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The Iowa Gambling Task: A Study of Convergent and Divergent Validity and Performance in Traumatic Brain Injury and Psychological Distress

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THE IOWA GAMBLING TASK: A STUDY OF CONVERGENT AND DIVERGENT VALIDITY AND PERFORMANCE IN TRAUMATIC BRAIN INJURY AND PSYCHOLOGICAL DISTRESS

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Title: The Iowa Gambling Task: A Study of Convergent and Divergent Validity and Performance in Traumatic Brain Injury and Psychological Distress

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The Iowa Gambling Task (IGT) has been used as a measure of decision-making among many clinical populations. However, not much is known about IGT performance in individuals with traumatic brain injury (TBI) and diagnoses of psychological distress. Additionally, evidence on convergent and divergent validity with other measures is lacking in the literature. Archival neuropsychological evaluation data from 74 outpatients at an academic medical hospital were collected. This study investigated convergent validity of the IGT to other executive functioning tasks in those with TBI. Data was analyzed through the use of a regression analysis. Results demonstrated that measures of executive functioning did not significantly predict scores on blocks 1 and 2 of the IGT (R^2 =.29, F (5, 27)= 2.17, p= .087). Contrary to what was hypothesized, scores on measures of executive functioning did not predict the scores on blocks 3, 4, and 5 of the IGT (R^2 = .18, F (5, 27)= 1.17 p= .350). Second, this study compared performance on the IGT in those with a diagnosis of psychological distress who also have a TBI to those with no history of TBI but have a diagnosis of psychological distress. This was accomplished through the use of a t-test. There was no significant difference in performance between the groups on the IGT NET score t(72)= -2.10, p= .323. Third, this study examined convergent and divergent validity of the IGT NET across all subjects by calculating Pearson correlations on the IGT NET score with scores on measures of delayed memory, visual perception, and executive functioning. The IGT NET score significantly correlated with the score on the COWAT ($r=.25$, $N=74$, $p=.034$), Trails B ($r=.36$, $N= 74$, $p= .001$), categories completed on the Wisconsin Card Sorting Test ($r=.27$, $N= 74$, $p= .022$), and Judgment of Line Orientation Test ($r =.28$, $N=67$, $p=.021$). The IGT Net score did not show significant correlations with Verbal Paired Associates II ($r=.19$, $N=73$, $p=.103$) or the score from Logical Memory II ($r=.18$, $N=74$, $p=.120$). Exploratory analyses for each hypothesis were also run. Explanation of the data, interpretation of the findings, limitations, and directions for future studies are discussed.

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CHAPTER I

LITERATURE REVIEW

Introduction

Examination of executive functioning is an integral component of a complete neuropsychological assessment. There have been many different tasks developed in order to assess executive functioning including: The Wisconsin Card Sorting Test, The Stroop Test, and the Controlled Oral Word Association Test (Rabin, Burton, & Barr, 2005). The Iowa Gambling Task (IGT) developed by Bechara, Damasio, Tranel & Anderson in 1994 as a research tool at the University of Iowa, has recently been employed by neuropsychologists for use in the clinical setting. This task purports to measure the decision-making aspect of executive functioning by mimicking a real world situation involving risk, reward, and punishment for the examinee.

The literature on the IGT is diverse, as it has been employed with numerous clinical populations. One issue still to be clarified is whether the task measures executive function across different diagnostic groups including depression, anxiety, and traumatic brain injury (TBI). To further examine this issue, this paper will first review the nature of the prefrontal cortex, problems with assessment of executive function, separation in the literature of “hot” versus “cold” aspects of EF as well as different theories of EF. It will also explain the theoretical basis of the IGT and review existing evidence for its validity in lesion studies and neuroimaging studies. It will then examine the literature on convergent and divergent validity with the IGT with other measures and briefly touch upon IGT performance in clinical populations where decision-making deficits would be expected. Finally, the limited research examining the IGT in people diagnosed with depression and with TBI will be discussed in greater depth, leading to the conclusion that it is important to study convergent and divergent validity of the IGT with other tasks in these populations.

The Prefrontal Cortex and Executive Function

Executive functions (EFs) control some of the most complex cognitive aspects of human behavior. The prefrontal cortex (PFC) is the most anterior part of the frontal lobes and it has been associated with carrying out executive functions (Fuster, 2008). The two main parts that comprise the PFC are the dorsolateral prefrontal cortex (DLPFC) and the orbitomedial prefrontal cortex (omPFC). The DLPFC is most associated with executive functions that include working memory, judgment, planning, sequencing of activity, abstract reasoning and dividing attention (Swenson, 2006). The omPFC is implicated in impulse control, personality, reactivity to a person's surroundings and mood (Swenson, 2006). Therefore, damage to the prefrontal cortex can alter both cognitive as well as affective and emotional aspects of personality (Fuster, 2008). The case of railroad worker Phineas Gage is one of the earliest and most prominent examples of the effect of frontal lobe damage on an individual. After a tamping iron penetrated through his left orbit, Gage's personality underwent a complete transformation. Compared to before the accident, Gage became profane, had difficulty with planning and inhibition, was unable to hold a job and was uncontrollably impulsive (Fuster, 2008).

Even though executive functioning has become a topic of great importance in neuropsychology and is mentioned abundantly in the literature, there is little consensus on a precise definition (Salthouse, 2005). However, it is widely accepted that executive function provides control, planning, and direction to our behavior and includes different components such as organizing, inhibiting, impulsivity, working memory and set shifting. More recently, different aspects that fall under the purview of executive functioning have begun to be conceptualized as "hot" and "cold". "Cold" executive functioning is mechanistic and logically based in nature and does not include much emotional arousal. Alternatively, "hot" executive functions are tapped by affectively laden tasks that include use of reward and punishment. Despite this dichotomy of "hot" and "cold" in the literature, an important consideration in assessing EF is whether tasks that tap "cold" EF are really devoid of emotion. First, it is important to discuss difficulties surrounding the assessment of executive function. After discussing these difficulties, this paper will review of some of the different models of executive functioning that relate to the "cold" and "hot" aspects of executive functioning.

Assessment of Executive Function

Executive Functions (EF), which are subserved by the prefrontal cortex, include the ability to organize a sequence of actions towards a goal (Fuster, 2008). There are certain difficulties that go along with assessing EFs, which are inherent in both the current assessments used and the diverse nature of EF itself. Common tests of executive functioning frequently employed by clinical neuropsychologists include: the Wisconsin Card Sorting Test, Rey-Osterrieth Complex Figure Test, Halstead Category Test, Trail Making Test, Controlled Oral Word Association Test, Block Design and Similarities tests from the Wechsler Adult Intelligence Scale, Stroop Test, Picture Arrangement, Porteus Maze Test, Tactual Performance Test, Booklet Category Test, Ruff Figural Fluency Test, and Tower of London Test (Rabin et al., 2005). All of these measures have a specific set of instructions and required materials, making the assessment environment for frontal lobe functioning highly structured. The examiner relays explicit directions of what to do for each task to the examinee. This poses a significant problem for measuring EF, because the frontal lobes are most evoked in situations that are unstructured where an individual can create structure for themselves (Lezak, Howieson, & Loring, 2004). The structure of assessment makes it difficult for deficits to show with any aspect of executive functioning. Aspects of executive functioning entail setting a goal and initiating behavior, identifying the steps that need to occur to carry out that behavior, translating that plan into behavior and being able to monitor, adjust, and evaluate success of a behavior. Therefore, one of the most problematic aspects of assessment of executive functioning is that the current testing environment and assessments used may not elicit actual deficits in executive functioning abilities (Lezak et al., 2004). As a result of these difficulties, careful observation of the patient during tests of executive functioning may provide the examiner with more information than actual scores obtained through assessment.

Another challenge in assessing executive functioning is the consideration of all the component parts that make up this set of abilities. Executive functioning is multifaceted and poor performance on measures of executive functioning may be due to a number of factors. This is primarily the case because executive function is sensitive to damage in other parts of the brain (Lezak, Howieson, Bigler, & Tranel 2012). The PFC is highly interconnected with other brain regions, which also makes proper assessment even more difficult. For example, the medial and orbital regions of the PFC are regions implicated in emotional and social behavior and are tied to limbic structures including the hypothalamus, anterior thalamus, and amygdala (Fuster, 2008). As a result of this interconnectivity, damage to these subcortical areas could mimic effects of damage to executive function. Furthermore, because executive functioning is an umbrella term for a wide range of functions, performance on one measure of executive functioning has little predictive value for how that person will perform on other measures (Chan, Shum, Toulopoulou, & Chen, 2008). Accordingly, ecological validity becomes an issue with the assessment of executive function as current measures provide limited insight into how a person will navigate their real-world environment (Chan et al., 2008). Self and informant report measures such as the Frontal Systems Behavior Scale (FrSBe) and Behavior Rating Inventory of Executive Function (BRIEF) have also been developed as more ecologically valid ways to capture deficits in executive function that are not gleaned through objective testing. These real-world measures assess how deficits in EF are affecting a patient in their daily life.

"Cold" Executive Functioning

The literature has started to discuss EF as having "cold" and "hot" aspects. "Cold" EFs are described as purely cognitive because they do not include emotional arousal and are logically based (Chan et al., 2008). Cold EFs have been associated with the DLPFC. Abilities of "cold" EFs include strategic planning, organization, goal setting, behavior monitoring, problem solving, inhibition, working memory, and cognitive flexibility (Chan et al., 2008). Models of EF have traditionally been concerned with the cold aspects of EF. These models have become the basis upon which our assessment measures of EF have been developed.

Alexander Luria (1966), the famous Russian neuropsychologist, wrote extensively about what can now be conceptualized as "cold" executive functions. Luria believed that the human mind was made up of three functional units that work together. According to his model, the first unit, which was located in the brainstem, is responsible for regulating and maintaining arousal of the cortex (Chan et al., 2008). The second unit, which he believed was located in the temporal, occipital, and parietal lobes encodes, processes, and stores information. Luria purported that the third unit housed the frontal lobes. According to Luria, the third unit is responsible for programming, regulating, and verifying human behavior. The prefrontal cortex, within the frontal lobes, is the structure responsible for regulating, controlling and verifying mental activity and behavior (Chan et al., 2008). Through patient observation, Luria theorized that damage to the prefrontal cortex would disrupt complex behavioral programs and a person's ability to verify or regulate the outcomes of their own behavior. Damage to this area can also lead a person to replacing a complex behavior with more basic or stereotypical behavior that is illogical, irrelevant, or inappropriate to achieving a specified goal (Chan et al., 2008). An example of one of the motor tasks developed from his model of executive functioning is the "go-no-go" task. Directions given to the examinee in this task are to squeeze the examiner's hand when they say the word "red" and do nothing when they hear the word "green". This task allows the examiner to determine if the patient is able to respond to one cue and withhold or inhibit a response to another cue, an aspect of executive functioning that can be considered "cold" in nature.

Norman and Shallice's Supervisory Attentional System (SAS) model (1986) is an extension of Luria's work and provides another example of "cold" EFs. This model discusses the control and allocation of attention by executive functions and use of schemas. Schemas can be thought of as scripts that specify how a person should behave in a certain situation. According to this model, there are two hierarchical systems that manage and control the use of schemas. They include 1) contention scheduling and 2) supervisory attention.

The contention scheduling system, which is lower in the hierarchy of attention, regulates schema using routine, automatic, and familiar behaviors or tasks and allows us to prioritize the order of how these behaviors are carried out (Fuster, 2008). These routine behaviors are carried out without ever coming to the attention of the SAS (Fuster, 2008). The SAS is responsible for regulating tasks that are novel to an individual and adjusts to solve problems that already existing schema cannot solve. According to this model, using routine behavior would not be advantageous in situations that 1) involve planning or decision making, 2) involve error correction or troubleshooting, 3) where responses are not well-learned or contain novel sequences of actions, 4) where danger is anticipated, and 5) which require the overcoming of a strong habitual response or resisting temptation (Chan et al., 2008, p. 203). An example of an assessment that was created from this framework of executive function is Conners' Continuous Performance Test. In this computerized test of sustained attention, the examinee is presented with letters that continuously change on a screen. They are instructed to press a button for every letter that they see except for when the letter "x" flashes.

Lezak et al. (2004) presents a behavioral conceptualization of executive functioning that has four different components: 1) volition, 2) planning, 3) purposive action and 4) effective performance. In her model of "cold" EF, volition refers to the intentional behavior of a person. This intentional behavior includes judging a situation, generating different solutions and ideas to that situation, choosing which of these ideas is most suitable, and abstracting from the situation what is important. It also includes motivation to carry out intentional behavior. The planning aspect of executive functioning relates to generating strategies and identifying steps needed to carry out intentional behavior. Planning relies heavily on working memory and also includes being able to anticipate consequences of behavior. The translation of an intention or plan into actual behavior describes the purposive action component of executive functioning (Lezak et al., 2004). Doing so requires a person to "initiate, maintain, switch, and stop sequences of complex behavior in an orderly and integrated manner" (Lezak et al., 2004, p. 621). The effective performance facet of executive functioning requires a person to monitor, adjust, and evaluate the success of their intentional behavior in the problem-solving situation. People with impairment in executive functioning usually display a combination of these deficits, which vary according to the individual.

In summary, “cold” EFs have been conceptualized as mechanistic and logically based processes unaffected by emotion. “Hot” EFs on the other hand, are tied to affect and are often seen in situations that evoke emotion.

“Hot” Executive Functions

Hot EFs have been conceptualized as the influence of empathy, theory of mind, emotional regulation, and affective decision-making on a person’s ability to organize, structure, and execute behavior (DeLuca & Leventer, 2008; Happaney, Zelazo, & Stuss, 2004). An example of this is the experience of reward and punishment or regulation of one’s own social behavior (Chan et al., 2008). Some authors also view “hot” EFs as “emotional/motivational EFs” (Ardila, 2008). Overall, Hot EFs stress the importance of emotional regulation.

Hot executive functions have been associated with the ventromedial and orbitofrontal regions of the prefrontal cortex. The orbitofrontal cortex is complex and receives direct input from the dorsolateral thalamus, temporal cortex, ventral tegmental area, olfactory system, and amygdala as well as reciprocal connections with other regions of the PFC (Rolls 1999 as cited in Clark & Manes, 2004). The orbitofrontal cortex is also linked to the limbic system and thus tied to emotion. These areas of the brain work together to coordinate emotion and cognition and to control personal impulses (Ardila, 2008). Traditionally, problem solving was conceptualized to entail “cold EFs”, however, everyday problem solving almost always includes an emotional component (i.e. talking with a coworker and deciding how to spend money). Therefore, it is important to take into account how “hot EFs” work in conjunction with “cold EF” processes in everyday problem solving.

“Hot” EF has become an increasingly popular topic of study in developmental research as a way to understand development of orbitofrontal cortex (OFC) function across the lifespan.

For example, OFC functioning has been examined with 3 and 4 year olds through use of the Children's Gambling Task, a simplified version of the IGT (Kerr & Zelazo, 2001). In addition, Brock, Rimm-Kaufman, Nathanson and Grimm (2009), stress the difficulty that children have in the classroom setting when they encounter emotionally charged situations where they require use of Hot EFs. Examples of this include waiting for their own turn in line, inhibiting impulses to play with others, and complying with the overall behavioral demands of the classroom. As described by these authors, Hot EF skills include the ability to delay gratification and down-regulate emotional responses which children require in order to engage in problem solving situations and to focus on the coursework and be successful in the academic environment.

Somatic Marker Hypothesis and its Integration of "Hot" and "Cold" EF

Until fairly recently, there have not been models that consider the influence of "hot" executive functions. However, Antonio Damasio's somatic marker hypothesis is a relatively new model of executive functioning that examines this hot or affectively laden aspect of executive functioning.

