THE EFFECTS OF INDUCED POSITIVE AND NEGATIVE EMOTION ON WAIS-IV

WORKING MEMORY AND PROCESSING SPEED PERFORMANCE

by

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I. INTRODUCTION

Background

Research on mood and emotion is a major topic of interest within psychology. Likewise, there is an abundance of research surrounding cognitive performance and factors that influence it. A range of factors influence cognition such as chronic pain, clinical depression, traumatic brain injury (TBI), stroke, dementia, substance abuse, and others (Etherton & Tapscott, 2014; Chepenik, et al., 2007). However, the effects of factors such as mood seem to have been frequently overlooked, despite the fact that mood is a pervasive feature of the human experience (Chepenik, et al., 2007). Consequently, information on how mood and emotion might relate to cognitive performance is relatively sparse.

However, there are some conclusions about the general effects of mood on cognitive performance. When negative affect is induced, individuals are better at sifting through information to develop a more accurate conceptualization of what has been presented to them (e.g. Chepenik, et al., 2007; Matovicet, et al., 2014.). In contrast, when positive affect is induced, individuals express greater levels of cognitive flexibility and speed (e.g. Martin & Kerns 2011; Palmiero, et al., 2015.). However, there is a lack of consensus regarding the different ways that mood may influence cognition.

Indeed, reviewing the body of literature reveals a sense of uncertainty about this interaction. Many studies have explicitly made note of the dearth of evidence surrounding this topic (e.g. Chepenik, et al., 2007; Pretz, et al., 2010; Schnitzspahn, et. al., 2014; Scrimin & Mason, 2015). Additionally, there are discrepancies in both theory and evidence, and some data-supported hypotheses are contrasting and incompatible

(Oaksford, et. al., 1996).

For example, Oaksford et al. (1996) describes two hypotheses which are frequently used to draw support for theories and research involving mood and cognition. The facilitation hypothesis postulates that positive mood facilitates improved performance on cognitive tasks that relate to creative problem solving. A prime example of this is in Isen et al.'s (1987) experiment in which participants in neutral, positive, or negatively induced moods were asked to support a lit candle using only a box of tacks and some matches. Participants that were induced with positive moods succeeded at completing this task at a much higher rate when compared to the other groups. It has been argued that because divergent, creative thinking and convergent, deductive reasoning both exploit working memory, similar effects should be observed in both of these areas. Evidence for this proposal can be observed in articles such as Isen & Patrik, (1987), Yang et al., (2013), and Schomaker et al., (2016) where mood induction leads to improvements in tasks which utilize working memory.

In opposition to this is the suppression hypothesis. The suppression hypothesis is based on resource allocation theory, originally proposed by Ellis and Ashbrook (1987). Resource allocation theory states that because individuals in negative and positive mood states show a recall bias for negative and positively valanced materials respectively (Oaksford et al., 1996), these individuals have fewer available resources for tasks involving working memory. Theoretically, positive and negative moods act as a retrieval cue for such material, allowing for spontaneous retrieval which may in turn lead to task-irrelevant processing and depletion of working memory capacity (Oaksford et al., 1996). Other studies have also demonstrated that mood state leads to decreased performance on tasks which utilize working memory (e.g. Martin & Kerns, 2011)

Significance

Regardless of discrepancies in the direction of effects, there is notable evidence that induced mood is associated with changes in many cognitive processes. If the growing body of literature continues to reinforce what has already been observed, many could find it necessary to take the mood and emotions of their participants into account in their research.

If we were to find that certain cognitive domains are significantly affected by an individual's mood, this knowledge could be important enough to factor into how we conduct assessments. Theoretically, if results from a particular assessment show improvement when the positive affect of an individual is intense, could we hypothesize that this is their optimal performance? That is, has positive affect offset factors that may hinder cognitive ability? Alternatively, could intense positive affect act as a hindrance to optimal performance? Similar questions could be hypothesized for the effect of negative moods on cognitive processes based on our findings.

