 2010). Nonetheless, the empirical data on the effects of physiological arousal, as determined by cortisol levels, on cognitive performance is limited.

The Current Study

The current study sought to determine how self-reported anxiety and an indicator of physiological stress differentially affect performance on the four indices of the WAIS-IV. It was predicted that self-reported anxiety would adversely impact performance on PSI, WMI and PRI, whereas, stress, as determined by cortisol levels, would enhance performance on PRI.

MATERIALS AND METHODS

Participants

Participants were 25 undergraduate students enrolled at the University of Massachusetts, Amherst. The mean age of the participants was 19.5 years (*SD* = 1.26, range = 18-22 years; Table 1). Twenty-percent of participants (*n* = 5) stated that they have been diagnosed with a Learning Disability and 28% (*n* = 7) stated a previous diagnosis of attention deficit hyperactivity disorder (ADHD). Inclusion criteria were being native English speakers and completing the UMass SONA system prescreen, which consisted of questions pertaining to the eligibility criteria of the active studies. Participants completed the study in exchange for extra credit in a psychology course.

Characteristics	Number of Participants (%)
Gender	
Female	18(72)
Male	7 (28)
Ethnicity	
Caucasian	3(12)
African American	2(8)
Asian American	2(8)
Other	2(8)
Physical Health	
Excellent	11(44)
Good	10 (40)
Fair	4(16)

Table 1 provides information on the characteristics of the participants, such as gender, ethnicity, physical, and mental health. The majority of participants were females, Caucasians, and in Excellent to Good physical and mental health.

Measures

WAIS-IV

The WAIS-IV is composed of 10 core subtests, which comprise four index scores, VCI, PRI, WMI, and PSI; a Full Scale IQ (FSIQ) is calculated from all 10 subtests. Reliability and validity of the WAIS-IV were reported by Canivez in his detailed review in 2010. Internal consistencies range between .97-.98 for the FSIQ, between .87-.98 for the four index scores, and between .73-.96 for the subtests. The test-retest stability coefficients were highest for the FSIQ (.94-.96) and VCI (.94-.95), followed by WMI (.82-.90), PRI (.80-.88), and PSI (.76-.89), and lowest for the subtests (.51-.93) (Sattler and Ryan, 2009, p. 38). Interscorer agreement was .98-.99 for standardized subtests and ranged from .91-.97 for the subtests where examiner judgment is involved. Validity analysis showed that subtests within an index category were more highly correlated with each other than with subtests from a different index category. The FSIQ is highly correlated with academic achievement measures. These validity and reliability details were reported by Canivez 2010.

Self-report Measures of Anxiety

The Positive and Negative Affect Schedule (PANAS) is used to assess emotional state and affect (Leue and Beauducel 2011). Participants are asked to indicate the extent to which they are feeling 20 various emotions at the moment on a 5-point scale that ranges from very slightly (1) to extremely (5). Positive affect is considered a measure of positive mood, such as alertness, enthusiasm, energy, and joy, whereas negative affect suggests negative mood, such as nervousness, sadness, irritation, guilt, or contempt (Watson and Clark 1997). The PANAS is considered moderately reliable. The Cronbach alpha coefficient is .86-.90 for the Positive Affect Scale and .84-.87 for the Negative Affect Scale. The test-retest correlations are .47-.68 for the PAS and .39-.71 for the NAS (Clark and Watson).

The Ten Item Personality Inventory (TIPI) consists of 10 pairs of traits, two belonging to each of the five subscales of openness, conscientiousness, extraversion, agreeableness, and emotional stability. Participants rate the extent to which the pair applies to them in general with 1 = Disagree Strongly and 7 = Agree Strongly (Denissen et al. 2008). Test-retest reliability of TIPI ranges from .62-.77 for the five subscales (Gosling et al. 2003). TIPI helps to determine important personality differences between participants. It was important to determine whether participants who are generally more anxious (neurotic) performed worse on any of the indices. Each of the five factors was correlated with the four WAIS indices using the SPSS software. Emotional stability was of the most interest in this study because a low score on emotional stability indicates neuroticism and anxiousness.