Damasio created this model after years of studying patients with damage to the ventromedial (VMPFC) and medial orbitofrontal (omPFC) areas of the prefrontal cortex. He realized that even though patients with damage to the VMPFC and omPFC regions had intact intellectual, language, learning, retention, working memory and attention abilities, they were having profound difficulties in their day to day lives (Damasio, 1995). Damasio and his colleagues noticed that they had difficulty in planning their work day, planning their future, and choosing suitable friends or partners (Damasio, 1995). He also noticed that their decision-making abilities, which were altered when compared to their premorbid decision-making skills, would often lead to financial and social loss. Even though these patients were struggling in their daily lives, they would not show impairment on traditional tests of neuropsychological functioning. Damasio and his colleagues realized that even though patients with damage to the VMPFC area of the brain were intact on neuropsychological measures, they did have a compromised ability to express emotion and experience feelings in situations that warranted emotion; these abilities would have presumably been present pre-injury (Damasio, 1995). It appeared to Damasio that poor judgment and decision-making skills could be explained by an inability to use emotion-based learning, which provides an individual with information about the outcome of a decision and their possible emotional outcomes (Turnbull, Evans, Bunce, Carzolio, & O'Connor, 2004).

In an attempt to account for and understand decision-making deficits in otherwise intact individuals with VMPFC damage, Damasio created the somatic marker hypothesis (SMH). The SMH integrates the "cold" and "hot" aspects of EF and describes their influence on one another in decision-making. Regardless of the separation between "cold" and "hot" EFs in the literature, both are very interconnected and are used in combination in daily functioning (DeLuca & Leventer, 2008). The SMH recognizes and illustrates this interconnectivity.

According to the somatic marker hypothesis (SMH), affect and emotion help guide decision-making. Damasio (1995) has suggested that normal decision-making in humans is often assisted by somatic markers such as bodily states or brain representations of bodily states (Maia & McClelland, 2004). These somatic markers correspond to emotional reactions to possible courses of action and reflect whether a certain outcome was positive or negative (Maia & McClelland, 2004). Somatic markers assist the cognitive or "cold" aspects of decision-making. Overall, they are emotion-based signals arising from the body that are integrated in the VMPFC to regulate decision-making in situations that are complex or uncertain to an individual (Damasio, 1995). They provide a shortcut in the decision-making process in that options previously associated with reward are highlighted and those that were associated with a negative outcome are suppressed (Clark & Manes, 2004).

It has been argued that damage to the VMPFC and other structures involved in the representation and regulation of body-state (including amygdala, insula, somatosensory cortex, cingulate, basal ganglia and brain-stem nuclei) lead to impaired decision-making because the somatic marking system can no longer be activated (Dunn, Dalgleish, & Lawrence, 2006). The VMPFC is believed to be the crucial area of the brain that integrates actual or predicted bioregulatory state representations with potential response options, therefore, it is important in creating somatic markers (Dunn et al., 2006). Somatic markers can operate consciously or subconsciously. When the somatic marker is operating consciously, the person experiences a "gut feeling" about whether the action they take will produce a good or bad outcome, thus assisting with decision-making (Maia & McClelland, 2004).

Somatic markers can also operate unconsciously, which can lead people to make good or bad decisions before they are consciously aware of which decision is advantageous (Maia & McClelland, 2004). Therefore, somatic markers can help guide decision-making in tasks that tap "hot" aspects of EF while also affecting "cold" EF.

IGT

The Iowa Gambling Task (IGT) is an assessment measure that has provided substantial support for the SMH. Although the methods section will have a complete description of the task, a fairly detailed description of the nature of the task needs to be given now in order to understand the findings in the literature.

Originally developed as a laboratory probe to measure decision-making in neurological patients with VMPFC damage, it has recently begun to be used in the clinical setting. The IGT requires participants to select cards from four decks labeled A, B, C, and D. The task is set up so that selections from decks A and B are considered disadvantageous, and selections from decks C and D are considered advantageous. Selections from decks A and B will provide the participant with high immediate gain but occasional large losses that result in net loss over time. On the other hand, selections from decks C and D present the examinee with smaller wins and smaller losses, but continuously choosing from these decks provides the examinee with a net profit over time. Participants are told that the object of the task is to win as much money as possible, but if not, to avoid losing as much money as possible. Participants are not informed about the contingencies of reward by winning money and punishment by losing money of each deck. Instead, they are given the instruction that some decks are worse than the others and that they should stay away from the worst decks. Throughout the task, participants are supposed to learn contingencies of decks A, B, C, and D. In examinees without damage to the VMPFC, they may learn the contingencies and stay away from certain decks because of a hunch or gut feeling they experience.

This neuropsychological assessment is believed to tap the “hot” aspect of executive function, which is not examined by using traditional measures of executive function. The IGT was developed to assess and quantify decision-making deficits of neurological patients by simulating real-life decision in conditions of reward and punishment, and of uncertainty (Bechara, Damasio, Tranel, & Damasio, 2005). The task presents the examinee with a novel, ambiguous, unstructured situation, which evokes true frontal lobe functioning in an individual. This contrasts with the traditionally structured assessments of frontal lobe functioning used by neuropsychologists which inherently provide structure for the examinee.

In order to put the following research studies into a better context, a brief explanation of the dependent variables of the IGT is warranted. There are 100 trials of the IGT. The IGT can be examined in terms of overall net score, which is calculated by subtracting the number of selections from disadvantageous decks (A+B) from the number of selections from advantageous decks (C+D) across all 100 trials. It is also possible to interpret the IGT in terms of net or block scores. There are 5 net scores in the task and each net consists of 20 trials. Each net score is calculated the same way as the overall net score (C+D- (A+B)). As will be explained in further detail later, it may be the case that the first two blocks present the examinee with decision-making under ambiguity, while the last three present the examinee with decision-making under risk.

An early study by Bechara, Tranel, Damasio, and Damasio (1996) reported that normal participants "decide advantageously before knowing the advantageous strategy" in a simple card game used to mimic real-life decision-making. In this study, participants without brain damage selected the most advantageous cards before they had conscious knowledge that the selections they were making were the most advantageous. Also of importance in this study was when participants were about to make a disadvantageous selection, they had higher skin conductance responses as compared to when they were about to make an advantageous or good decision. This suggests that they were experiencing a bodily reaction to the anticipated risk before they had conscious knowledge about the goodness or badness of the course of action they were about to take (Maia & McClelland, 2004). Skin conductance responses were used in this study as somatic markers, which allowed participants to make advantageous selections in the game before they were able to consciously verbalize knowledge of their choices, thus supporting the somatic marker hypothesis (Maia & McClelland, 2004).

A correlation between successful performance on the IGT and development of somatic markers, specifically measured by skin conductance response levels has been established in healthy participants (Bechara et al.,1996). These somatic markers were absent in people with damage to the VMPFC and were associated with poorer performance on the IGT (Bechara et al., 1996).

Construct Validity of the IGT: Lesion Studies and Neuroanatomical Correlates

Construct validity is the extent to which an assessment measures a specified variable of interest (Leong & Austin, 2006). One way of examining the construct validity of an assessment instrument is by looking at brain-behavior relationships (Gansler, Jerram, Vannorsdall, & Schretlen, 2011). Therefore, results from lesion studies and neuroimaging studies can provide insight into the construct validity of an assessment. The literature reveals that the IGT activates the brain areas that it was created to activate. Overall, findings from lesion studies and neuroimaging studies seem to support the use of the IGT as a measure of frontal lobe functioning.

The IGT was first developed to assess decision-making abilities in patients with lesions to the ventromedial regions (VMPFC) and medial orbitofrontal (omPFC) regions of the prefrontal cortex (Bechara, 2007). However, it has been shown that patients with lesions in other areas may also exhibit poor performance. In the professional manual of the IGT, Bechara asserts that the IGT is a sensitive measure of impaired decision-making in individuals with brain lesions in the following areas: omPFC and VMPFC, amygdala, and insular and adjacent parietal cortex areas (Bechara, 2007). Overall, studies seem to support that individuals with lesions in these areas evidence more disadvantageous performance on the IGT. Research is consistent with the

SMH because many of these limbic structures have reciprocal connections with the PFC and dysfunction in any of these areas can alter PFC function due to heavy interconnectivity.

Bechara, Damasio, Damasio, and Anderson (1994), examined a patient named E.V.R. along with other patients with lesions to the VMPFC, healthy controls, and patients with lesions to occipital, temporal, and dorsolateral frontal regions. They found that healthy patients and brain damaged controls make more selections from good decks and avoid the bad decks while patients with lesions to the VMPFC select fewer cards from the good decks and more from the bad decks (Bechara et al., 1994). In this same study, the authors repeated administration of the IGT one month after the first administration, 24 hours after that, and six months later. They found that the performance of healthy participants improved over time, but that performance of E.V.R. and other patients with lesions to the VMPFC did not improve over time. Results of this study showed that decision-making deficits in people with damage to the VMPFC are stable over time and do not improve.

Bechara (2004) found severe impairments in decision-making as measured by the IGT in patients with bilateral damage to the amygdala and damage to the omPFC and VMPFC. In a study by Bechara, Tranel, and Damasio (2000), patients with bilateral lesions of the omPFC and VMPFC performed worse by persisting in the selection of cards from more disadvantageous decks than patients with lesions of the lateral temporal or occipital cortex and healthy controls.

Effects of laterality of lesion in the VMPFC on IGT performance has also been studied. Tranel, Bechara, and Denburg (2002), examined IGT performance in 4 patients with lesions to the right VMPFC and 3 patients with lesions to the left VMPFC. They hypothesized that the right VMPFC plays a more crucial role in social conduct, decision-making, and emotional processing than the left VMPFC. Their hypothesis was confirmed. The authors found that individuals with damage to the left VMPFC shifted from bad decks to good decks as the task progressed, but individuals with right VMPFC damage did not. Overall, individuals with right-sided VMPFC performed disadvantageously on the IGT in comparison to individuals with left-sided lesions. Deficits in decision-making on the IGT in individuals with right-sided lesions was consistent with patient reports of impairment in daily functioning provided by the authors. Although a limitation of this study is the small sample size, results support the notion that the right VMPFC regions may be more instrumental in social conduct, decision-making and emotional processing than left VMPFC regions.

Research examining patients with lesions to particular brain areas is difficult and some results in the IGT literature that attempt to distinguish impaired performance in certain areas of the brain are messy. For example, results of some studies suggest that patients with lesions to the dorsolateral prefrontal cortex performed similarly to healthy controls on the IGT while patients with lesions to the VMPFC evidence impaired performance (Bechara et al. 2000; Fellows 2004).

Other researchers have not found specificity of the IGT to ventral frontal brain regions. Manes et al. (2002) compared healthy controls to groups of patients with different lesions including discrete orbitofrontal lesions, dorsolateral lesions, dorsomedial lesions, and large frontal lesions. They found impairment on the IGT in the patients with dorsolateral, dorsomedial, and large lesions to the frontal lobes. Specifically, people in these lesion groups selected more cards from risky decks than controls. In contrast to other studies, individuals with lesions to the orbitofrontal cortex performed similarly to healthy controls. Another study by Fellows and Farrah (2005) revealed similar results, as patients with ventromedial and dorsolateral prefrontal cortex lesions were both impaired on the IGT. Differing results could reflect the strong interconnectivity between different areas of the PFC. By looking at IGT performance in traumatic brain injury (TBI) patients who had both focal frontal lesions and diffuse injury, Fujiwara, Schwartz, Gao, Black, and Levine (2008) also did not find specificity of the task to focal frontal lesions.

It has also been shown that patients with bilateral damage to the amygdala evidence poor decision-making. Bechara, Damasio, Damasio, and Lee (1999) compared performance on the IGT of four patients with bilateral amygdala damage to 13 healthy controls. Results showed that patients with damage to the amygdala selected more cards from the disadvantageous decks on the IGT than individuals from the control group. However, a limitation of this study was its small sample size. These results also illustrate the extent to which the amygdala has reciprocal connections with the PFC.

Patients with brain damage to the insular and adjacent parietal cortex, particularly when the damage is on the right side, evidence severe impairment in social interaction, judgment, and decision-making (Bechara, 2007). Tranel, Bechara, and Damasio (2000), as cited in Bechara (2007), examined performance on the IGT in healthy controls, individuals with lesions to the right parietal cortex that included the insula and adjacent somatosensory cortex, and individuals with lesions to these same areas on the left side. They found that patients with right-sided lesions performed the worst on the IGT, indicating poor decision-making capacity. Meanwhile, patients with left-sided lesions performed similarly to healthy controls. Results also highlight the fact that multiple structures are heavily involved in emotion and have connections to the PFC where emotion is integrated. Overall, the literature using lesion studies and the IGT lends support to the idea that impairment on the IGT is related to deficits in frontal lobe functioning, although the specificity of frontal lobe areas tapped has been challenged.

The majority of neuroimaging studies with the IGT also support its relationship to frontal lobe functioning (Buelow & Suhr, 2009). Using positron emission topography (PET), Ernst et al. (2002) examined neural activation of 20 healthy individuals performing the IGT. They found activation in areas including orbitofrontal, dorsolateral, prefrontal, and anterior cingulate cortices during completion of the IGT. Activation of the frontal lobe during the IGT has also been seen in patient populations including those who abuse cocaine. Bolla et al., (2003) compared 13 healthy participants to 13 cocaine users using PET scans on the participants taking the IGT They found that cocaine use was associated with greater activation in the right orbitofrontal cortex and less activation in the dorsolateral prefrontal cortex when compared to healthy controls. Findings also showed less activation in the medial prefrontal cortex.

There have also been some studies using functional magnetic resonance imaging (fMRI) to investigate neurological correlates to the IGT. Fukui, Murai, Fukuyama, Hayashi, & Hanakawa (2005) used event-related fMRI to assess neural responses to risk anticipation during the IGT by adapting the IGT to 14 Japanese subjects. They found that during the risk-anticipating phase, when participants were deciding what deck to choose cards from, the task exclusively activated the medial frontal gyrus. They concluded that the more successful participants were in terms of performance on the IGT, the more medial frontal activities they exhibited via fMRI (p. 258). This same pattern of neural activation was observed by Lawrence, Jollant, O'Daly, Zelaya, and Phillips (2009) who adapted the IGT for use with event-related fMRI, which allowed for examination of neural activation for different aspects of the task. Using 15 healthy males as volunteer participants, they found that the medial frontal gyrus plays a key role in risky decision-making and successful task performance. Results from this study also suggest that the left lateral orbitofrontal cortex and dorsal cortex are important in learning to win on the task (Lawrence et al., 2009). This suggests that a larger number of brain areas are activated during IGT.

A study conducted by Li, Lu, D'Argembeau, Ng, and Bechara (2010) used fMRI to examine brain activity in healthy individuals during the IGT. They found that the brain areas activated during the task match the neural circuitry proposed by the somatic marker hypothesis upon which the IGT was created. Specific brain areas activated included the dorsolateral prefrontal cortex which is instrumental in working memory, the insula and posterior cingulate cortex which are associated with representing emotional and somatic states, and the medial orbitofrontal and ventromedial prefrontal cortex which is important for linking working memory and emotional and somatic states (Li et al., 2010). The ventral striatum and anterior cingulate and supplemental motor area, which are associated with implementing behavioral decisions, were also activated during completion of the IGT (Li et al., 2010). Findings from this study converge with brain areas purported by the authors to be activated by the IGT in the test's professional manual.

Support for sex-related differences in decision-making as measured by the IGT has also been seen with neuroimaging. Bolla, Eldreth, Matochik & Cadet (2004) examined decision-making using the IGT and positron emission topography. They found that women were not as good at decision-making as men on this task. According to their findings, men activated large regions of the lateral orbitofrontal cortex, bilaterally, using the right hemisphere, right dorsolateral prefrontal cortex and right parietal lobe more so than their left hemisphere counterparts (p. 1231). Women, on the other hand, activated the left medial orbitofrontal region during completion of the IGT. Since successful performance on the IGT relies more heavily on right hemisphere functions, males exhibited greater performance (Manes et al., 2002). Results of neuroimaging studies using both PET and fMRI lend credence to the idea that the IGT is related to frontal lobe functioning.

Convergent and Divergent Validity of IGT

Another important aspect in determining construct validity of an assessment measure is to examine its relationship to other instruments that purport to measure the same construct (Leong & Austin, 2006). This is known as convergent validity. Relatively few studies have investigated convergent validity of the IGT with other measures of executive function and decision-making. However, given that few measures assess “hot” executive functions, this is not surprising. It could be the case that the IGT is a stand-alone measure of executive functioning because of its affective link to decision-making. Moreover, the studies that do examine convergent validity of IGT with other measures of executive function include comparison with measures created around assessing “cold” executive functions.