Implications of Research

The furtherance of this concept and the questions associated with it would have many practical implications for both clinical practice and research. For instance, significant findings could suggest that when administering an assessment, it would be appropriate to first emotionally prime the examinee with a mood induction procedure so that they would be most likely to produce their best performance. Alternatively, it could be appropriate to determine the current mood state of an examinee in order to determine if it might affect the results of the assessment.

This research could also have implications for school psychology and assessments related to school and education. Children experience fluctuations in mood far more frequently than adults, and adolescents even more so than children (Lennarz et al., 2019). Therefore, finding that mood influences cognition in a college sample might be significant to those interested in performing assessments with younger populations. Possible strategies could include watching an affect-inducing video prior to taking an assessment, or halfway through a lengthy procedure to help maintain affective consistency.

Problem/Objective

Issues with Mood Induction/Rating

The literature surrounding affect and cognition doesn't appear to develop a consistent narrative of how the two variables interact with each other. As discussed previously, facilitation and suppression hypotheses of mood and cognition exist which are incompatible yet justified by research. One possibility for this could be that there is a dearth of evidence surrounding the topic (Chepenik et al., 2007), therefore a consistent narrative cannot be derived from the available data. Another possibility is that there are inconsistencies in how researchers induce moods and emotions, resulting in unintentional variability (e.g. Chepenik et al., 2007; Martin & Kerns 2011; Palmiero et al., 2015). For instance, in a study by Chepenik, et al., (2007), mood congruent music was used to induce the desired mood, and changes in mood were measured on a visual analog scale. However, this method of mood induction is suboptimal according to a widely cited study by Westermann et al. (1996) which claims that mood induction using music produces only a moderate effect size, while mood induction using films produces a large effect size and "is clearly the most effective procedure" (p.575).

We determined that multiple studies cited in this paper used what could be perceived as less than optimal methods of mood induction (Grol & De Raedt, 2018; Pretz et al., 2010; Yang, et al., 2013). Therefore, further additions to mood-cognition literature which use consistent, validated, and optimal research methods could be seen as beneficial.

Lack of Research Surrounding Induced Affect

Another issue we have identified is that while some studies have previously evaluated cognition in the context of specific emotions and moods (Chepenik et al., 2007; Martin & Kerns, 2011; Palmiero et al., 2015), fewer studies assess whether affect has an effect on cognitive processes, as affect is distinct from mood and emotions (described in detail later). Additionally, many studies are quasi-experimental in that they seek out individuals in affective states (e.g. depression) rather than employing a true experimental method. Therefore, a study which tests how induced affect effects cognitive processes such as working memory and processing speed would be a valuable addition to the literature.

Hypothesis

Affect as Information Model

Our hypothesis is derived from the "affect as information" (AAI) model, which seeks to provide a greater understanding of the relationship between affect and cognition (Isbell, 2003; Wyer et al., 1999). The AAI model states that affective feelings provide individuals with conscious feedback about unconscious processes (Isbell, 2003). AAI model draws upon theories of appraisal which state that humans are continuously and unconsciously evaluating their surroundings in the frame of their current objectives (Isbell, 2003). Different affective feelings arise from these appraisals, negative feelings from a poor appraisal and positive feelings from a good appraisal, which can direct future judgements. The feelings from these appraisals then help the individual to better assess whether an environment is safe or problematic (Bless et al., 1996; Isbell, 2003). Furthermore, newly formed assessments of the current environment change the way incoming information is processed. Negative affect indicates there is something troublesome in the environment (socially, physically, etc.), and therefore incoming information is processed with increased scrutiny to more thoroughly assess one's surroundings (Bless, 2011; Bless et al., 1996; Isbell, 2003). Conversely, positive affect indicates that the environment is safe, thus incoming information is processed with decreased scrutiny. There is additional evidence that this could also increase one's confidence in abstract information such as stereotypes, general knowledge, and past information that has been useful (Bless, 2011; Bless et al., 1996; Isbell, 2003). It is assumed that this occurs because information of this nature has previously proven to be beneficial, therefore it is prioritized in favor of using additional resources to address a given situation. Therefore, in situations where a danger is unlikely, cognitive systems rely on what they already learned when processing new information and will not be prompted to engage in more thorough processing of finer details.