A general Stress Questionnaire was created for this study. It consisted of five questions, three of which were coded numerically and two were open-ended. Self-report measures of general anxiety-proneness and specific anxiety during the study were obtained using the questionnaire. For the purpose of the study, only the numerically-scored questions were used. The open-ended questions would require a detailed system of valid and reliable scoring system, which was difficult to create with such a small sample. SPSS software was used to run correlations between the anxiety scores and the four indices of the WAIS

Cortisol

Four saliva samples, approximately evenly spaced out throughout the study, were collected in sampling tubes with polyester swabs. The participants were instructed to keep the swab in the mouth for two minutes. The goal was to measure cortisol about every half hour to obtain an ongoing assessment of the physiological stress response. The first sample provided a baseline cortisol level, whereas the data from the latter three samples provided information on stress and changes in stress over the testing session. Right after the study ended, samples were stored in a freezer, which was kept at -20 degrees Fahrenheit. The samples were shipped to Salimetrics, Inc., Station College, PA to assay for cortisol approximately six months after the data from the 25 participants were collected.

Procedure

The current study is part of a larger study, which is designed to evaluate associations between IQ and reading skills. Eligible participants were contacted via email with an invitation to participate in the study.

Participants were greeted by a trained research assistant. The research assistant briefly explained the study before obtaining written informed consent. Participants subsequently completed the first PANAS and provided the first saliva sample. Next, participants completed a demographic questionnaire and the TIPI. The research assistant administered the WAIS subtests according to standardized administration procedures. Some of these subtests are paper-and-pencil tests, some are verbal, while others involve motor ability. Five subtests including Block Design, Similarities, Digit Span, Matrix Reasoning, and Vocabulary were administered. At the end of the Vocabulary subtest, participants completed the second PANAS and provided the second saliva sample. WAIS-IV testing was resumed with five more subtests including Arithmetic, Symbol Search, Visual Puzzles, Information, and Coding. This marked the end of the WAIS-IV battery, which was followed by the third PANAS and saliva sample. At no point during the experiment were participants directly informed that their intelligence was being assessed. The participants were, then, administered the four subtests of Woodcock-Johnson III Tests of Cognitive Abilities for another part of the project. The next step was to complete two forms of the Nelson Denny Reading Test, again for the larger study. Participants, then, completed the fourth PANAS and provided the fourth saliva sample. Finally, participants completed the Stress Questionnaire. Before ending the experiment, the research assistant debriefed the participants and gave them an opportunity to ask questions.

Data Management

Average cortisol during the WAIS-IV administration (henceforth referred to as average WAIS-IV cortisol during testing) *was calculated (e.g., samples two, three, and four). Prior to aggregation, the cortisol* data were transformed using the logarithm function to normalize the data. The first sample was used for comparison to estimate change in cortisol levels.

Positive and Negative Affect scores were calculated for the four instances that the PANAS was administered. The four scores for the Positive Affect and Negative Affect were then averaged to obtain the Average Positive Affect and the Average Negative Affect, respectively.

RESULTS

It was hypothesized that self-reported anxiety would adversely impact performance on PRI, WMI, and PSI subtests significantly more than VCI subtests. Self-reported test anxiety was indeed negatively correlated with performance on PRI (r = -.40, p = 0.05); however, there were no significant correlations of WMI or PSI with anxiety (Table 2). The result supports the prediction on the PRI that greater anxiety, specifically test anxiety, is associated with poorer performance on the PRI.

Cortisol was expected to enhance performance on the PRI. Consistent with the predictions, results indicated that the PRI was significantly and positively correlated with average WAIS-IV cortisol during testing (r = 0.41, p = 0.04); however, the VCI, WMI, and PSI were not significantly correlated with average cortisol during testing (Table 2). Thus, greater cortisol was associated with better performance on perceptual reasoning tasks only.

Self-reported general anxiety indicated by the Emotional Stability score on the TIPI (Table 3) and the PANAS (Table 4) did not significantly correlate with any of the indices of the WAIS-IV.

WAIS-IV Indices	General Test Anxiety r (p)	Average Cortisol During Testing r (p)
VCI	-27(.19)	.04(.87)
PRI	-.40(.05)*	.41(.04)*
WMI	-.28(.17)	.02(.92)
PSI	.11(.61)	.12(.58)
FSIQ	-.29(.16)	.17(.41)

Table 2 illustrates Pearson correlation coefficients (r) and p-values (p) for both the Test Anxiety (general anxiety in testing situations) and Average Cortisol during the testing period with the WAIS-IV: Verbal Comprehension Index (VCI), Perceptual Reasoning Index (PRI), Working Memory Index (WMI), Processing Speed Index (PSI), and Full Scale Intelligence Quotient (FSIQ). The only significant correlations involved the PRI, which negatively correlated with self-reported test anxiety and positively with average cortisol during testing. This means that the participants who reported higher test anxiety performed worse than those who reported lower test anxiety, and greater cortisol was associated with better performance on perceptual reasoning tasks.