One of the most frequently used tests to examine executive functioning by neuropsychologists is the Wisconsin Card Sorting Test (WCST) (Rabin et al., 2005). The WCST is believed to tap executive functioning abilities associated with the dorsolateral prefrontal cortex (DLPFC) (Shurman, Horan, & Nuechterlein, 2005). Abilities associated with the DLPFC can be considered “cold” executive functions. Studies examining the relationship between performance on the IGT and performance on the WCST are mixed, however most studies show no relationship. This is not surprising given the fact that they most likely measure different components of executive functioning (“hot vs. “cold”). Overman et al. (2004) found no significant correlation between performance on the IGT and performance on the WCST in 60 healthy young adults. This lack of relationship between the IGT and the WCST has also been seen in patient populations. Bechara, Dolan, Denburg, Hindes, Anderson, and Nathan (2001) showed that performance on the IGT was not related to performance on the WCST in patients with substance abuse, patients with lesions to the VMPFC and healthy controls. In this study low positive correlations between scores on the IGT and scores on the WCST for all groups were found. Furthermore, in this study, there were no significant correlations between the IGT, the Stroop Test, and Tower of Hanoi task (ToH), two other commonly used neuropsychological tests of executive functioning (Bechara et al. 2001). In a study by Grant, Contoreggi, and London (2000), thirty polysubstance abusers evidenced impaired performance on the IGT but did not differ from healthy controls on the WCST. Must et al. (2006) revealed no significant association between IGT performance and performance on the WCST among medicated individuals diagnosed with unipolar depression.

Despite the lack of evidence suggesting a relationship between the IGT and the WCST, this may be due to the nature of how these tests have been compared. It may be the case that a relationship between the IGT and WCST exists when performance on the IGT is analyzed in separate block trials. It has been proposed by Brand, Recknor, Grabenhorst, and Bechara (2007) that different blocks of trials in the IGT may tap into different neuropsychological domains. Brand et al. (2007) conducted a study in which 97 healthy participants were administered the IGT, WCST, Tower of Hanoi (ToH), National Adult Reading Task (NART), and the Matrix Reasoning and Vocabulary subtests from the Wechsler Abbreviated Scale of Intelligence (WASI). The authors analyzed IGT performance in five block scores by dividing the 100 trials of the task into 20 trial increments instead of running statistical analyses using the task's overall net score. Results from this experiment show that number of perseverative errors on the WCST was the only predictor for IGT performance in blocks 2, 4, and 5. Also, net scores for blocks 2-5 significantly correlated with measures of the WCST, with the net score from block 5 showing the strongest relationship between the IGT and the WCST. No correlations with general intellectual abilities as measured by the NART and the subtests of the WASI were found. Overall, this study shows that the relationship between the IGT and the WCST is stronger in the later blocks of the IGT than in the earlier blocks. One explanation for these results is that in the earlier blocks of the IGT, the participant is unaware of the contingencies of reward and punishment for each of the decks and is therefore making decisions under ambiguous circumstances. However, in the later trials, it is hypothesized that the participant becomes more aware of these contingencies and is therefore making decisions under risk, which correlates more closely with other executive functioning measures.

In addition to the Brand et al. (2007) study, Toplak, Sorge, Benoit, West, and Stanovich (2010) conducted a review on the associations between performance on the IGT and other cognitive ability measures including executive functions in studies using clinical and nonclinical samples. Specific executive functions examined included performance on tasks associated with inhibition, working memory, and set-shifting abilities. Overall, results showed a lack of association between these domains of EF and performance on the IGT. This study used correlation coefficients to report effect sizes, which will be noted in parentheses below. Specifically, only five out of 21 studies reported a statistically significant correlation between inhibition and IGT performance ($r = -.47$, $p < .05$; $r = .42$, $p < .01$; $r = -.49$, $p < .07$; $r = .28$, $p < .05$; $r = .29$, $p < .01$). Five out of the 38 studies examining set-shifting revealed a significant association with IGT performance ($r = .36$, $p = .003$; $r = -.40$, $p < .05$; $r = -.18$, $p < .05$; $r = -.32$, $p < .05$; $r = -.35$, $p < .001$). Lastly, only four out of 25 studies examined reported a significant association between IGT performance and working memory ($r = .56$, $p < .01$; $r = -.40$, $p = .001$; $r = .33$, $p < .01$; $r = .32$, $p = .001$). Results of this review suggest a dissociation between the EF functions of inhibition, set-shifting, and working memory and IGT performance. However, an important limitation of this study is that most studies analyzed the IGT using its IGT NET composite score (number of choices from advantageous decks C+D minus the number of choices from disadvantageous decks A+B). Using this composite may mask the finding that later trials of the IGT, which are associated with decision-making under risk, may be a better measure of EF then earlier trials of the task which may be associated more with decision making under ambiguity. In addition to these studies by Toplak et al. (2010) and Brand et al., (2007), another task that has been used to specifically measure risk-taking in relation to decision making is the Balloon Analog Risk Task.

The Balloon Analog Risk Task (BART) is another measure of risk taking in relation to decision-making. Performance on the BART has been compared to performance on the IGT. On this computer task, in which an individual pumps a balloon to earn money, risky behavior is rewarded up until a certain point (Lejuez et al, 2002). However, if the individual keeps clicking the balloon to earn money without stopping to collect the money, at a certain point the balloon pops and all money earned is lost. No correlations were found between performance on the BART and performance on the IGT among adult smokers (Lejuez et al., 2003).

In addition to their first experiment, Brand et al. (2007) conducted another experiment examining the relationship between performance on the IGT and performance on the Game of Dice Task (GDT). Even though the IGT and the GDT are both decision-making tasks, one important difference is that with the GDT participants are given explicit information at the beginning of the task about the gains and losses associated with given choices. Therefore, the GDT is assumed to be a measure of decision-making under risk. It has been proposed that the later blocks of the IGT, specifically blocks 3-5, are assumed to also measure decision making under risk. Some researchers believe that by that time in the task (blocks 3-5), the participant should have developed awareness of the probabilities of wins and losses associated with each deck (Brand et al. 2007; Gansler et al. 2011; Monterosso, Ehrman, Napier, O'Brien, & Childress, 2001). Results from this experiment support the idea that later blocks of the IGT measure decision-making under risk. The best relationship between the IGT and the GDT involved the last part of the IGT with the last three blocks correlating most highly with GDT performance (Brand et al., 2007). This finding is important because decisions under risk may draw more heavily upon neural systems used to process executive functions (Brand et al. 2007). Overall, performance on the IGT may correlate with other measures of executive functioning when scores from later blocks of the task are examined, instead of using the overall net score.

Another aspect of executive functioning that has been researched in relation to IGT performance is working memory. Results relating to the dissociation between working memory and decision-making as measured by the IGT are mixed and vary by lesion location. Manes et al. (2002) found that people with large lesions to the frontal lobes as well as people with lesions to the dorsolateral region were impaired on IGT performance and performance on a spatial working memory task from the Cambridge Neuropsychological Test Automated Battery. Others have found that patients with damage to the VMPFC have intact working memory abilities, intelligence, and executive functioning but perform poorly on the IGT (Bechara et al., 2000; Fellows, 2004).

There have also been findings regarding the specificity of lesion location to the VMPFC in terms of working memory. Bechara, Damasio, Tranel, and Anderson (1998) found that patients with lesions to the VMPFC/omPFC regions exhibited impaired performance on the IGT. The authors also found that if the VMPFC patients' lesions were more anterior in location, they performed normally on a working memory task, whereas VMPFC patients with more posterior lesions evidenced poor performance on both tasks. In this study, patients with lesions to the right dorsolateral/ high medial prefrontal cortex areas were impaired on the working memory task but not on the IGT and patients with left-sided DLPFC lesions were not impaired on either the working memory task or the IGT. Dretsch and Tipples (2007) found that high working memory load interferes with and impairs performance on the IGT. Overall, some studies suggest a dissociation of decision-making and working memory while others have found that working memory impacts decision-making.

In a study using patients with subarachnoid hemorrhage secondary to rupture of anterior communicating artery, Escartin et al., (2012) examined convergent validity of the IGT with other measures of executive function. The working memory component of executive function was assessed using the Digits, Arithmetic, and Letter-Number subtests from the Wechsler Scales of Adult Intelligence, Third Edition. Letter fluency and category fluency, as well as the Modified Wisconsin Card Sorting Test (categories completed, perseverative errors, and nonperseverative errors) were also used as measures of executive function. Using the overall net score from the IGT, they found significant correlations with semantic and phonemic fluency. A negative correlation was found between the IGT and number of perseverative errors, nonperseverative errors, and categories completed on the WCST. Furthermore, the researchers did not find an association between IGT score and tests of working memory.

Lehto and Elorinne (2003) studied the relationship of the IGT to other measures of executive functioning (as measured by the WCST and Letter Fluency) and fluid intelligence (as measured by the Ravens Progressive Matrices) in children and adults. Findings revealed that tasks of EF correlated more highly with the IGT in children than in adults. This may suggest that different aspects of EF are more related in childhood versus adulthood (Lehto & Elorrine, 2003).

One limitation of this study is the lack of clinical populations being tested. Another limitation is that the only dependent variable used by the authors was the number of good cards selected throughout the whole task. They also failed to analyze specific block scores in relation to other measures of EF. The authors examined IGT performance with only a limited number of tests which is not comparable to the number of tests and domains covered in a typical outpatient neuropsychological evaluation. Therefore, the results of this study may be limited in terms of clinical utility.

Currently, only one study thus far has sought to examine both convergent and divergent validity of the IGT with a broader range of neuropsychological domains more representative of that assessed in a typical outpatient assessment. Gansler et al. (2011) administered a comprehensive neuropsychological battery of 25 different tests from varying functional domains including intelligence, memory, executive functioning, psychomotor abilities, and attention. The tests were administered to 214 healthy participants and included the Information, Digit Span, Arithmetic, Similarities, Picture Completion, Block Design, and Digit Symbol subtests from the Wechsler Adult Intelligence Scale-Revised, Logical Memory and Visual Reproduction subtests from the Wechsler Memory Scale-Revised, and the Matrix Reasoning subtest from the Wechsler Abbreviated Scale of Intelligence. Other tests administered included the Brief Test of Attention, Trail Making Test Parts A & B, Calibrated Ideational Fluency Assessment, the Grooved Pegboard Test, The Boston Naming Test, Visual Motor Integration, Rey Complex Figure Test, Connors' Continuous Performance Test, the learning trials and delayed recall trial from the Hopkins Verbal Learning Test and Brief Visuospatial Memory Test, and the categories and perseverative error scores of the modified Wisconsin Card Sorting Test. Using structural equation modeling, the authors examined convergent and divergent validity of the IGT with other measures administered. The authors examined the data with the conventional IGT metric used in most studies, which includes subtracting disadvantageous selections from decks A and B from advantageous selections from decks C and D for the whole task (CD-AB for trials 1-100). They also used three alternative metrics to "reduce error due to location bias and to heterogeneity of decision-making processes by removing early trials" (p. 3). The first alternative metric examined the difference score of disadvantageous choices from decks A and B from advantageous choices from decks C and D over the last 60 trials of the task (CD-AB trials 41-100). The second alternative metric looked at the difference in selection from the disadvantageous deck A from the advantageous deck D over the whole task (D-A trials 1-100), and the third involved looking at this same difference but in the last 60 trials of the task (D-A trials 41-100).

Gansler et al. reported intriguing findings from this study. They found that general intellectual ability (G), specifically the fluid (Gf) component of G is meaningfully associated with IGT performance. In terms of convergent and divergent validity, the authors found that the conventional IGT metric (CD-AB trials 1-100) emerged as a member of the attention domain, whereas the alternative metric (CD-AB trials 41-100) emerged as a member of both the attention and executive function domain, although it is more robustly associated with attention (p. 9). These findings suggest that earlier in the task, the examinee is posed with an ambiguous decision-making situation in which attention is measured more so than executive functioning. Later in the task, the IGT represents decision-making under conditions of known risk (Brand et al. 2007), and therefore taps the executive functioning domain. Even though this study is important in its contribution to the IGT literature, there is a lack of research examining both convergent and divergent validity in clinical populations. Therefore, it would be important to examine convergent and divergent validity of the IGT in clinical populations in the future.

In summary, the literature supports the idea that IGT is a measure of frontal lobe functioning. However, evidence for convergent and divergent validity of the IGT to other measures is weaker. As a result, examining convergent and divergent validity is an area where additional research would be beneficial (Buelow & Suhr, 2009).

IGT Performance in Clinical Populations

The IGT has been used in clinical populations that evidence impairment in decision-making, thereby lending more support for its construct validity as an assessment instrument (Gansler et al., 2011). Impairments in IGT performance have been noted in substance users (Grant et al. 2000; Bolla et al., 2003; Monterosso et al., 2001; Verdejo-Garcia, Bechara, Recknor, & Perez-Garcia 2006). Individuals with gambling addiction have also exhibited impaired performance on the IGT when compared to healthy controls (Cavedini, Riboldi, Keller, D'Annucci, & Bellodi, 2002; Brand, Kalbe, Labudda, Fujiwara, Kessler, & Markowitsch, 2005). Impairment in performance on the IGT has also been noted in individuals with Schizophrenia (Shurman et al., 2005; Sevy et al., 2007). Obsessive-compulsive disorder is strongly associated with frontal lobe dysfunction, and people with this diagnosis have exhibited poor decision-making as measured by the IGT (Cavallaro et al., 2003). There has also been evidence supporting disadvantageous decision-making by psychopathic individuals on the IGT (Mitchell, Colledge, Leonard, & Blair, 2002). Research surrounding impairment of adults diagnosed with attention-deficit hyperactivity disorder (ADHD) is inconsistent with some studies noting impairment in IGT performance in those diagnosed with ADHD (Malloy-Diniz et al. 2007) and others not reporting impairment (Ernst et al. 2003). Performance on the IGT has also been examined in populations with medical or neurological conditions that have been associated with risky decision-making or frontal lobe dysfunction (Buelow & Suhr, 2009). For example, impairments on the IGT have been noted HIV+ men (Martin et al. 2004) and people diagnosed with neurological conditions including Huntington's and Parkinson's disease (Campbell, Stout, & Finn, 2004; Perretta, Pari, & Benninger, 2005). Decision-making deficits in individuals with rupture to the anterior communicating artery have also been observed (Escartin et al., 2012).

Overall, studies that examined clinical populations that are expected to have difficulties with decision-making revealed poor performance on the IGT. However, many of these studies fail to assess if subjects had global neurocognitive deficits. For example, it is well known that patients with schizophrenia do poorly on virtually all cognitive tasks (O'Carroll, 2000), making the finding regarding IGT unremarkable. Decision-making deficits as well as deficits in executive functioning have been noted in those diagnosed with depression and those who have incurred traumatic brain injury (Must et al., 2006; Levine et al., 2005). This paper will now specifically review the limited literature on the IGT in depression and the IGT in TBI more in depth.

IGT and Depression

It is accepted that major depressive disorder (MDD) can negatively impact executive functions and alter sensitivity to reward and punishment (Must et al., 2006). However, to date, the research examining the impact of depression on IGT performance is limited and provides mixed results.

Deficits in decision-making have also been linked to MDD. Specifically, people with depression have sensitivity to reward and punishment that varies from healthy controls. This aspect of MDD has been studied using the IGT. Cella, Dymond, and Cooper, (2010) examined flexible decision-making (defined by the authors as switching contingencies of the IGT) in 19 outpatients diagnosed with MDD. They administered the standard IGT (identified as Phase 1) and added on 120 more trials (identified as Phase 2) in which the contingencies of reward and punishment changed between the decks three times. The authors compared performance of the outpatients to the performance of 20 healthy controls. Results revealed that patients with MDD performed more poorly than healthy controls with significant differences occurring between the two groups evident in the last few blocks of the task (blocks 3, 4, and 5) of the standard IGT when compared to healthy controls in Phase 1. In Phase 2 where the contingencies of the decks shifted three times, patients with MDD did not show any signs of improvement or learning. Furthermore, the ability to shift from bad to good decks improved for the control group but did not change for members of the MDD group. Findings support the notion that altered sensitivities to reward and punishment that are found in depression may play a role in the impaired decision-making within this population (Cella et al., 2010). A limitation of this study is the absence of other neuropsychological measures of executive functioning as a basis for comparison of these deficits (Cella et al., 2010).