Beyond the AAI Model

We built upon these theories to hypothesize that affect could have some impact on processes such as working memory and processing speed. Working memory holds limited amounts of information which likewise has a limited duration within that space

(McLeod, 2012). Therefore, distractions or the introduction of newer information can lead to the abandonment of previously stored information in favor of something else. We hypothesized that because of the AAI model, negative affect might increase attention to information stored in working memory, therefore leading to better performance on such tasks. However, it's entirely possible that the previously introduced suppression hypothesis could have come into play as well. If this is the case, we could have seen a decrease in performance because of a reduction in working memory capacity. If this was true, we could have seen the same effect with positive affect.

Likewise, we hypothesized that we would see unique effects in terms of processing speed as well. Processing speed refers to the speed at which information is processed. Because of the implications of the AAI model, we predicted that individuals who have higher positive affect would spend less time processing information presented to them, thereby allowing them to perform better on tests of that nature. In theory, positive situational appraisals would lead individuals to see their environment as benign, therefore they would not go through additional measures to process new information.

Ultimately, based on the information presented, the proposed hypotheses were that (1) positive mood induction would result in improved processing speed performance; and (2) negative mood induction would result in improved working memory performance. We were likewise cautious to the effects of suppression and facilitation hypotheses and how they could have interacted with propositions of the AAI model.

II. LITERATURE REVIEW

Mood and Affect

Defining Mood, Affect, and Emotions

Affect refers to the subjective state of experiencing positive or negatively valanced emotions at a given point in time (Watson et al., 1988; Wyer et al., 1999). Positive affect includes feeling enthusiastic, active, and alert, or a general sense of positive emotion (Watson et al., 1988; Wyer et al., 1999). In contrast, negative affect includes feelings of distress, anger, contempt, disgust, guilt, fear, and nervousness (Watson et al., 1988; Wyer et al., 1999) Put more simply, positive affect can be described as the various feelings people experience when things seem to be going well, and negative affect can be most easily described as the experience that things are not going well (Diener et. al., 2017).

Oddly enough, we found that many researchers neglect to provide a proper definition for mood at all (e.g. Maekawa et al., 2018; Matovic & Forgas, 2018; Pretz et al., 2009). Regardless, in the present-day mood is typically defined as long-lasting, generally either positive or negative feelings which are not immediately attributed to a single event (Diener et al., 2015; Schimmack et al., 2000). This is in contrast to emotions, which are typically defined as short-lived, specifically targeted feelings which could be attributed to a single event (Diener et al., 2015; Schimmack et al., 2000). Emotions have also been defined as an action tendency (Hofmann et al., 2018). This means that emotions are essentially a tendency to act in a certain way as a result of an external stimuli. In this same context, emotions are forces which aid survival by encouraging us to engage in a beneficial action, such as to flee in terror, or to seek companionship because of love.

As such, moods and emotions generally may be distinguished by whether the feelings are clearly and purposefully directed towards a specific target (Schimmack et al., 2000). We can observe this distinction in everyday language through phrases such as, "I was sad to see 'X' go, but I'm happy for them (emotions). However, since then I've been feeling down (mood)."

It is also worth noting that many researchers tend to use "affect" interchangeably with "mood" as some consider both constructs to be synonymous (e.g. Jonauskaite et al., 2018; Mohanty, 2014; Stumm, 2018; Vranić & Tonković, 2017; Xie & Zhang, 2018). Perhaps this is because historically the taxonomic qualities of affect have been less solidified than those of mood and emotions (e.g. Schimmack et al., 2000). There is evidence that as late as 1992, experts in this field failed to differentiate between not only affect and mood, but occasionally mood and emotions as well (Ekkekakis, 2015). This has led to some referring to the current taxonomic state of mood, emotions, and affect as a "terminological gordian knot" (Ekkekakis, 2015, p. 40). Only recently have experts seen a need to have clearly distinct definitions for these concepts for the sake of more accurate research and communication between professionals.