DISCUSSION

Consistent with previous research by Hopko, Crittendon, Grant, and Wilson 2005, self-reported test anxiety correlated negatively with performance on PRI, whereas physiological stress correlated positively with the PRI performance. These findings indicate that physiological activation facilitates performance on perceptual reasoning tasks, which is supported by previous findings (Hopko, Crittendon, Grant, and Wilson 2005). However, participants who tended to be highly anxious in test-taking situations performed worse on the PRI than low-anxious participants. This implies that even though physiological stress can improve performance on the PRI, the WAIS-IV scores on the PRI may be biased against highly anxious people. Conversely, WMI, PSI, and VMI were not adversely impacted by anxiety or stress; the lack of findings regarding the WMI and PSI were surprising and somewhat in contrast to previous findings (Hopko, Hunt, and Armento 2005; Österberg et al. 2009). More importantly, anxiety in general may not be a critical factor. Instead, anxiety in testing situations in specific appears to be an important variable affecting performance on perceptual reasoning subtests.

Cortisol and Cognitive Testing

Cortisol was predicted to enhance performance on perceptual reasoning tasks, and indeed, the effect was found. The effects of physiological stress on cognitive performance can be illustrated by the "inverted-U shape" model for cortisol (Souza-Talarico et al. 2010). According to this model, low and high levels of cortisol can negatively impact performance, whereas moderate levels may improve performance. It is possible that the situational stress induced during the current study was not high enough to have a negative impact on PRI. Instead, the levels of cortisol released in response to the testing situation may have been moderate, and thus, there was a positive effect on performance. Participants completed the study in exchange for extra credit for one of their psychology courses, and participants knew that the number of extra credit points awarded is solely based on the time they would spend in the lab, regardless of their performance. Thus, participation was a low-stakes experience. However, in reality, people are administered neuropsychological assessment for high-stake decisions, e.g., to diagnose learning disabilities etc. In such real situations, people are more likely to be personally invested in their testing scores, and some might experience high and potentially impairing levels of anxiety; future research is needed to address this issue.

Another important factor to consider while interpreting the cortisol data is the time of testing. The circadian rhythm of cortisol entails highest levels of cortisol in the morning after waking up. Cortisol then continually declines throughout the day till it hits the lowest level at night. This factor was not controlled in the study. Twenty participants were tested in the morning and afternoon and five were tested in the evening. Therefore, comparison of the cortisol results between participants in response to testing is complicated by this factor.

Self-reported Anxiety and Cognitive Performance

As expected, self-report test anxiety was negatively associated with PRI scores. Although the participants that reported general high levels of anxiety in testing situations performed significantly worse on the PRI subtests, the results must be interpreted with caution because correlation does not imply causation. Even though self-reported anxiety was negatively correlated with the PRI, this finding does not indicate whether anxiety causes the deficit in performance or the deficit in performance reflects on an actual lack of skills, which may cause high levels of anxiety. Nevertheless, test anxiety has been shown to have a substantial negative impact on the composite PIQ score, and more specifically on the block design and picture arrangement sub-tests, as reported by Hopko, Crittendon, Grant, and Wilson 2005. The authors inferred that the block design and picture arrangement subtests may require "complex perceptual-organizational processes" that may be more sensitive to anxiety than the skills required for matrix reasoning, digit-symbol coding, and symbol search. The timed nature of two of the three core PRI subtests (Block Design and Visual Puzzles) may also explain the deficit in performance because none of the subtests of VCI are timed. This kind of timed structure of tests has been reported to negatively impact performance (Tsui, J. and M. Mazzocco 2007). Interestingly, one WMI subtest (Arithmetic) and both PS subtests (Symbol Search and Coding) are also timed, but such a deficit in performance was not observed in either domain. The lack of deficit in performance on the timed subtests in other cognitive domains implies that the structure and the nature of the skills and resources required by the perceptual reasoning tasks are more sensitive to physiological arousal.