Impaired performance on the IGT has also been seen with depressed patients who have attempted suicide. Westheide et al. (2008) investigated the role of suicidal ideation on neuropsychological performance. The authors analyzed performance on decision-making ability as measured by the IGT. Specifically, they examined inpatients who have attempted suicide and separated the patients into two groups: those with current suicidal ideation and those without suicidal ideation. Their performance was compared to performance of healthy controls. They found that suicide attempters who were currently experiencing suicidal thoughts showed significantly impaired decision making on the IGT when compared to attempters without current suicidal ideation and healthy controls. This divide remained even after depressive symptoms were controlled for in the statistical analysis. Unfortunately, this study has a number of limitations including a small sample size (n=29 depressive inpatients and n= 29 matched healthy controls) which limits generalizability of results, and the absence of a clinical control group of depressive suicide non-attempters. However, results do suggest that suicidal ideation in depressed patients could contribute to impairment in decision-making.

Contrary to the research findings discussed above, Smoski et al. (2008) found that depressed patients exhibited better performance than controls on the IGT. The authors hypothesized that since people with depression show higher responsiveness to punishment, depressed individuals would initially sample from all decks but then learn to avoid risky decks with higher punishment during the later trials of the task. They found that relative to normal controls, depressed individuals chose fewer cards from risky decks across all trials of the IGT, not just during the latter part of the task. They were also more successful at gaining more money at the end of the task than control participants. An important limitation of this study to consider is that depressive symptoms were assessed through use of a screening interview (the Hamilton Depression Rating Scale) and not a formal diagnostic assessment of depression. Using a diagnostic assessment of depression may have provided a more precise picture of the effects of depression on learning through feedback (Smoski et al., 2008).

Even though the literature is mixed, studies suggest that depression could result in impaired performance on the IGT. However, literature on convergent and divergent validity of the IGT to other measures with depressed individuals is lacking. Must et al. (2006) administered the Wisconsin Card Sorting Test (WCST) and IGT to 30 medicated patients diagnosed with unipolar depression and 20 healthy controls. They found that patients with MDD exhibited impaired performance on the IGT, as well as impaired performance on the WCST. Even though executive functions were impaired in patients with MDD, a significant association between performance on the WCST and the IGT was not found. Therefore, impairment in executive function did not account for poor performance on the IGT (Must et al., 2006).

One interesting aspect of this study is that the authors also administered an altered version of the IGT called the EFGH version. In this version, if the participant chose a card from an advantageous deck, they would receive a large immediate punishment but an even larger future reward. This version differs from the original version where the participant receives an immediate small reward and even smaller future punishment when selecting from an advantageous deck. On the EFGH version, patients with MDD showed normal performance and the severity of depression predicted performance on this version; less severe depressive symptoms were associated with better performance. These results are intriguing, however, the practical significance of this study is limited by a small sample size (n= 30). Suhr and Tsanadis (2007) also examined the relationship between affect and performance on the IGT. They found that higher negative mood was related to riskier performance on the IGT (Suhr & Tsanadis, 2007). Taken together, the literature suggests that it is important to consider the impact of depression on IGT performance.

Depression and anxiety are disorders that are very much related. Even though depression and anxiety are diagnosed as separate conditions, some researchers have realized that the two entities might not be as separable as previously thought. For instance, Nutt (2004) discusses several factors for depression and anxiety being considered a part of the same disorder. Specifically, they often co-exist and have an overlap of symptoms. Nutt also discusses the idea that anxiety can predispose an individual to developing depression and depression can predispose and individual to developing anxiety. Regarding neurochemistry, both are also similar in that they most likely involve deficits in serotonin. Exposure to stress can also impact someone developing both depression and anxiety. Also lending credence to that idea that depression and anxiety are not separable entities is the success of treatment of both with selective serotonin reuptake inhibitors (Nutt, 2004).

Feldman (1993) investigated the distinction between anxiety and depression by conducting factor analyses on several sets of correlation matrices on self-report measures of anxiety and depression. Findings from factor analyses support a single construct underlying both anxiety and depression in both clinical and nonclinical samples. Consideration of depression and anxiety as disorders that are closely related and that may measure a similar construct will be taken into account in this study when examining IGT performance in archival data of outpatient assessments.

IGT and TBI

There are other gambling tasks used with the TBI population including the Probability Associated Gambling task and Cambridge Gambling Task (Newcombe et al., 2011; . But these tasks mainly differ from the IGT in that rules for the task are more explicit and probabilities associated with certain choices are better defined for the examinee than in the IGT. This review will only focus on the IGT in TBI. The literature in this area is also limited.

Similar to the problems plaguing the correlation between the IGT and depression, one limitation of whether the IGT correlates with other measures of EF in the TBI population is that the literature reviewing this topic is also limited. Sigurdardottir, Jerstad, Andelic, Roe, and Schanke (2010) performed a one-year prospective study using 115 participants with mild, moderate, and severe TBI as designated by Glasgow Coma Scale (GCS) scores. They administered the IGT and three tasks of executive function from the Delis-Kaplan Executive Function System (verbal fluency test including letter fluency, category fluency, and verbal fluency/switching, design fluency including filled, empty, and switching between empty and filled dots, and the color-word interference test including color naming, word reading, inhibition, and inhibition/switching conditions). Findings showed that phonemic fluency, the switching condition of design fluency, and the inhibition condition on the color-word interference test had moderate correlations with the IGT (Sigurdartottir et al., 2010). However, according to the authors of this article, important limitations in this study include small sample size and the absence of a control group.

Levine et al. (2005) also examined the relationship between the IGT and other neuropsychological tests in 71 patients with TBI and 22 comparison participants. Patients were contacted one year after their injury and were placed into groups according to the severity of their TBI, as determined by scores on the GCS. The authors administered tests of executive function, working memory, and processing speed, all of which are impacted by TBI. Tests administered included: Symbol Digit Modalities Test, Trails A & B, phonemic word list generation, the Hopkins Verbal Learning Test, Self-Ordered Pointing Test, and the WCST. Results of this study also highlighted the importance of analyzing the IGT in terms of card selection over time (by examining block scores) rather than using the overall net score. The authors found that the IGT is sensitive to TBI, but that patients shifted towards a more advantageous strategy by Block 5 as compared to healthy controls who shifted to this strategy by Block 2 (Levine et al., 2005). In this study, performance on the IGT was correlated to other measures of executive functioning, speed of processing and working memory most consistently in the third and fourth blocks of the task. The overall IGT net score was also examined.

Specifically, IGT performance was significantly related to working memory (as measured by the self-ordered pointing test) in block 4 and in the overall score of the IGT. Significant correlations were found between IGT performance of individuals with TBI and speeded information processing (as measured by Trails A & B) in blocks 3 and 4. Executive functioning, as measured by the WCST (using categories, and response perseverations scores) also significantly correlated with IGT performance in block 4 of the task and with the overall IGT score. Another important finding from this study was that performance on the IGT did not distinguish mild, moderate, and severely injured persons (Levine et al. 2005). Results of this study support the notion that both the overall score and scores for blocks in the later part of the IGT more strongly correlate with other measures of executive function, and may be affected by other neuropsychological domains such as working memory and processing speed.

In another study using the same data from Levine et al. (2005), Fujiwara, Schwartz, Gao, Black, and Levine (2008) examined IGT performance in 58 TBI patients one year post injury. They classified 18 participants with focal cortical contusions and 40 patients with diffuse injury into mild, moderate, and severe groups using GCS. A comparison group of 25 friends and family of patients were also used. Replicating findings by Levine et al. (2005), they also found that TBI patients performed differentially across blocks of the IGT. Overall, comparison subjects improved in advantageous decision making from blocks 1 through blocks 5. In contrast, patients with TBI started to improve later in the task during block 3. The authors of the study also discuss the finding that structural integrity of the ventral frontal cortex was not reliably related to performance on IGT. Therefore, one of the important aspects of the results of this study is that impaired IGT performance in TBI may not be confined to the specificity of damage to the ventromedial prefrontal cortex.

In a more recent study, , Fonseca, Zimmermann, Cotrena, Cardoso, Haag Kristensen and Grassi-Oliveira (2012) compared individuals with TBI and healthy controls on the IGT NET score and IGT block scores. The researchers found no difference between TBI survivors and healthy controls on either the net score or individual block scores of the task. However, the TBI group chose more risky decks (A and B) versus the control group. Another interesting facet of this study was the authors' intent to examine hot and cold aspects of the assessment of executive functioning. Along with the IGT, the researchers administered the Trail Making Test (TMT), and the Hayling Test. Seven patients presented with impairment on the IGT and evidenced normal performance on both the TMT and Hayling Test, suggesting a dissociation between "hot" and "cold" executive functions. Limitations of this study include a small sample size (18 outpatients with TBI and 16 non-brain-damaged adults as a control group), unclear inclusion criteria of the severity of the TBI the individual sustained, and not considering present or past psychiatric disorders in participants.

Bonatti et al. (2008) used the IGT as a measure of decision-making under ambiguity and the Probability Associated Gambling task (PAG) as a measure of decision-making under risk, since the probabilities of the task are defined for the examinee. The authors administered a battery of measures to 21 participants with TBI and 20 healthy controls. Neuropsychological domains assessed in both the TBI and control groups included verbal short-term memory, verbal working memory, psychomotor speed, cognitive flexibility, verbal fluency, cognitive estimation, planning, categorization, inhibition control, and mental complex calculation. The individuals in the TBI group were also administered tasks that assessed verbal episodic memory and divided attention.

In comparison to healthy controls, TBI patients made less advantageous decisions on the IGT. Patients in the TBI group also showed deficits in executive function compared to healthy controls. The frequency of advantageous choices in block 5 as well as the frequency for choices throughout the whole task for the TBI group were positively correlated with processing speed, cognitive flexibility and planning. In the last three blocks of the task, TBI patients selected cards from disadvantageous decks more frequently than healthy controls. The authors explain that this may be due to impaired learning since TBI patients showed both reduced cognitive flexibility in switching from bad decks to good decks after receiving negative feedback, and poor maintenance of set, which entailed persistent selection from good decks even after negative feedback. Both cognitive flexibility and ability to maintain set are aspects of executive function. Therefore, results suggest that advantageous performance on the IGT may be aided by other executive functions. The authors also found significant correlations between the number of advantageous choices on the IGT and higher performance on cognitive flexibility (as measured by Trails B), planning (as measured by the planning test), and psychomotor speed (as measured by Trails A). These results lend further support to the idea that executive functions aid advantageous decision-making.

Overall, research examining convergent and divergent validity with the IGT in the TBI population is scarce. However, the research available suggests that the IGT may be related to other measures of executive function, working memory, and processing speed, especially in the later blocks of the task. Additional research examining convergent and divergent validity in this population would be beneficial.

Psychiatric Diagnoses and TBI

In the United States alone, an estimated 1.5 to 2 million people incur TBI each year (Rogers and Read, 2007). Making this statistic even more significant is that individuals sustaining a TBI often experience post-injury impairment in emotional, behavioral, and psychological domains. Traumatic brain injuries are a complex health problem. Accordingly, psychological disturbance after TBI can be just as crippling to an individual as the precipitating brain injury event. After even a mild TBI, psychiatric morbidity following TBI can have a deleterious effect on the post-event recovery process (Rogers and Read, 2007).

There is a high frequency of comorbidity with TBI and post-injury psychiatric disturbance. Typical diagnoses observed within the context of TBI include affective disorders such as depression, anxiety disorders, and bipolar affective disorders (Reekum, Cohen, & Wong, 2000). Rogers and Read (2007) describe how survivors of TBI are susceptible to develop psychiatric disturbances including major depression, generalized anxiety disorder, and post-traumatic stress disorder. This is supported in a study by Whelan-Goodinson, Ponsford, Johnston and Grant (2009) which studied an Australian sample of individuals with mild to severe TBI 0.5 to 5.5 years after their injury. It was found that 65% of the people in their retrospective study received a diagnosis of psychiatric disturbance with major depression being the most common (45%), followed by anxiety (38%) and substance use disorder (21%). Furthermore, of these cases, more than two-thirds of post-injury diagnoses of anxiety and depression were new and not found in the individual pre-injury.

Using a prospective cohort, Fann et al. (2004) found that mild, moderate and severe TBI were significant risk factors for post-injury development of psychiatric illness. Specifically, among subjects with moderate to severe TBI, 49% had evidence of a psychiatric illness in the year following TBI compared with 34% in those with mild TBI and 18% in non-TBI comparisons (Fann et al., 2004). Additionally, individuals with a history of psychiatric illness pre-injury had a substantially greater risk of post-injury psychiatric illness. In terms of affective disorders, the authors found that patients with mild TBI had higher odds and risk ratios for affective disorders than those who had sustained TBIs that were classified as moderate and severe.

In a retrospective study, Koponen et al. (2002) evaluated the occurrence of Axis I and Axis II disorders in 60 individuals after they sustained TBI. Patients had sustained TBI between 1950 and 1971 and were referred for neuropsychological evaluation to Turku University Central Hospital in Finland between 1966 and 1972. A unique aspect of this study is that the average follow-up for individuals who sustained TBI was thirty years after their injury. The authors found that the most common novel disorders after traumatic brain injury were major depression (26.7%), alcohol abuse or dependence (11.7%), panic disorder (8.3%), specific phobia (8.3%), and psychotic disorders (6.7%) (Koponen et al., 2002). This study is significant because it suggests that TBI can cause temporary as well as permanent, longer-term vulnerability to psychiatric disturbance. Consequently, psychiatric disturbance, specifically major depression and generalized anxiety disorder (GAD) are important factors to consider in the post-injury evaluation of individuals who have sustained TBI in both the short and long-term.

Among the psychiatric disturbances to manifest following a TBI, the research cited above has shown that major depression, GAD, and PTSD are among the most prevalent and demand the most attention**.** The prevalence of major depression after TBI was documented in 13 studies reviewed by Rogers and Read (2007). They found that 24.5% of patients were diagnosed with major depression after sustaining a TBI. However, the temporal pattern of onset varied from study to study as some patients met criteria when they were discharged from the hospital while others were diagnosed months or years after injury (Rogers and Read, p. 1323).

The literature examining how long a TBI survivor remains at risk for developing major depressive disorder post-injury is mixed. Some authors contend that TBI survivors remain at risk for years to decades following TBI. Jorge et al. (2004) showed that 33% of TBI patients were diagnosed with major depression one-year post-injury. Other research shows that risk decreased within the first six years post-injury. A study performed by Ashman et al. (2004), found that the frequency of Axis I disorders including depression decreased over the first 6 years post-injury. Current research has shown major depression to be both a frequent complication of TBI and be associated with poorer functional outcome (Rogers and Read, 2007).

Along with major depression, Generalized Anxiety Disorder (GAD) is another common psychiatric disturbance to manifest as a consequence of TBI. In three studies reviewed by Rogers and Read (2007), 24.5% of TBI patients met criteria for GAD. Hoofien et al. (2001) found that 44% of patients met diagnostic criteria for GAD fifteen years after sustaining a TBI, suggesting that there is an elevated risk for this anxiety disorder years after injury. Van Reekum et al. (1996) reviewed five studies, and found that there was a 2.3 fold increase in risk for GAD post-injury.

Another psychiatric disorder found to manifest after sustaining TBI is Post-traumatic stress disorder (PTSD). The loss of consciousness that comes with increasing severity of TBI can be a protective factor for the development of PTSD, as the person may not have encoded a traumatic memory of the event. Alternatively, there have been reports that PTSD can in fact occur after TBI even when there has been a loss of consciousness and loss of memory for the event (Hibbard et al., 1998). Research has also found that having a premorbid psychiatric disorder is the strongest predictor of developing PTSD following TBI (Ashman et al., 2004).