As opinions of proper taxonomic classifications continue to develop, many experts insist that affect is a distinct entity from mood (Diener et al., 2015; Ekkekakis, 2015; Schimmack et al., 2000). Proponents of this classification would say that out of emotion, mood, and affect, affect is the most general form of feeling which includes both moods and emotions (Diener et al., 2015). Therefore, in this case, affect is susceptible to relatively rapid shifts – less than emotion, but more so than mood alone (Schimmack et al., 2000). Affect is a collection of consciously accessible feelings, though more accurately, it is the active direction of those feelings which are consciously available, and it provides a cognitive springboard from which other feelings are derived. In *The Measurement of Affect, Mood, and Emotion: A Guide for Health-Behavioral Research,* Ekkekakis and Russell (2013) say "[Affect] provides the experimental substrate upon which the rich tapestry of moods and emotions is woven," (p. 40) and furthermore, "[Affect is] the most elementary consciously accessible affective feelings" (p.38). Building off the example in the previous paragraph, we can observe this distinction in everyday language through the phrase "I was sad to see 'X' go, but I'm happy for them (emotions). However, since then I've been feeling down (mood). Though, I appreciate you helping to cheer me up (affect)"

Mood Induction Procedures

Mood induction procedures (MIPs) are the many ways in which a person might have their affect or emotions altered for the purpose of an experiment (Westerman, 1996). Historically there are many techniques with varying degrees of effectiveness for different situations. Descriptions of these MIP techniques have been gathered primarily from Westerman (1996) with some additional information from Marcusson-Clavertz et al. (2012).

Imagination: With this method subjects imagine situations from their lives that would invoke the desired mood (e.g. Grol & De Raedt, 2018). *Velten:* Developed by Emmett Velten (1968), the subject is instructed to read a number of either positive or negative self-referential statements (e.g. "I feel great," "I've doubted that I am a worthwhile person"), and try to feel the mood described in the statement. *Film/story:* here, subjects are presented some material involving an emotion inducing narrative to help stimulate imagination (this method is occasionally employed with specific instruction along the lines of "get involved in the situation" or "think about these emotions" (e.g. Masuyama & Mochizuki, 2018). *Music:* subjects listen to mood-suggestive classic or modern music after being instructed to reciprocate the mood the music is suggesting (this method is occasionally employed with specific instruction along the lines of "get involved in the situation" or "think about these emotions" (e.g. Chepenik et al., 2007). *Feedback:* subjects are given positive or negative feedback about their performance on a test. *Social interaction:* subjects interact with a confederate trained to express a particular mood, and it is assumed the affect of the subject will be affected by that of the confederate. *Gift:* this method is based on the assumption that most people will experience positive affect upon receiving an unexpected gift (e.g. Yang & Yang, 2014). *Facial expression:* the face of the subject is manipulated in order to induce moods associated with that face (frowns, smiles, etc.).

According to a meta-analysis by Westermann et al. (1996), the expected effect size for the experimental induction of positive or negative mood is medium to large, i.e. they are associated with point-biserial r values generally between 0.24 and 0.37 (point-biserial r is closely related to the standardized difference between group means, d, according to Cohen (1977)). When transformed to z values, and weighted based on sample size, the mean effect is 0.47. More specifically, the weighted effect was 0.41 for positive mood and 0.53 for negative mood. They also reported that of all mood induction techniques, the most effective one's were film/story, music, Velten, and facial expression techniques. They noted that according to experts in the field, on average 75 percent of subjects have the desired change in affect when using film/story and music MIPs, and

Velten and facial expression MIPs achieve the desired change in affect in about 50 percent of subjects. However a direct comparison of these techniques in meta-analytic format revealed that film/story plus instruction is clearly the most effective MIP for the induction of both positive and negative mood states having a weighted mean effect of 0.738 (0.726 for positive moods and 0.743 for negative moods. Derived from z scores). The mean effect size of music plus instruction was 0.440, the mean effect size of Veltan was 0.467, and the mean effect of feedback was 0.494.