WAIS-IV Indices	Extraversion r (p)	Agreeablenes s r (p)	Conscientiousness r (p)	Emotional Stability r (p)	Openness r (p)
VCI	-.49 (.01)*	-.33(.11)	-.24(.26)	-.08(.71)	-.15(.47)
PRI	-.08(.69)	-.41(04)*	-.20(.33)	.13(.55)	-.03(.88)
WMI	-.23(.27)	-.48(.02)*	-.02(.91)	.16(.44)	-.17(.41)
PSI	-.17(.42)	-.45(.02)*	.52(01)*	-.07(.73)	-.40(.05)
FSIQ	-.26(.20)	-.54(.01)*	-.04(.86)	.07(.76)	-.25(.23)

Table 3. demonstrates Pearson correlation coefficients (*r*) and p-values (*p*) for each of the five personality characteristics of the Ten-Item Personality Inventory with the WAIS-IV: Verbal Comprehension Index (VCI), Perceptual Reasoning Index (PRI), Working Memory Index (WMI), Processing Speed Index (PSI), and Full Scale Intelligence Quotient (FSIQ). Even though there were significant correlations with some traits, there were none with emotional stability, which is most closely related to stress and anxiety.* Significant correlations

The Importance of the Current Study

Even though previous studies reported significant impact of anxiety on various aspects of neuropsychological assessment, the literature is limited because the effects of anxiety and stress were assessed on the previous editions of the WAIS. The current study substantively progressed the empirical research in this field because it is the first study to examine the effects of anxiety and stress on the WAIS-IV. Previous studies have shown effects of anxiety on one or a very limited set of subtests of previous editions of the WAIS. This is the first study to explore the impact of anxiety on the entire WAIS-IV battery. Additionally, it is one of the very few studies that incorporated a two-dimensional assessment method of anxiety and stress (i.e., self-report and physiological measures). Even though a larger sample size is needed to properly understand the impact of anxiety on performance, the results of the current study show significant relationships even with a very small sample. The implication is that the WAIS-IV scores should be interpreted in a way to eliminate the confound effects of anxiety and stress on performance. More research is needed to possibly introduce a systematic method or models to determine and control for the impact of anxiety and stress. It may also be important to develop techniques and programs that could help alleviate the anxiety symptoms in highly anxious people during neuropsychological assessments.

Limitations & Future Directions

The study was limited by a small sample size. The sample also consisted of college students, and the age range was very narrow, which limits generalizability to other populations. Additionally, the only physiological measurement in this study was the cortisol data from the saliva samples. For a better understanding of the effects of arousal on neuropsychological assessments, physiological data like heart rate and blood pressure should be included. Furthermore, the Stress Questionnaire was created for the purpose of this study, and it is possible that the wording may not be completely valid. To increase the validity and reliability of the results, future studies should use clinically-reliable anxiety scales.

WAIS-IV Indices	Average Positive Affect r (p)	Average Negative Affect r (p)
VCI	-.23(28)	-.28(.18)
PRI	.32(.12)	-.22(.30)
WMI	.25(.23)	-.22(.30)
PSI	.16(.43)	-.14(.50)
FSIQ	-.13(.55)	.25(.24)

Table 4 displays Pearson correlation coefficients (*r*) and p-values (*p*) for both the Average Positive Affect and the Average Negative Affect of the *Positive and Negative Affect Schedule* with the WAIS-IV: Verbal Comprehension Index (VCI), Perceptual Reasoning Index (PRI), Working Memory Index (WMI), Processing Speed Index (PSI), and Full Scale Intelligence Quotient (FSIQ). There were no significant correlations with Positive or Negative Affect.

* Significant correlations

Conclusions

Moderate levels of physiological stress may facilitate performance on the PRI, whereas high self-reported test anxiety is associated with lower performance on the PRI. It is, however, important to replicate these findings with a larger and more diverse sample. High-stake decisions are based on neuropsychological test data, such as diagnosis of specific learning disabilities and mental retardation. Considering the clinical, psychological, legal, educational, and personal implications, neuropsychological test data should be interpreted with caution and should accommodate the effects of anxiety and stress on performance. The goal of continuing research in this field is to obtain better understanding of the effects of anxiety and stress on neuropsychological assessment to improve the reliability and validity of the data that are collected.

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