Rogers and Read (2007) reviewed six studies that investigated the prevalence of PTSD after TBI. Their findings revealed 16.5% of people with TBI met diagnostic criteria for the disorder post-injury and suggested that PTSD can be a common psychiatric disturbance to develop following TBI.

Substance abuse is unique as it is well established that TBI is a consequence or risk factor of engaging in substance use and abuse (Lezak, 2012). About half of all TBIs involve the use of alcohol and about one-half of these individuals are under the influence at the time of injury (Zasler, Katz, and Zafonte, 2012). Rogers and Read (2007) examined five studies focused on substance abuse after TBI. They found that 11.5% of TBI cases met diagnostic criteria for substance abuse. In one particular study, (Fann et al, 2004), the most significant factor contributing to a diagnosis of substance abuse after TBI was a history of premorbid psychiatric disorder.

Premorbid drinking habits were also important in determining substance abuse post TBI. In a 30-year follow-up study of TBI patients conducted by Koponen et al., (2002), 71% of the 11.7% of patients diagnosed with substance abuse had a premorbid history of abuse. Substance abuse patterns after sustaining TBI appear to depend on premorbid abuse patterns and coping strategies (Rogers and Read, 2007). Given this research, substance abuse appears to be more of a causal agent for TBI than TBI is a causal agent for substance abuse. However, premorbid substance use is a good indicator of post-injury use.

Psychiatric comorbidity and psychiatric syndromes are consistently present at an elevated rate following TBI. Individuals with TBI appear particularly susceptible to major depression, GAD, and PTSD (Rogers and Read, 2007, p. 1331). Consequently, psychiatric disturbance should be considered an important factor of post-injury evaluation in individuals who have sustained TBI. Additionally, due to the high frequency of psychiatric disturbance observed in individuals pre and post TBI, comorbidity of psychiatric diagnosis with head injury also will be taken into consideration when using the archival data for this study. It is likely that individuals who present for an outpatient neuropsychological evaluation post TBI will have comorbid psychiatric disturbance.

Current Study

The IGT has been used in a variety of clinical populations, has been shown to lend support to the somatic marker hypothesis upon which it was created, and has been validated as a measure of frontal lobe functioning through neuroimaging studies. However, there is limited research on convergent and divergent validity of the IGT to other measures of executive functioning (EF) and measures of different neuropsychological domains. Particularly, divergent validity of the IGT with other neuropsychological measures is lacking (Gansler et al., 2011). Furthermore, convergent and divergent validity has not been examined enough in those experiencing psychological distress and those who have incurred a TBI.

There are several goals of this study. First, this study will investigate convergent validity of the IGT to other EF tasks in those with TBI. Second, to the best of the investigator's knowledge, there have been no studies comparing performance of individuals with TBI and psychological distress and performance of individuals suffering from psychological distress without history of TBI on the IGT. Therefore, a second aim of this study will be to compare performance on the IGT in those with a diagnosis relating to psychological distress who also have a TBI and those who have no history of TBI but have an Axis I and II disorder. Third, this study will examine convergent and divergent validity of the IGT across all subjects, regardless of group structure.

Achieving the aims of this study would add to the already existing literature base on the IGT. Information from the current study would also enhance clinicians' knowledge about decision-making as measured by the IGT in TBI and emotional distress and in those with a diagnosis associated with emotional distress. Examining convergent and divergent validity of the IGT would contribute to the limited literature on convergent and divergent validity of the IGT in clinical populations.

Hypotheses

Hypothesis 1

The first hypothesis will examine convergent validity of IGT performance to other measures of EF in TBI. There is evidence of a relationship between IGT performance and performance on other measures of EF (Sigurardottir et al., 2010; Levine et al., 2005; Bonatti et al., 2008; Brand et al., 2007). It has been found that performance on other measures of EF significantly correlate with IGT performance in the later blocks of the task, with healthy participants (Brand et al., 2007) and with those who have incurred TBI (Levine et al., 2005). Scores on blocks 3-5 may best illustrate decision-making under risk. It is hypothesized that performance on the last three blocks of the task for those with TBI and emotional distress will show moderate correlations with other measures of EF. Specifically, correlations between scores on blocks 3, 4, and 5 and other EF tasks will be greater than the correlation from blocks 1 and 2 with other measures of EF. Measures of EF will include perseverative errors and categories completed on the Wisconsin Card Sorting Test (WCST), the total score for the Controlled Oral Word Association Test, the score for the color/word trial of the Stroop Test, and the score for Trails B.

Hypothesis 2

IGT performance in those with emotional distress, specifically disorders of depression and anxiety have only been examined in a few studies to date; however, research based on imaging studies has shown that there may be similarities amongst the areas of the brain tapped by the IGT, those affected by TBI, and those affected by depression and anxiety. Results are mixed for those with depression but more studies demonstrate evidence of impaired performance on the IGT (Must et al., 2006, Smoski et al., 2008, Cella et al., 2008). Individuals with high levels of trait anxiety exhibit poor performance on the IGT as well (Miu, Heilman, and Houser, 2008; deVisser et al. 2010). Additionally, those who have suffered traumatic brain injury show worse performance on the IGT compared to healthy controls (Bonatti et al., 2008; Levine et al., 2005).

Results from neuroimaging studies of the IGT have revealed that the IGT taps areas of the brain including omPFC, dorsolateral prefrontal cortices, VMPFC, prefrontal and anterior cingulated cortices, and ventral striatum (Ernst et al., 2002; Li et al., 2010). Imaging studies in individuals diagnosed with depression reveals that brain areas implicated in the disorder include the amygdala, omPFC and medial prefrontal cortex, striatum and thalamus (Drevets, 2001). Anxiety and decision-making also share some of the same underlying neural substrates as the IGT, including the striatum, amygdala, medial and DLPFC (deVisser et al., 2010). Multiple areas of the brain are also affected and damaged in individuals who have sustained a TBI. A TBI affects the brain at the focal areas of contusion, which may include the DLPFC or medial prefrontal cortex and the damage is typically diffuse in nature. For example, diffuse axonal injury may result from shearing and tearing of axonal fibers (Rao and Lyketsos, 2000).

Since the brain areas tapped by the IGT are similar to the areas affected when someone incurs a TBI or experiences disorders of anxiety or depression, and since there is evidence in the literature of impaired performance of those on the IGT with depression, TBI, and anxiety, it is hypothesized that participants with a TBI and psychological distress will evidence impaired performance for overall NET score on the IGT that is similar to those with just emotional distress, with no significant between-group difference.

Hypothesis 3

Lastly, because this study is examining convergent and divergent validity of the IGT with measures of other neuropsychological domains (including visual perception, delayed memory, and executive function), several sub-hypotheses can be made regardless of group structure. It is believed that the overall NET score on the IGT will not correlate with scores on Judgment of Line orientation (a measure of visual perception), Logical Memory II and Verbal Paired Associates II (measures of delayed verbal memory). It is hypothesized that these measures will show divergent validity with the IGT. It is also hypothesized that the overall NET score on the IGT will correlate with other measures of executive functioning including: perseverative errors and categories completed on the Wisconsin Card Sorting Task, the total score for the Controlled Oral Word Association Test, the score for the color/word trial of the Stroop Test, and the score from Trails B. It is believed that these measures will show convergent validity with the IGT.

CHAPTER II

METHODS

Participants

This study reviewed archival data from 74 outpatients at Allegheny General Hospital who were evaluated from the beginning of 2012 until the spring of 2013 for sequelae relating to a traumatic brain injury (e.g. falls, motor vehicle accidents) and symptoms relating to psychiatric disorders indicating psychological distress. The ages of participants ranged from 18 to 66 (M=43.95, SD=14.13), and there were 27 males and 47 females. Participants were chosen for inclusion into one of two groups. One group contained individuals who were evaluated due to cognitive complaints post head injury (maximum 27 months from their reported injury). Individuals in this group either had a pre-existing diagnosis of a disorder of emotional disturbance on Axis I or were given a diagnosis as the result of the evaluation. However, there was one individual who was evaluated 72 months after their brain injury that was included because records indicated that emotional disturbance was experienced after their brain injury with a descriptor on Axis III reading " post chronic brain injury". Diagnoses related to emotional disturbance that were used in this study can be found in Table 1. There were 33 individuals in this group that ranged in age from 18 to 66 (M= 40.18, SD=13.92).

Individuals with a diagnosis pertaining to emotional disturbance on Axis I who had no history of head injury or who reported to have a "mild" concussion in the past (i.e., more than 10 years ago) were included in group 2. There was one individual who had an Axis III indicator of "multiple benign meningioma", one with status post CVA, one with an "unspecified neurologic disturbance", one with "seizure disorder" and another with Multiple Sclerosis. The 41 individuals in this group ranged in age from 19 to 64 (M= 46.98, SD=13.72). Diagnoses in this group can be found in Table 1.

Table 1

Axis I Diagnoses for Individuals in Group 1 and Group 2

Group 1	Group 2
Adjustment disorder	Major Depressive disorder in partial remission
Adjustment disorder not otherwise specified	Depressive disorder not otherwise specified,
Dysthymic disorder	Anxiety disorder not otherwise specified
Adjustment disorder with mixed anxiety and depressed mood	Adjustment disorder with anxiety
Post traumatic stress disorder	Adjustment disorder with anxiety and depressed mood
Post traumatic stress disorder in partial remission	Dysthymic disorder
Major Depressive disorder	Post traumatic stress disorder
Major Depressive disorder recurrent mild	Generalized Anxiety disorder
Mood disorder due to traumatic brain injury	Generalized Anxiety disorder with panic episodes
Mood disorder not otherwise specified	Post traumatic stress disorder with depressive features
Adjustment disorder with anxious features	Major Depressive disorder in remission
Adjustment disorder with depressed mood	Major Depressive disorder recurrent mild
Anxiety disorder not otherwise specified	Major Depressive disorder recurrent with anxious features
Major Depressive Disorder Single Episode in full remission	Depressive disorder recurrent
Major Depressive disorder recurrent	Major Depressive disorder recurrent severe
Major Depressive disorder single episode with anxiety	Major Depressive disorder recurrent
Generalized Anxiety disorder	Major Depressive disorder in partial remission
Depressive disorder not otherwise specified	Major Depressive disorder single episode unspecified
Major Depressive disorder, mild	Anxiety disorder not otherwise specified
Major Depressive disorder, recurrent mild	Adjustment disorder with mixed features of depression and anxiety
Mood disorder due to traumatic brain injury	Adjustment disorder not otherwise specified

Assessment of Cognitive Functioning

A total of 8 different neuropsychological tests were reviewed in order to determine an overall impression of cognitive functioning in 3 different domains (see Table 2). These assessments included measures of executive function, visual perception, and delayed verbal recall. Following data collection, each test result was converted to a T score based on the normative data for each test in order to serve as a universal metric of comparison between each group and with other tests. Conversion of raw scores to T-scores also helped to address the effects of age on executive functioning ability. Raw scores were used for JOLO and number of categories completed on WCST.

Table 2

Neuropsychological Tests Administered, Domain Assessed, and Operational Definition

Measure	Domain Assessed	Operational Definition
Iowa Gambling Task	Executive Function	NET, T from blocks 1-5
Trails B	Executive Function	Time required to complete task
Controlled Oral Word Association Test (COWAT)	Executive Function	Total number of words starting with F, A, and S produced in one minute
Stroop Color Word Test	Executive Function	Time required to complete task
Wisconsin Card Sorting Test	Executive Function	Number of categories completed, and number of perseverative errors made
Judgment of Line Orientation	Visual Perception	Total number correct
Logical Memory II	Delayed Memory	Total items recalled after delay
Verbal Paired Associates II	Delayed Memory	Total word pairs recalled after delay

Measures

Iowa Gambling Task

The Iowa Gambling Task is a computer-administered task of decision-making ability for persons aged 18 years and older. On the bottom of the screen, four decks of cards are displayed: “A”, “B”, “C”, and “D”. The examinee is given a $2,000.00 credit visually presented as a green bar on the top of the screen and is instructed to “pick a card” from any of the four decks. The red bar indicates how much money the examinee borrowed to play the game and how much they will have to “pay back” when the game ends. Each time the examinee selects a card, the computer makes a distinct sound when money is won and when it is lost. It also generates the message “you have won x dollars” and “you have lost x dollars”. A smiley face is also present on the screen when the examinee wins and becomes a frown when the examinee loses money. Standard administration of the IGT includes 100 trials.

Directions to the examinee about the task are intentionally ambiguous and do not inform the participants about contingencies of each deck. For the complete standard directions, please refer to Appendix A. Decks “A” and “B” are disadvantageous and decks “C” and “D” are advantageous. Choosing from decks “A” or “B” yields large immediate gain but unpredictable high penalties (Bechara, 2007). Choosing from decks “C” and “D” yield smaller immediate gains and smaller loss (Bechara, 2007).

The IGT produces several scores for the clinician to examine. The manual provides the clinician with three different T- score ranges to use in interpretation: first: T= ≤ 39 as “Impaired” second: T=40-44 as “Below Average”; third, T= ≥ 45 as “Nonimpaired”. These ranges can be used for interpretation of all scores produced by the IGT. The “NET TOTAL” score is derived using the difference between the total number of cards selected from decks “A” and “B” (the disadvantageous decks) minus the total number of cards from “C” and “D” (the advantageous decks; Bechara, 2007, p. 9). A positive score indicates advantageous decision-making and a negative score indicates disadvantageous decision-making (Bechara, 2007, p. 8). Five “Block Net Scores”, calculated from blocks of trials of the IGT are also generated. Each block score is calculated for twenty cards, and is generated the same way as the net total score, by subtracting the total number of disadvantageous cards chosen from the total number of advantageous cards chosen. Examination of the five block scores can inform the clinician about whether the examinee developed a learning curve over successive trials on the task and therefore, learned to make more advantageous decisions over time (Bechara, 2007, p. 8). A negative learning curve would alert the clinician to abnormal performance or impaired decision-making, and a positive learning curve would imply normal performance (Bechara, 2007, p. 8).

Judgment of Line Orientation

Judgment of Line Orientation is one of the most commonly used measures of visuospatial abilities. During this 30-item task, the examinee is asked to match line pairs to eleven numbered lines below that form a semi-circle. Scores range from 0-30 and one point is awarded to subjects that identify the correct orientation for both lines in the pair presented. This test is sensitive to those with right hemisphere damage (Lezak et al., 2012).

Trails B

The Trail Making Test is composed of two parts: Trails A and Trails B. Trails A assesses visual sequencing and psychomotor speed. In this task the examinee is asked to sequence numbered circles as quickly as they can without making any mistakes. Trails B will be examined in this study. For this task, the examinee is asked to alternate between connecting numbers and letters in order (i.e. 1-A-2-B-3-C). Trails B is used as a measure of executive functioning because the examinee is required to be cognitively flexible when alternating between numbers and letters (Lezak et al., 2012). If the examinee makes a mistake on the task, they are stopped by the examiner. The total time for the examinee to complete the task successfully is used as the metric for scoring.

The Trail Making Test is highly sensitive to the effects of brain injury (Lezak et al., 2012). Slowness on the task has been seen with patients who have sustained mild brain injury, and this slowness increases with severity of injury when performance is compared to controls (Lange, Iverson, et al., 2005). Research also suggests that those diagnosed with depression may perform more slowly on the task than control subjects (Lezak et al., 2012). It has also been documented through fMRI that Trails B activates left-sided dorsolateral and medial frontal areas of the brain in healthy participants (Zakzanis, Mraz, & Graham, 2005).

Controlled Oral Word Association Test

The Controlled Oral Word Association Test (COWAT) assesses phonemic fluency, which falls under the purview of executive function subserved by the frontal lobes. This task consists of three one-minute trials where the examinee is asked to generate as many words as they can that start with a particular letter. The letters used in the task include “F”, “A”, and “S”. Examinees must abide by the rules of not using proper nouns, same words with different endings, or numbers for each of these trials. Violation of the task’s rules, perseverations and repetitions made by the examinee are noted at the end of each trial. The total number of correct words generated across all three trials are used for scoring and are corrected for age, gender, and education.