Another thing we understand from research surrounding MIPs is that the affective changes that result from mood induction lead to changes in multiple domains. That is, it is difficult to induce any single feeling without producing any additional changes across the rest of the affective spectrum. This has been well established for some time, as we can see explained in early studies which make claims such as, “one emotion can almost instantaneously elicit another emotion that amplifies, attenuates, inhibits or interacts with the original emotional experience” (Izard, 1972, p. 77), and “we should be aware that our investigations of "an emotion" are most probably investigations of several simultaneous emotions” (Polivy, 1981, p. 816). Ultimately, from this we can conclude that MIPs are more accurately “affect induction procedures” since mood alone is difficult to manipulate, and MIPs produce broad emotional changes which could simply be described as changes in affect.

Affect and Cognition

Background and Theories

It is widely accepted that affect interacts with certain cognitive judgements. This interaction has been fleshed out among numerous theories. Mood priming theory states that mood primes an individual for reactions of the same nature as one's mood (Isen et al., 1978). Affective realism theory states that affective influences alter the foundations for affective consciousness and future judgements (Anderson et al., 2012). The affect infusion model states that the degree of affect infusion into judgments varies along a processing continuum in which judgments requiring heuristic or substantive processing are more likely to be infused by affect than direct access or motivated judgments (Forgas, 1995). Additionally, there are the affect-as-information model, facilitation hypothesis, and suppression hypothesis which were explained earlier (Schwarz & Clore, 1983). However, the theory we believe is most relevant to this research is the affect as information (AAI) model. This is because we believe the AAI model is well explored and offers the clearest predictions for how induced emotion would affect cognitive functioning.

For review: humans continuously and unconsciously evaluate their surroundings in the frame of their current objectives (Isbell, 2003). Different affective feelings arise from appraisals: negative feelings from a poor appraisal and positive feelings from a good appraisal, which direct future judgements, and feelings from these appraisals help the individual to better assess their environment (Bless et al.,1996; Isbell, 2003). Newly formed assessments of the current environment change the way incoming information is processed. Negative affect indicates there is something troublesome in the environment (socially, physically, etc.), which leads to increased scrutiny (Bless et al., 1996; Bless, 2011; Isbell, 2003). Alternatively, positive affect indicates that the environment is safe, which leads to decreased scrutiny. (Bless et al., 1996; Bless, 2011; Isbell, 2003).

Social and evolutionary psychologists hypothesize that the reason for this phenomenon is that humans have historically needed to more carefully examine their surroundings whenever their affect is negative, because negative affect could signal that there is something wrong (perhaps even dangerous) within the environment. Therefore, increased consideration to how incoming information is processed could lead to better chances of survival by more carefully evaluating input for indications of potential threat (Huntsinger & Ray, 2016). However, while negative affect could lead to better chances of survival in some situations, people are more often in a positive mood (Diener et al., 2015; Huntsinger & Ray, 2016). The hypothesized reasoning behind this is that when negative stimuli are absent, a positive mood would actually be more beneficial for survival and could also increase the chances of reproductive success (Diener et al., 2015). Positive moods provide survival utility by strengthening relationships and improving the ability to adapt and think creatively (Diener et al., 2015). Therefore, positive affect seems to be a baseline emotional state which is used to produce more benefit for an individual in a majority of situations (Diener et al., 2015). In contrast, negative affect arises when a threat to safety or survival emerges that needs solving (Diener et al., 2015).

Varying levels of scrutiny and reliance on stereotypes might very well produce changes in the way participants pay attention, learn and store information, and the speed at which these processes are completed. Therefore, in theory, the AAI model could have explained some of the effects (if any) we saw on our assessment post manipulation.