The COWAT has been proven to be a sensitive measure of brain dysfunction, and has been associated with activation of left dorsolateral prefrontal areas (Wood, Sailing, Abbott, &

Jackson, 2001). Diminished verbal fluency has been noted in patients with traumatic brain injury and is associated with measures of severity of injury including length of coma and post-traumatic amnesia (Lezak et al., 2012).

Stroop Test

The Stroop Test has become an established and widely used measure of frontal lobe functioning (Strauss, Sherman, and Spreen, 2006). Although there are different variations of this task, its main components consist of three 45 second trials. In the first word-naming trial, the examinee is instructed to read printed words (i.e., RED, GREEN, BLUE) aloud as quickly as they can. In the second color-naming trial, the examinee is instructed to name colors of X's that are printed on the page. Performance on both the word-naming and color-naming trials can be considered an index of processing speed. Colors involved in the original task are also red, blue, and green. In the third color-word interference trial, examinees are asked to name the color that the word is printed in without reading the word itself (i.e. saying, "blue" if that is the color the word "red" is printed in). This trial assesses the examinee's ability to inhibit an over-learned response. In all three trials the examinee is told by the examiner when they commit an error. Scores are calculated by the number correct in each trial within the 45-second duration allotted for the task.

Research has shown that people with left hemisphere lesions have greater Stroop interference (Lezak et al., 2012). In a meta-analysis by Demakis (2004), impairment in Stroop performance was seen most often with individuals who had frontal lobe lesions. This task, specifically the interference condition, requires a great part of concentration on the part of the examinee. People with disorders of anxiety and depression will be included in this study. A diagnosis of depression or anxiety could entail difficulty with concentration (Andrews et al., 2010; Goldberg, Bridges, Duncan-Jones, and Grayson, 1988). As such, it could be the case that individuals with these diagnoses may also exhibit poor performance on this task

Wisconsin Card Sorting Test

The Wisconsin Card Sorting Test (WCST) has been used by neuropsychologists to assess executive functioning, specifically set-shifting and perseveration. In this task, the examinee is presented with four stimulus cards. Each stimulus card has a different design: one red triangle, two green stars, three yellow crosses, and four blue dots. They are also provided with a deck of 64 cards that they must match to the stimulus cards. There are three principles by which the examinees must match the cards: color, form, and number. Examinees are told to match the cards in the best way they think possible. The examiner provides feedback and says “right” or “wrong” after each match the examinee makes. Through use of the examiner’s feedback, the examinee is supposed to learn the principle to match the cards. After the examinee completes 10 correct matches for a certain principle (i.e., color), the examiner switches without warning to the next principle (i.e., form). Scores are derived for the number of categories completed, trials to complete first category, perseverative errors, perseverative responses, learning to learn, and failure to maintain set. Since category switching and inability to change problem solving strategies are indicative of executive dysfunction the number of categories the examinee completes and number of perseverative errors they commit are important diagnostic information for this study.

The WCST is sensitive to diffuse and focal brain damage in the frontal lobe area (Kongs, Thompson, Iverson, & Heaton, 2000). It has been noted that people with frontal lobe lesions made more perseverative errors and failure to maintain set errors when compared to those with more posterior lesions (Lezak et al., 2012). Performance on this task may also be influenced by depression. Channon (1996) found that depressed undergraduates made more perseverative errors on the task and showed slight impairment in describing the sorting categories when compared to healthy controls.

Logical Memory II

Logical Memory II (LMII) is a task from the Wechsler Memory Scales (Wechsler, 2009) and assesses memory for complex verbal information. This task is divided into two subtests. In Logical Memory I, the examiner reads two paragraph-length narratives to the examinee. After each paragraph is read, the examinee is asked to immediately recall as many details from the story as possible. In Logical Memory II, which will be used in this study, the examinee is asked to recall details of the two stories after a 20-30 minute delay. This task is scored based on the number of correct details the examinee recalls from the story. LMII also has a recognition component where examinees are asked to answer "yes" or "no" to questions about the first and second stories. Guilmette and Rasile (1995) found that LM has differentiated between healthy controls and people who have sustained a mild traumatic brain injury. Dikmen, Machamer, Temkin and McLean (1990) examined scores on LM of patients with moderate to severe head injuries two years post-injury. They found that LM scores differentiated from scores of a comparison group composed of friends, even when positive improvements were shown.

Verbal Paired Associates II

Verbal Paired Associates II (VPA II) is also a task from the Wechsler Memory Scales (Wechsler, 2009), which assesses memory for word pairs. In the first part of this task (Verbal Paired Associates I), the examinee is read 14 word pairs over four trials. After each trial they are given the first word of each pair and are asked to recall the second word. Some word pairs make sense (i.e., "sock and shoe"), while others do not make sense (i.e., "laugh" and "stand"). In VPA

II, after a 20-30 minute delay, examinees are again given the first word of each pair and asked to recall the second. Scores are calculated using the number of correct pairs recalled. There is also a recognition component to VPA II. In this recognition component, the examinee is given a word pair and they have to indicate whether the word pair was on the original list that was read repeatedly by answering “yes” or “no”. They are instructed to only respond “yes” if both words in the pair were on the original list. VPA II, as studied in the earlier versions of the Wechsler Memory Scales, has been documented to detect differences between depressed patients and healthy control subjects (Lezak et al., 2012). Research on VPA II from the latest Wechsler Memory Scales fourth edition is limited.

CHAPTER III

RESULTS

Hypotheses

The current study had several aims. This study first investigated convergent validity of the IGT to other EF tasks in those with TBI and emotional distress. Second, this study compared performance of individuals with TBI and emotional distress and performance of individuals suffering from emotional distress without evidence of TBI on the IGT. Third, this study examined convergent and divergent validity of the IGT with other measures used in a neuropsychological battery across all subjects, regardless of group structure. SPSS version 20 was used to perform all statistical analyses. A power analysis was conducted in order to determine an appropriate sample size, resulting in approximately 34 participants in each of the two groups for a total of 68 data sets to detect a large effect size of 0.8 ($\alpha = .05$, $1-\beta = .95$). This study had a total of 74 participants including 27 males and 47 females. Due to the established differences in males and females on tests of executive functioning (Fuster, 2009), t-tests were conducted to see if any differences between males and females existed on the measures. Results revealed no significant differences due to gender on the color word condition of the Stroop Test ($t(72) = -1.73$, $p = .086$), categories completed on the Wisconsin Card Sorting Test ($t(72) = -.144$, $p = .886$), Perseverative errors on the Wisconsin Card Sorting Test ($t(72) = .144$, $p = .886$), Controlled Oral Word Association Test ($t(72) = -.898$, $p = .973$), or Trail Making Test ($t(72) = -.132$, $p = .896$). Furthermore, no significant differences between males or females were found on the IGTNET score ($t(72) = -.018$, $p = .986$), block 1 of the IGT ($t(72) = -1.03$, $p = .305$), block 2 ($t(72) = -.143$, $p = .887$), block 3 ($t(72) = .138$, $p = .891$), block 4 ($t(72) = -.598$, $p = .551$), or block 5 ($t(72) = 1.27$, $p = .209$).

Table 3

Descriptive statistics for performance on neuropsychological measures

	N	Range	Minimum	Maximum	Mean	Std. Deviation
LMII_T	74	47	20	67	43.36	9.69
VPAII_T	73	50	20	70	48.29	10.61
TMTT	74	80.7	-6.8	73.9	47.88	15.48
STROOP	74	53	20	73	43.39	8.95
WCSTC	74	6	0	6	4.59	1.76
WCSTErr	74	62	19	81	44.16	11
FAST	74	36	27.5	63.5	44.69	8.6
IGTNet	74	45	26	71	49.73	9.55
IG1	74	62	19	81	52.32	11.87
IG2	74	39	32	71	51.57	10.59
IG3	74	39	27	66	50.09	9.48
IG4	74	46	19	65	48.46	9.4
IG5	74	47	19	66	46.68	11.81
JOLO	67	19	11	30	23.67	5

Hypothesis 1

The first hypothesis is that scores on IGT blocks 3, 4, and 5 in people who have TBI and emotional disturbance (Group 1, N=33) will correlate more highly than blocks 1 and 2 with other measures of executive function (Levine et al., 2005). In order to investigate this hypothesis, a multiple regression analysis was conducted to see if the scores on other tests of executive functioning predicted the early blocks of the Iowa Gambling Task. The scores from blocks 1 and 2 were combined into a composite and the total was divided by 2. This composite was called "IGT early" and served as the criterion variable. The scores from measures of EF including perseverative errors and categories completed on the Wisconsin Card Sorting Test, total score for the Controlled Oral Word Association Test, score from the color/word trial of the Stroop test and the score from Trails B, were used as predictors in a multiple regression analysis. Scores from these EF measures did not significantly predict scores on blocks 1 and 2 for individuals in Group 1 R^2 =.29, F (5, 27)= 2.17, p= .087. This finding was expected. The results of the regression analysis indicated that the 5 predictors explained 28.7% of the variance in the scores from blocks 1 and 2.

Table 4

Regression analysis using scores on measures of executive function to predict the score on blocks 1 and 2 of the IGT in Group 1 (TBI and psychological distress).

Criterion	Predictor	β	t	*p*	R^2	*Adj.* R^2	*F*	*df*	*p*
IGT Early					0.29	0.16	2.17	5, 27	0.087
	TMTT	1.79	1.79	0.085					
	STROOP	-0.76	-0.76	0.452					
	WCSTC	-1.49	-1.49	0.147					
	FAST	1.57	1.57	0.127					
	WCSTErr	1.18	1.18	0.247					

Predictors: errors on Wisconsin Card Sorting Test (WCSTErr), Trails B (TMTT), Controlled Oral Word Association Test (FAS), categories completed on Wisconsin Card Sorting Test (WCSTC), color/word condition from Stroop test (STROOP) ; Dependent Variable: IGEarly

Next, for people in Group 1, the IGT scores from blocks 3, 4 and 5 were combined into a composite score and used as the criterion variable while the same scores of EF were used as the predictor variables. The composite score was created by adding the scores of blocks 3, 4, and 5 and dividing the total by three. The results of the regression analysis indicated that the 5 predictors explained 17.8% of the variance and did not significantly predict the IGT scores from blocks 3,4, and 5, R^2 = .18, F (5, 27)= 1.17 p= .350. This finding did not support the hypothesis that in people with TBI and emotional disturbance, scores on the later blocks of the IGT correlate more highly with measures of executive functioning compared to scores on the earlier blocks of the task. This same analysis was conducted using the composite score of adding blocks 4 and 5 and dividing the total by two. This was done in order to obtain average score of performance of the IGT on the last two blocks of the task. The results of this regression analysis indicated that the 5 predictors explained 17% of the variance and did not significantly predict the IGT scores from blocks 4 and 5, $R^2 = .170$, F (5, 27)= 1.07 p= .401.

Table 5

Regression analysis using scores on measures of executive function to predict the score on blocks 3,4, and 5 of the IGT.

Criterion	Predictor	β	t	*p*	R^2	*Adj.* R^2	*F*	*df*	*p*
IGT Late					0.18	0.03	1.17	5, 27	0.350
	TMTT	0.28	1.19	0.246					
	STROOP	-0.26	-1.03	0.310					
	WCSTC	0.18	0.78	0.441					
	FAST	0.22	0.99	0.333					
	WCSTErr	0.08	0.39	0.702					

Predictors: errors on Wisconsin Card Sorting Test (WCSTErr), Trails B (TMTT), Controlled Oral Word Association Test (FAS), categories completed on Wisconsin Card Sorting Test (WCSTC), color/word condition from Stroop test (STROOP)
Dependent Variable: IGLate

Hypothesis 2

Participants were placed into one of two groups. Group one (N=33) was composed of individuals who had sustained a TBI and who were also experiencing psychological distress. Group two was composed of individuals who had a diagnosis pertaining to psychological distress and no history of sustaining a TBI (N=41). There was no significant difference in age between the two groups t(72)= .91, p= .909. This hypothesis predicted that performance in both groups would evidence impairment on the IGT Net score and that there would be no difference in performance. Results of an independent samples t-test revealed no significant difference between groups 1 and 2 on the IGT Net score, $t(72) = -2.10$, $p = .323$. Also, the means of these two groups on the IGT Net score were not impaired for either group (Group 1 $M = 48.90$; Group 2 $M = 50.31$) as seen in Figure 1. In order to elucidate any group differences between the blocks of the IGT, t-tests were calculated for each block. Results revealed no statistically significant difference in performance, as seen in Figure 1. According to the IGT manual, a T-score of ≤ 39 indicates impairment and T-scores between 40-44 fall in the below average range. One part of this hypothesis, that both groups would show impairment on the IGT Net score was not supported. However, the part of the hypothesis that both groups would evidence similar performance on the IGT Net scores was supported by the results.

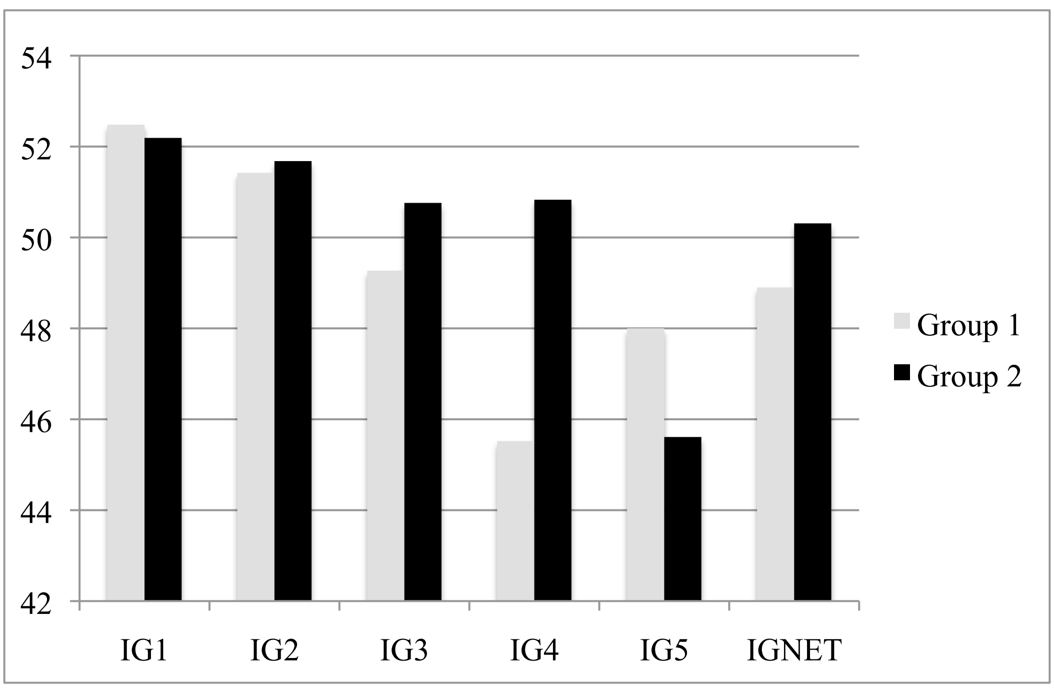

Figure 1. T-Scores indicating group differences on IGT Block Scores and IGT NET Score.

Hypothesis 3

Hypothesis 3 of this study is based on convergent and divergent validity of the IGT Net score with scores of other measures used in a neuropsychological battery. To examine convergent and divergent validity of the IGT with other measures across all participants, Pearson correlation coefficients were calculated between the IGT Net score and the scores on the COWAT, categories completed and perseverative errors components of the Wisconsin Card Sorting Test, color/word condition of the Stroop test, Trails B, Verbal Paired Associates II, Logical Memory II and Judgment of Line Orientation. Although a Multi-trait, Multi-method (MTMM) analysis (Campbell and Fiske, 1959) is considered a standard method for looking at convergent and divergent validity, Pearson correlation coefficients were used in this study because the "method" of how an assessment was administered was not considered an important variable. As expected, the IGT Net score significantly correlated with the score on the COWAT ($r=.25$, $N=74$, $p=.034$), Trails B ($r=.36$, $N= 74$, $p= .001$), and categories completed on the Wisconsin Card Sorting Test ($r=.27$, $N= 74$, $p= .022$). An anomalous finding was that the IGT Net score and the score from the Judgment of Line Orientation Test were also significantly correlated ($r =.28$, $N=67$, $p=.021$). Even though it was predicted that the IGT would show significant correlations with the perseverative error score on the Wisconsin Card Sorting Test and color/word condition from the Stroop Test, there were no significant correlations between the IGT and WCST perseverative errors ($r=.21$, $N=74$, $p=.069$) or for the IGT and Stroop Test ($r=.20$, $N=74$, $p=.095$) although these do represent a trend. However, as predicted, the IGT Net score did not show significant correlations with Verbal Paired Associates II ($r=.19$, $N=73$, $p=.103$) or the score from Logical Memory II ($r=.18$, $N=74$, $p=.120$).

In addition to looking at correlations between scores on neuropsychological variables and the IGT Net score, performance on individual blocks of the IGT were also included in the analysis. The score on block 2 of the IGT (IG2) showed a significant correlation with the score on Trails B, ($r= 0.30$, $N=74$, $p= .009$). The score on block 3 (IG3) also showed a significant correlation with Trails B ($r= .26$, $N=74$, $p= .026$) and categories completed on the Wisconsin Card Sorting Task ($r=.24$, $N=74$, $p= .038$). Scores on block 4 (IG4) significantly correlated with Logical Memory II ($r= .26$, $N=74$, $p=.026$) and categories completed on the Wisconsin Card Sorting Task ($r=.28$, $N=74$, $p= .017$). Finally, the score on block 5 of the IGT (IG5) showed significant correlations with Trails B ($r=.26$, $N= 74$, $p= .027$) and with categories completed on the Wisconsin Card Sorting Task ($r=.24$, $N=74$, $p= .040$).

Table 6

Correlations between IGT performance and other measures

	LMII_T	VPAII_T	TMTT	STROOP	WCSTC	WCST Err	FAST	JOLO
LMII_T	1	**.44****	**.23***	**.31****	**.33****	**.27***	**.40****	**.48****
VPAII_T	**.44****	1	**.34****	**.58****	**.41****	**.34****	**.41****	**.36****
TMTT	**.23***	**.34****	1	**.45****	**.26***	0.13	**.39****	**.37****
STROOP	**.31****	**.58****	**.45****	1	**.45****	**.41****	**.47****	**.35****
WCSTC	**.33****	**.41****	**.26***	**.45****	1	**.57****	0.15	**.41****
WCSTErr	**.27***	**.34****	**0.13**	**.41****	**.57****	1	0.06	**.34****
FAST	**.40****	**.41****	**.39****	**.47****	0.15	0.06	1	**.40****
JOLO	**.48****	**.36****	**.37****	**.35****	**.41****	**.34****	**.40****	1
IGTNet	0.18	0.19	**.36****	0.20	**.27***	0.21	**.25***	**.28***
IG1	0.04	0.18	0.11	0.21	-0.05	0.10	0.17	0.12
IG2	0.06	0.04	**.30****	0.02	0.07	0.06	0.16	0.14
IG3	0.11	0.15	**.26***	0.03	**.24***	0.17	0.12	**.26***
IG4	**.26***	0.20	0.22	0.22	**.28***	0.19	0.15	**.25***
IG5	0.08	0.05	**.26***	0.15	**.24***	0.14	0.22	0.08

**Correlation is significant at the .01 level (2-tailed);
*Correlation is significant at the .05 level (2-tailed).
LMIIT: Logical Memory II, VPAIIT: Verbal Paired Associates II, TMTT: Trail Making Test B, STROOP: Color Word Condition of the Stroop Test, WCSTC: Categories completed from Wisconsin Card Sorting Test, WCSTErr: Perseverative Errors from Wisconsin Card Sorting Test, FAST: Phonemic Fluency from FAS Test, JOLO: Judgment of Line Orientation.

Post-hoc, Exploratory Analyses

Examining whether differences existed in the IGT Net score between Group 1 and Group 2 may have masked any differences in performance on the individual blocks of the IGT. In an attempt to elucidate any differences that may have existed in IGT performance between Group 1 and Group 2, t-tests were conducted for each separate block of the IGT. A Bonferroni-adjusted significance level of $p = .0083$ was calculated to account for the increased possibility of Type I error with the number of comparisons being made. Results showed that there was no significant difference in performance between Group 1 and Group 2 on blocks 1, 2, 3, 4 and 5. Scores on blocks 4 and 5 of the IGT were also combined into a composite score to look at possible differences in performance in the later blocks of the task. There was no significant difference between Group 1 (*M*= 93.51) and Group 2 (*M*= 96.44) on the composite score of blocks 4 and 5 (t= -.69, df= 72, p= .488).

Individuals with other comorbid conditions, (10 people in Group 2) were extracted to form a purer analysis of individuals with psychological distress (defined as conditions on Axis I and III). The individuals extracted had "family history of dementia", Multiple Sclerosis, past cerebral vascular accidents, a "TBI of unspecified severity" 13 years before the current outpatient evaluation, "unspecified neurologic disturbance", "multiple benign meningioma" and "exposure to TCE" in the past. The IGT Net score from this subset of people was compared with the Net score from individuals in Group 1. There was no significant difference in performance t(45)= -3.10, p= .935; Group 1 *M*=49.57, Group 2 *M*= 50.87). An analysis comparing these two groups on the scores of each of the blocks of the IGT was also conducted. A Bonferroni-adjusted significance level of *p*= .0083 was calculated to account for the increased possibility of Type I error. No significant differences between the groups was found.

PAI scores from the Depression and Anxiety scales were used as a proxy measure of psychological distress. Scores on the affective, cognitive, and physiological components of anxiety and depression were averaged to form a single anxiety and depression score, respectively. Hierarchical regression analysis was performed with gender, education, anxiety, and depression entered at the first step. Then, executive functioning measures using WCST errors and categories completed, TMT, and Stroop were entered in the following step. The IGT Net score was the outcome variable in this analysis. Gender, education, anxiety, and depression (Model 1) accounted for 6% of the variance in the IGT Net score. Introducing the executive functioning measures in Model 2 explained an additional 17% of the total variance accounted for in IGT Net performance and the R^2 change was significant (p = .020), indicating that executive functioning contributed significantly to the model, F(9, 64) = 2.15, p = .038. Therefore, there is some evidence that suggests executive functioning measures significantly account for the variance in IGT Net performance after accounting for education, gender, anxiety and depression within a clinical population using the entire sample. However, the results reveal that TMT (β = .20, p = .015) was the only significant predictor of the IGT Net score. These results are seen in Table 7.

Table 7

Summary of regression analysis with Personality Assessment Inventory scores

	β	*t*	Sig.	*R*	R^2	*Adj.* R^2	$R^2 \Delta$	*Sig. F Δ*
Model 1				.240a	0.06	0.00	0.06	0.385
Gender	0.70	0.29	0.770					
Education	0.90	1.88	0.064					
Anxiety	-0.08	-0.49	0.624					
Depression	0.05	0.32	0.749					
Model 2				.481b	0.23	0.12	0.17	0.020
Gender	1.30	0.56	0.580					
Education	0.90	1.78	0.079					
Anxiety	-0.03	-0.18	0.861					
Depression	0.04	0.26	0.795					
TMT	0.20	2.49	0.015					
Stroop	-0.24	-1.37	0.176					
WCST Cat	0.62	0.81	0.421					
WCST Err	0.19	1.47	0.147					
FAS	0.15	0.99	0.328					

a Predictors: Depression average, gender, education, anxiety average

b Predictors: Depression average, gender, education, anxiety average, Wisconsin Card Sorting Task perseverative errors, Trail Making Test B score, Controlled Oral Word Association Test score, categories completed on Wisconsin Card Sorting Task, and color/word condition of Stroop Test

CHAPTER IV

DISCUSSION

Hypotheses

This study examined the Iowa Gambling task and had several aims. One of the goals of this study was to investigate convergent validity of the IGT with other EF tasks in individuals with TBI and emotional disturbance. Second, this study compared performance of individuals with TBI and emotional disturbance to IGT performance of individuals suffering from emotional disturbance without evidence of TBI. Third, this study examined convergent and divergent validity of the IGT with other measures used in a neuropsychological battery across all subjects, regardless of group structure.

The following outcomes were predicted to result from the analyses 1) that in individuals with emotional distress and TBI, scores on blocks 3, 4 and 5 would correlate more highly with measures of executive functioning than scores on blocks 1 and 2 2) that there would be no difference in performance of Group 1 and Group 2 on the IGT Net score and that both groups' scores would be impaired , 3) the IGT Net score for all individuals, regardless of group structure would correlate with the score for COWAT, Trails B, number of categories completed on WCST, perseverative errors on WCST, and color word condition of the Stroop test, and the IGT Net score on all individuals, regardless of group structure would not correlate with the scores on Verbal Paired Associates II, Logical Memory II, and Judgment of Line Orientation.

Parts of hypotheses 1, 2, 3 were supported. There was no significant difference in performance between Group 1 and Group 2 on the IGT NET score. Results showed that IGT NET scores on all individuals weakly but significantly correlated with Trails B, number of categories completed on the WCST, and the COWAT. Scores also unexpectedly correlated with the JOLO. Although not significantly correlated, scores on the number of perseverative errors on the WCST and color word condition of the Stroop test showed a trend with IGT NET scores. Scores on IGT NET did not correlate with scores on Logical Memory II or Verbal Paired Associates II.

Hypothesis 1

The idea of separating the IGT into two different parts has started to emerge in the literature. Some researchers have found evidence to suggest that the early part of the tasks (i.e. Blocks 1 and 2) represent "decision making under ambiguity" because the examinee is recruiting aspects of cognition such as working memory and attention in order to understand the task (Brand et al., 2007). Instead, the later part of the task (Blocks 3, 4 and 5) correlate more highly with measures of executive function because they are hypothesized to reflect "decision making under risk" as the examinee becomes more aware of the contingencies of the decks in the task. Consistent with other research (Brand et al., 2007; Levine et al., 2005) measures of executive functioning did not significantly predict the scores on blocks 1 and 2. These results suggest that other cognitive processes besides executive functioning abilities may tap into the early part of the task. Clinical neuropsychologists who use the IGT in evaluations may benefit from the corroboration of the current finding with other previous research. It may be the case that the IGT is not solely a measure of executive functioning, especially in the beginning of the task in clinical populations. It is possible that the beginning blocks of the IGT are associated more highly with learning. Neuropsychologists should be aware of this possibility as they interpret results of the IGT into their case conceptualization and report writing. Future studies should investigate this possibility by comparing the beginning blocks of the IGT to a visual-based task with a learning index, such as the Benton Visual Memory Test-Revised. The same should be done with measures of working memory and attention, by correlating scores from the Digit Span task or parts of the Connor's Continuous Performance Test.

Unlike Brand et al. (2007), this study did not find that measures of executive functioning predicted later parts of the task. A few reasons emerge to explain this finding. First, even though Brand et al. (2007) had a similar sample size to the current study (32 participants versus 33 in the current study), the study utilized healthy controls. In contrast, this study examined a clinical population which could have effected the results. Additionally, Brand et al. (2007) used the Game of Dice Task (GDT) to compare to the IGT. Those researchers conceptualized the GDT as a measure of executive functioning, specifically decision making under risk, because the task provides explicit rules to the examinee. Subjects' performance in the last three blocks of the IGT significantly correlated with their performance on the GDT ($r = 0.35$ for block 3, $r = 0.57$ for block 4, and $r = .041$ for block 5). One reason for this could have been due to the fact that both tasks are gambling tasks and therefore share similarities. In contrast, other measures of executive functioning were used in this study, which could also account for the lack of association. Since executive functioning is such a broad area that includes numerous abilities, it could be the case that other measures of executive functioning may have better predicted this latter part of the task. Future studies should investigate this possibility.

Levine et al. (2005) also found that measures of executive functioning more highly correlated with the later block scores of the IGT in a TBI population. The reason for the discrepancy between past research and the current study is unclear. However, a possible explanation may be due to methodological differences. The exclusion criteria for Levine et al.'s study also differed substantially from that of the current study. Specifically, the researchers excluded participants with a significant psychiatric history. In contrast, individuals with a significant psychiatric history were included in the current study.

Hypothesis 2

To the best of this writer's knowledge, this is the first study that compared performance on the IGT in individuals with psychological distress and individuals with TBI and psychological distress. Consistent with part of hypothesis 2, results of this study indicated that there was no statistically significant difference in performance between Group 1 and Group 2. However, the second part of this hypothesis asserted that both groups would evidence impaired performance on the IGT Net score, which was not supported. There are several possible explanations for this finding.

When considering the findings of this study in comparison to other studies investigating IGT performance in individuals with emotional disturbances, an important factor is the absence of control participants, although using normative T-scores implied the use of a statistical control group. Cella, Dymond, and Cooper (2010) found that outpatients diagnosed with Major Depressive Disorders performed more poorly than healthy controls on the last three blocks of the IGT. Westheide (2008) found that suicide attempters evidenced impaired decision making on the IGT as compared to non-suicide attempters and healthy controls. Similarly, Must et al. (2006) found significant differences in performance between 30 medicated patients with unipolar depression and healthy controls.

Studies examining performance on the IGT in individuals with TBI have also used the inclusion of a control group as a comparison. For instance, Bonatti et al. (2008) found that TBI patients made less advantageous decisions on the IGT compared to healthy controls. In comparison to healthy controls, Fujiwara, Schwartz, Gao, Black and Levine (2008) found that individuals with TBI one year post-injury improved in advantageous decision making later in the task than compared with healthy controls. However, Fonseca et al. (2012) found no difference in healthy controls and individuals with TBI on the IGT net score and IGT block scores. The current study compared two clinical groups, which is less likely to yield a statistical difference between performance versus comparison between a clinical group and a control group as previous studies have done.

Second, previous studies examining performance of the IGT in individuals with psychological disturbance examined specific groups depending on their diagnosis. In the current study, there were not enough individuals who met inclusion criteria to create groups for different diagnostic conditions (i.e., major depression, generalized anxiety, adjustment disorder). As a result, individuals with any disorder pertaining to psychological distress were included into Group 1 and Group 2. Similarly, for individuals with brain injury, there were not enough participants with available information on Glasgow Coma Scale Score, length of loss of consciousness or length of Post Traumatic Amnesia to properly classify the injury as “mild”, “moderate”, or “severe” TBI. Not being able to separate groups into more distinct categories may have also impacted any true differences between individuals in performance on the IGT in the current study. However, a lack of significant results may serve to further highlight the vast heterogeneity of cognitive deficits post-traumatic brain injury.

Third, all of the individuals included in this study had a diagnoses pertaining to psychological distress, specifically disorders of depression and anxiety. Common characteristics of these disorders include risk aversion and sensitivity to negative feedback (Cella et al., 2010). It could be the case that the outpatients in this study were especially sensitive to the punishment/reward contingencies of the various decks in the IGT and learned early in the task to avoid the “riskier” decks. It could also be the case that people with diagnoses of depression are better judges of contingency than non-depressed individuals, as previous research has shown (Vazquez, 1987). This behavior may have, in turn, contributed to a nonimpaired overall Net Score. Regarding Group 1 (TBI and psychological distress), it is important to recognize that psychological distress can develop as a consequence of TBI or be a pre-existing condition. Individuals with TBI and psychological distress still evidenced non-impaired performance, as a whole. It could be that this group performed well on the IGT as the result of mechanisms of their psychological disturbance and not necessarily from the result of the brain injury suffered. The date at which psychological distress was diagnosed was not taken into consideration in the analyses. Therefore, it is not known whether those with TBI and a diagnosis of psychological distress as a consequence of their injury would have indicated impaired performance. Consequently, there are a variety of factors that could have been taken into consideration, which may have produced different results. Future studies should consider classifying groups while taking into account the temporality in which an individual with TBI was diagnosed with emotional disturbance as this may reveal impaired performance in those who had pre-existing psychological distress.

Another factor contributing to these results may have been the duration of time since the precipitating traumatic brain injury event. The criteria for inclusion of individuals into Group 1 was based on the injury having occurred no more than two years ago. Further, records did not include Glasgow Coma Scale Scores, length of Post Traumatic Amnesia, or length of loss of consciousness to properly classify the severity of the TBI sustained. As a result, at the time of the evaluation most injuries were described as mild and were denoted as a “concussion”.