Affect and Decision Making

Positive affect induces the use of stereotypes and other heuristics as a basis for judgement (Bodenhausen et al., 1994) and decreases attention to argument strength (Schwarz et al., 1991). Alternatively, sad moods seem to be associated with systematic information processing where judgements are based on careful scrutiny (Bodenhausen et al., 1994), and individuals with negative moods are less likely to be persuaded by weak arguments (Schwarz et al, 1991). For example, Isbell (2004) conducted an experiment in which participants would first hear either a negative or a positive description of a person, and then a story about the person which implied equal numbers of positive and negative attributes (i.e. the person was essentially "neutral"). Their results indicated that after hearing the story, happy individuals gave more negative reviews of the person when the initial description of them was negative, and more positive reviews of the person when the initial description was positive. However, unhappy people gave appraisals that were more neutral regardless of how the person was initially described to them. This implies that happy people rely on stereotypes to form perceptions more so than the actual characteristics of a person, and unhappy people rely on stereotypes to a lesser extent. Instead, they use discretion to perform a bottom-up assessment which is not heavily influenced by top-down factors such as stereotypes.

Affect and Executive Functioning

Negative Affect. Even though mood is a salient and pervasive feature of everyday life, researchers rarely consider it when performing a cognitive assessment. Therefore, for most studies of cognition, we can only assume that participants are in a neutral or average mood (Chepnik et al., 2007). In 2007, Chepnik et al. described the current research surrounding how mood affects executive function as a "dearth of evidence." However, a few researchers have examined this relationship. Most studies appear to focus on depression and melancholy (e.g. Austin et al., 1999; Matovic, 2014) perhaps because depression and melancholy are considered problematic affective states, unlike positive affect.

A thorough study by Chepnik et al. (2007) covered a variety of cognitive assessments in relation to negative affect through mood congruent music plus script MIP. Two tests specifically targeted working memory: object 2-back and digit span. Object 2-back is a standard 2-back paradigm with random polygons in which participants were asked to respond “yes” or “no” to indicate whether or not each shape matched the one that appeared two shapes ago. Digit span is a standard digit measure in which participants must read back increasing lengths of number strings in-order and then backwards. The task is terminated in both cases when participants fail to recall two trails consisting of the same number of digits.

Two tests specifically targeted attention and perception: Stroop color-word interference and go/no-go. In Stroop color-word interference words are presented one at a time in a standard color Stroop experiment. Reaction time of responses was measured and compared between experimental and control groups. In go/no-go, numbers are displayed one at a time every second. Participants are instructed to hit a button as quickly as possible in response to every number except “4” and reaction time was recorded.

Three assessments specifically targeted attention, perception, and memory for affectively valanced materials: attention probe, free recall and recognition memory, and facial emotion recognition. Attention probe begins with a fixation signal replaced after 1 second by a pair of words consisting of a neutral-negative or neutral-positive word pair. Word pairs are displayed 4 cm apart vertically in the center of a computer screen for .5 seconds after which they disappeared, and an “X” or an “N” appeared in the same location as what was previously occupied by either the neutral or emotional word.

Participants were then told to press “X” “N” in response to the probe. Response time was recorded and used to calculate attention bias. In free recall and recognition memory, 1 word is displayed for 2 seconds in the center of a screen. Half of the presented words had negative emotional valence and half of them had neutral emotional valence. After a set of 16 words was completed, participants were asked to recall as many words as possible. After three sets were completed, participants were shown another list of words including the previously shown words plus an equal number of new words. They were then instructed to identify which words were in the original sets. Facial emotion recognition uses Ekman photographs of people displaying neutral facial expressions as well as expressions of happiness, sadness, anger, and fear. These faces were presented one at a time for .5 seconds, and participants were instructed to choose one of the five possible emotions to describe each face.

In their study, sad mood only appeared to positively affect memory for emotional words and facial emotion recognition. Other tasks showed no significant differences in performance when compared to the control. Other studies have similarly tested the effects of negative affect on cognitive processes. Matovic et al. (2014) tested the effects of affect on language understanding, and found that negative affect, induced by film clips, improved people’s ability to detect linguistic ambiguity. In their experiment, mood induction was followed by 12 trials in which participants would read a short vignette about an everyday event, and then a sentence about the event which they would rate in terms of “how precise and clear” it was at was at summarizing the event. In a second experiment, participants watched excerpts from a set of cartoon film clips. In 10 trials, participants were asked to answer multiple choice questions drawing inferences about the clip, to which the correct answer was always “Not clear.” In these experiments, those with negative affect were significantly better at identifying linguistic ambiguity, and had better recall of materials, though their mean processing latency was almost twice as long. All of these results are consistent with the AAI model.

Positive Affect. Turning to the opposite side of the spectrum, we see that positive affect seems to have its own unique effects on executive function. In a study by Grol and De Raedt (2018), positive MIP was used to determine how mood affects processing of cognitive flexibility. In addition to affect, they measured resilience as an additional aspect of their analysis (resilience has many definitions, but for the purposes of their research, they described it as a form of mental flexibility that people use to overcome obstacles). They sought to measure cognitive flexibility with a task switching paradigm. After mood induction using mental imagery, participants had to make a decision about emotional pictures (positive and negative) according to an affective and a non-affective sorting rule. In some trials, participants had to make a decision about whether the picture is positive or negative, while in others they had to make a decision based on the number of human beings depicted in the picture. In their results, they found that positive moods were associated with decreased task switching costs, reflecting greater flexibility. Additionally, they determined that positive mood enabled more top-down focused processing in their because responses to their task switching paradigm were quicker and more accurate.

Yang & Yang (2014) conducted a similar analysis to Grol & De Raedt. They too conducted a study which showed that positive affect plays a role in cognitive flexibility. Cognitive flexibility was assessed with a modified version of the Dimensional Change Card Sort task (DCCS). The DCCS measures task-switching performance in which participants are presented with bivalent cards depicting familiar objects that differ on two dimensions such as color and shape and asked to sort cards on one dimension. The sorting rules then change, and participants are instructed to sort the same test cards on the other dimension. Results showed that positive affect had a positive effect on the speed in which participants were able to complete trials of the DCCS. Because of this, they concluded that positive affect helps to effectively manage control costs needed for switching between tasks.

III. METHOD

Design

Our experimental design had between-subjects and within-subjects elements. There was a single independent variable with three levels: negative mood induction, neutral mood induction, and positive mood induction. This was manipulated through the introduction of a MIP. We used the Film/Story plus Instruction method of mood induction since meta-analysis shows this to be the most effective method for both positive and negative moods (Westermann et al., 1996). We employed the use of a manipulation check through the Positive and Negative Affect Schedule (PANAS), in addition to two seven-point Likert scales for rating overall positive feelings and negative feelings (Likert scales were added to the procedure after 55 participants were run using only the PANAS). The dependent variables were the WMI and PSI portions of the WAIS-IV. The procedure was performed as follows: Participants were randomly assigned to neutral MIP, negative MIP, or positive MIP conditions. All participants were then administered one PSI and one WMI subtest to establish baseline performance at Time 1. Then, a positive, negative, or neutral MIP was administered to the participant. Finally, PSI and WMI subtests different from those administered at baseline were administered at Time 2 At the completion of the experiment, we then asked participants if they believed the video they watched was successful in changing their mood (this was added to the procedure after 55 participants were run without being asked this question at the conclusion of testing). The procedure was counterbalanced to minimize confounding variables

Positive and Negative Affect Scale

The Positive and Negative Affect Schedule (PANAS), is a 10-item assessment developed by Watson et al. (1998) for measuring different affective states. It is the most popular tool for measuring affect. The PANAS has proven itself to be a very reliable measure, and its role in affective research is still significant (Nealis, 2016; Palmiero et al., 2015; Nealis et al., 2016).