Under most circumstances, individuals who sustain a mild TBI usually fully recover within a few months; slow or incomplete recovery could be explained by other factors (Iverson, 2005). In cases accompanied by psychological distress, cognitive symptoms tend to be prolonged. It may be the case that as the time from injury elapses, an individual can develop a psychological reaction. Accordingly, future studies should consider examining individuals whose injuries are closer to the time of evaluation than those in this current study. Overall, findings of this study support the idea that patients with a documented head injury and a diagnosis of psychological distress can maintain intact performance on the IGT.

Hypothesis 3

There is an abundance of literature on the IGT. However, one area of research that is somewhat limited concerns convergent and divergent validity of the measure to other assessments administered in a neuropsychological evaluation. The IGT is a unique task that was modeled after the Somatic Marker Hypothesis and integrates the "cold" and "hot" aspects of EF and their influence on one another in decision-making. Determining how the IGT "fits" into a standard neuropsychological battery is an interesting topic due to the research on "hot" and "cold" executive functioning. "Cold" executive functioning is mechanistic and logically based and does not include high levels of emotional arousal. Traditional tests of executive functioning are thought to tap "cold" EF and are associated with the dorsolateral prefrontal cortex. Alternatively, "hot" executive functions are tapped by affective- laden tasks that include use of reward and punishment, and are mediated by the ventral medial and orbital frontal areas of the prefrontal cortex. Examining convergent and divergent validity of the IGT to other measures is an area where additional research is needed and has practical implications (Buelow & Suhr, 2009). The results of this study have added to this small base of literature. Additionally, this study specifically addressed convergent/divergent validity among a clinical sample, which is lacking in the literature.

The Wisconsin Card Sorting Task (WCST) and the IGT are both tasks purported to tap EF, and have been investigated in the literature. Overman et al. (2004) examined correlations of the WCST with the IGT in healthy young adults, and Bechara et al. (2001) did the same with patients with substance abuse. Both studies found no relationship between the IGT and scores on the WCST. In the current study, the categories completed score on the WCST correlated with the overall IGT Net score as well as the block scores from blocks 3, 4, and 5 of the IGT. These findings support the research of Brand et al. (2007) and Gansler et al. (2011) who found that later blocks of the IGT showed stronger correlations with executive functioning measures, specifically the WCST. These weak but positive significant correlations were noted towards the middle and end of the task, which supports the idea that the latter part of the IGT is associated more with executive functioning because it is considered to be “decision under risk” (Gansler et al., 2011). Conceptually, both the IGT and WCST are similar in that the examinee needs to be cognitively flexible in the face of constantly changing schedules of reward and punishment, hence the correlation between the IGT score and the categories completed on the WCST.

From a neuroanatomical perspective, the significant correlation between the WCST and IGT NET score and score from blocks 3, 4, and 5 also seem to be consistent, even though some studies in the literature comparing these two measures show mixed results. The WCST activates the dorsolateral prefrontal cortex (Shurman, Horan, and Nuechterlein, 2005). Some studies using neuroimaging of the IGT indicate that the IGT taps both the orbitofrontal prefrontal cortex and dorsolateral prefrontal cortex (Ernst et al., 2002). Additionally, using fMRI, Li et al. (2010) found that the IGT activates the orbitofrontal prefrontal cortex, ventromedial prefrontal cortex, and dorsolateral prefrontal cortex. This finding is consistent with the notion of the somatic marker hypothesis in which our emotion guides our decision making and that our “cold” executive functions subserved by the dorsolateral prefrontal cortex work in synchrony with “hot” executive functions subserved by the orbitofrontal and ventromedical prefrontal cortex. The correlation between the IGT and WCST categories completed score may point to this notion as well.

Results suggest that the IGT requires some of the same components of executive functioning as the WCST. For example, both tests involve abstract reasoning, identifying different ways to problem solve, maintenance of a successful method of problem solving, flexibility in set shifting, and task switching demands based on feedback. The examinee must identify the “good” versus “bad” decks and use the feedback provided in order to avoid losing money. The score from Trails B also showed weak but positive significant correlations with the IGT Net score and the score from blocks 2, 3, and 5. This also supports the idea that the IGT may recruit aspects of executive function, including set-switching, ability to execute and modify a plan of action and cognitive flexibility. Additionally, Trails B is also conceptualized as a measure of complex visual attention, which can also be said of the IGT. Overall, this finding supports the notion that the examinee may recruit more executive functioning abilities in order to complete the IGT in the latter aspects of the tasks because this part of the task represents decision-making under risk rather than decision-making under ambiguity. However, since the correlations were weak and positive, results should be interpreted with caution.

Significant correlations between IGT Net and block scores with other measures of executive functioning (regardless of group structure) were found. Although significant, these correlations were weaker than hypothesized. It may have been the case that only weak, positive correlations were obtained because the IGT is a unique measure of executive functioning and taps the “hot” and affective- laden aspects of EF whereas the other EF tasks do not. Additionally, correlations may have been lower than expected due to the heterogeneous and intricate nature of executive functioning. For example, executive functioning is such a broad domain that encompasses disparate entities such as working memory, set-shifting, inhibition, abstraction, and problem solving. Furthermore, because executive functioning is an umbrella term for a wide range of functions, performance on one measure of executive functioning has little predictive value for how that person will perform on other measures (Chan, Shum, Toulopoulou, & Chen, 2008).

The significant but weak positive correlations between Judgment of Line Orientation and the IGT Net score as well as the IGT score from blocks 3 and 4 is an anomalous finding. One possible explanation for this may be that both are visual based tasks that recruit visuospatial and attention abilities. The score from Logical Memory II, a task of delayed memory, also significantly correlated with the score from block 4 of the IGT. Although this finding was unexpected, it could be the case that in the later part of the IGT, participants relied on aspects of delayed memory of “hunches” or contingencies of the decks to select the cards. Additionally, some research suggests that performance on the IGT involves learning and memory processes (Al-Khindi, Macdonald, & Schweizer, 2014).

Another possible explanation for lower than expected but significant correlations between the IGT and measures of EF could have also been age. Even though the scores on tests of executive functioning in this study were corrected for age, individuals did range in age from 18-66 years. The frontal lobes, the area which subsumes executive functioning, do not fully develop until an individual reaches their early twenties. As a result, research also suggests that different aspects of EF are less readily discernable in childhood versus adulthood (Lehto & Elorrine, 2003). It could be the case that scores on measures of EF have higher intercorrelations because the frontal lobes have not yet fully developed and matured, therefore there is less variance in scores. In contrast, developed frontal lobes in adults are able to carry out the distinct higher-order processes that compose the different abilities of executive functions.

Results from this hypothesis provide clinically useful information to neuropsychologists about how the IGT fits within an assessment battery. It is important for clinicians to be aware that the IGT may not solely be a measure of executive function. Specifically, the task may account for a different aspect of executive functioning than traditional "cold" measures of EF. The IGT may also involve other cognitive domains besides executive functioning such as delayed memory and visual-spatial ability. The results of this study help to bridge the gap in the literature of convergent and divergent validity of the IGT to other measures.

Expoloratory Analyses

Interestingly, comparison of group performance on the separate blocks of the IGT revealed significant group differences on the score for Block 4 of the task. Group 2, as a whole, had a higher mean score on block 4 as compared to group 1. This same trend was also observed when 10 individuals were extracted from Group 2 to form a "purer" diagnostic sample. In this analysis, the mean score for individuals in Group 2 was also significantly higher than the score for individuals in Group 1 and the score of individuals in Group 2 before 10 individuals were extracted and the analysis was rerun. Even though there were differences in scores, neither group evidenced impaired performance on the IGT. Although the reason for this finding is unclear, and a Bonferrroni-adjusted correction indicated that this was likely a chance finding, it may be the case that fatigue affected the performance of individuals in Group 1. The mean performance of individuals in Group 1 mostly decreased over time and then showed a slight increase in the last block of the task (IG1= 53.13, IG2= 52.03, IG3= 49.97, IG4= 45.60, IG5= 48.20). Even though both groups evidenced intact performance on each block by IGT standards, it is possible that individuals in Group 1 showed a decrease in performance due to cognitive fatigue associated with their brain injury. Individuals in Group 2 may have not had this same reaction due to the absence of brain injury. Further research should more closely examine group differences on block 4 of the IGT.

Limitations

The current study underwent several changes from the proposed study. Originally, this researcher hoped to classify individuals with TBI into "mild" and "moderate" groups. This was going to be achieved by using the score on the Glasgow Coma Scale (GCS), length of loss of consciousness (LOC) or length of Post-traumatic amnesia (PTA). In the absence of any documented GCS, LOC, or PTA, a documentation of "mild" or "moderate" TBI in the medical records or documentation by the interviewing neuropsychologist as "mild" or "moderate" was going to be used to determine inclusion into one of those categories. Unfortunately, when reviewing the data, it became clear that individuals rarely had GCS scores, or length of LOC or PTA in their medical charts. As a result, it was impossible to separate enough participants into "mild" and "moderate" TBI groups. It also became clear that there were only a handful of individuals who possessed the sole diagnosis of TBI without any comorbid Axis I diagnoses. Obtaining groups of individuals composed of "mild" and "moderate" TBI would have allowed for more accurate examination of severity of brain injury on IGT scores and other executive functioning measures. The high degree of emotional disruption as a comorbidity of TBI (ranging from 11 to 77%) increases the difficulty for obtaining a "pure" TBI cohort absent of any emotional disruption (Zasler et al., 2012). Even though the study conducted by Levine et al. (2005) showed no difference in performance between different levels of severity of TBI, this would have been an important area to replicate.

Information on lesion location of the brain injury was also proposed to be addressed in the current study. However, very few individuals had inpatient records from AGH indicating areas of the brain affected by their injury from a CT scan or MRI. Past studies have found mixed results in relating IGT performance to specified brain regions. Manes et al. (2002) and Levine et al. (2005), found that patients with large focal lesions to the prefrontal cortex evidenced impaired performance on the IGT. In contrast, research by Fujiwara, Schwartz, Gao, Black, and Levine (2008) did not find specificity of performance on the IGT to the prefrontal cortex. It would be beneficial for future studies to examine lesion location in relation to performance on the IGT to add to the literature in this area.

When this study was proposed, the researcher intended to examine a group of individuals who were "psychologically distressed". This group was going to include individuals who presented for an outpatient neuropsychological evaluation with a diagnosis related to depression or anxiety or who were given the diagnosis as a result of the evaluation. These individuals would have ideally not had any other diagnosis on Axis I. However, it was difficult to find enough people who had this presentation without the overlap of other psychological or health issues. The fourth group that was proposed to be included in the analysis was a control group of compromised individuals who did not have any Axis I diagnosis before or after the outpatient neuropsychological evaluation was completed. After examining the data, it became clear that there would not be any individuals in the control group. As a result, the researcher established two groups instead of the proposed four. The first group was composed of individuals who had a diagnosis of psychological distress and were being evaluated due to symptoms related to a TBI. The second group was composed of individuals who had no history of TBI but were given a diagnosis of a disorder relating to emotional distress.

As a result, one of the most prominent limitations of this study was the nature of the archival data used. It was not possible to obtain pure diagnostic groups with people who were just diagnosed with an emotional disorder and people who were diagnosed with an emotional disorder and traumatic brain injury without any diagnoses on Axis III. Not all individuals included in Group 1 and Group 2 were devoid of health issues on Axis III, personality issues on Axis II, and attention issues on Axis I. In this way, the data used serves as a limiting factor because diagnostic groups were contaminated, so-to-speak. Although this obscures definite conclusions in terms of performance, it is a reflection of real-world data and the comorbidity of disorders and health conditions that people present with for an outpatient neuropsychological evaluation. In this respect, the data are highly representative of what is seen in the clinical realm of outpatient neuropsychological assessment.

Caution should be taken when interpreting the results of this study due to the diversity of examiners included in outpatient assessment. Since there were different examiners conducting evaluations, administration or scoring of measures may not be reliable. One example of this was on Trails B. When scoring this measure, some examiners may have not taken into account reversing the score to account for the time component of the task. The errors that were identified when collecting the data were corrected before the z score was converted to a T score, but it is possible that other errors remained, undetected.

This study may have also possibly included a biased sample. The majority of individuals who present to the clinic for an outpatient assessment have some awareness that aspects of their cognitive functioning are interrupted. As a result, it could be that IGT scores were mostly unimpaired due to this awareness. Future studies should also examine a population of healthy individuals as a control group in addition to those with the clinical conditions examined in this study.

Another limitation of this study was that there were individuals who were either missing test scores or had scores from different editions of tests. An important example of this was seen in the data with the Wechsler Memory Scale III (WMS) edition and WMS IV edition. AGH started to replace the WMS III with the WMS IV in the middle of 2011. There were individuals in the database that better fit the inclusion criteria for Group 1 and Group 2. However, since these individuals were tested in early 2011, their test scores on Logical Memory II and Verbal Paired Associates II came from the WMS III and these two subtests changed from the third to the fourth version. As a result, individuals who were administered the WMS III were unable to be used.

Not utilizing raw scores for the different trials on the IGT was also an additional limitation because doing so could have provided information on an examinee's learning pattern throughout the assessment. Future studies should examine the examinee's raw scores on each trial to assess for the possibility of learning throughout the task. The raw scores for number of cards picked from decks A, B, C, and D and their relationship to other measures administered during a neuropsychological evaluation would also be interesting for future research to explore.

Overall, it appears that this study's contribution to the literature is significant for a number of reasons. To the best of this writer's knowledge, this was the first study to examine and compare individuals with TBI and a disorder relating to psychological distress and individuals with a disorder related to psychological distress without history of a traumatic brain injury. It showed that in an outpatient, clinical sample, individuals with this history can maintain intact performance on the IGT. Contrary to what was hypothesized, in individuals with TBI and psychological distress, measures of executive functioning did not correlate more highly with later blocks of the task than with earlier ones. Results from this study also suggest that the IGT is not solely a measure of executive functioning. Additionally, the task may tap into different aspects of executive functioning such as set shifting, divided attention, and cognitive flexibility, aspects of memory, and visual perception. This appears to be no different than other neuropsychological measures that are polluted in the sense that they do not assess a single construct and are influenced by a myriad of other abilities.This knowledge helps clinical psychologists in case conceptualization, interpretation of test scores and report writing. Importantly, the results of this study added to the limited literature on convergent and discriminant validity of the IGT to other measures. The study accomplished this goal by using an outpatient clinical sample, which is also limited in the literature but important from the standpoint of generalizability.

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Appendix A: IGT Instructions

"In front of you on the screen, there are 4 decks of cards A, B, C, and D. I want you to select one card at a time, by clicking on the card, from any deck you choose. Each time you select a card, the computer will tell you that you won some money. I don't know how much money you will win. You will find out as we go along. Every time you win, the green bar gets bigger. Every so often, however, when you click on a card, the computer tells you that you won some money, but then it says that you lost some money too. I don't know when you will lose, or how much you will lose. You will find out as we go along. Every time you lose, the green bar gets smaller. You are absolutely free to switch from one deck to the other at any time, and as often as you wish. The goal of the game is to win as much money as possible, and if you can't win, avoid losing as much money as possible. You won't know when the game will end. You must keep on playing until the computer stops. I am going to give you this $2,000 credit, the green bar, to start the game. The red bar here is a reminder of how much money you borrowed to play the game, and how much money you have to pay back before we see how much you won or lost. It is important to know that just like in a real card game, the computer does not change the order of the cards after the game starts. You may not be able to figure out exactly when you will lose money, but the game is fair. The computer does not make you lose money at random, or make you lose money based on the last card you picked. Also, each deck contains an equal number of cards of each color, so the color of the cards does not tell you which decks are better in this game. So you must not try to figure out what the computer is doing. All I can say is that some decks are worse than the others. You may find all of them bad, but some are worse than the others. No matter how much you find yourself losing, you can still win if you stay away from the worst decks. Please treat the play money in this game as real money, and any decision on what to do with it should be made as if you were using your own money."

Bechara, (2007)