WAIS-IV

The Wechsler Adult Intelligence Fourth Edition (WAIS-IV) is an assessment used as a measure general intelligence, as well as providing index scores for four distinct cognitive functions: Verbal Comprehension (VCI), Perceptual Reasoning (PRI), Working Memory (WMI), and Processing Speed (PSI) (Wechsler, 2008). The standardization sample (N = 2,200) was obtained using stratified proportional sampling across variables of age, sex, race/ethnicity, education level (Wechsler, 2008). Exclusionary criteria for standardization sample were uncorrected sensory impairments and communication limitations, upper extremity impairments limiting motor performance, medication use and physical illnesses that might affect cognitive test performance (Wechsler, 2008). The WAIS-IV has strong statistical evidence for reliability and validity. It has been revised substantially from its predecessor (Wechsler, 2008).

Participants

We were able to obtain 88 undergraduate college students (roughly 30 for each condition) from the participant pool at Texas State University. The mean age was 18.9 (min=18, max=36), 77% were female, and 40% were Caucasian (47% Hispanic or Latino, 8% Black or African American, 6% Asian). All were compensated with credit in an undergraduate psychology course.

Exclusion Factors

Exclusion factors for this experiment were consistent with those listed in the manual for the WAIS-IV, i.e. primary language not English, primarily nonverbal or uncommunicative, tested on any intelligence test in the past 6 months, familiarity with the administration of intelligence tests, uncorrected visual impairment, uncorrected hearing loss, upper extremity disability that would affect motor performance, currently admitted to hospital or psychiatric facility, currently receiving chemotherapy or received chemotherapy in the past two months, history of electroconvulsive therapy or radiation treatment of the central nervous system, period of unconsciousness greater than 20 minutes related to medical condition, or currently taking medication that might impact cognitive test performance (e.g. anticonvulsants, antipsychotics, some antidepressants and anxiolytics). Furthermore, this study was not advertised for persons previously or currently diagnosed with any physical condition or illness that might depress test performance such as: stroke, epilepsy, brain tumor, traumatic brain injury, brain surgery, encephalitis, meningitis, Psychotic Disorder, Parkinson’s disease, dementia.

IV. RESULTS

Analysis

For our analysis, we converted raw scores for PSI and WMI subtests to scaled scores per WAIS-IV tables, and statistics were then calculated using R. A mixed design, repeated-measures ANOVA was performed on two factors. The scores from time 1 and time 2 were the within-subjects factor, and condition (positive, negative, or neutral MIP) was the between-groups factor. This analysis was conducted twice, once with PSI scores as the repeated-measures variable, and once with WMI scores as the repeated-measures variable. Analysis of WMI and PSI scores showed no significant trends. Mean scores were calculated and presented in Table 1.

Table 1

Mean Scaled Scores of WAIS-IV Tests

		WMI				PSI			
		T1		T2		T1		T2	
Condition	Total Sample	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Positive	29	9.73	2.69	8.73	2.39	11.57	2.36	11.66	2.39
Negative	31	8.32	2.45	8.48	3.54	11.52	2.31	11.68	2.63
Neutral	28	8.18	2.61	8.29	2.46	10.25	2.62	10.25	2.62

Analysis After Effort Testing

Because we used the WAIS-IV digit span task, we were able to use "reliable digit span" (RDS) as a test of effort. RDS is a measure of the longest string of digits recalled on forwards digit span plus the longest string of digits recalled on backwards digit span (both trials correct). The most generally accepted cutoff for RDS is ≤ 6, as it has a specificity of around 90% (Schroeder et al., 2012). However, some studies instead opt for ≤ 7, though its specificity is much lower (<90%). For the purposes of this study, we considered an RDS ≤ 6 to be a fail, and we labeled an RDS ≤ 7 as "suspicious."

Out of 88 participants, 10 failed our effort test, and 20 participants had suspicious RDS (RDS=7). When analyses were run again excluding those with RDS ≤ 6, we found that the main effect of mood condition for PSI scores was significant, $F(2,75)=3.22$, $p=0.04$ (Table 2). However, Bonferroni post-hoc analysis revealed no significant pairwise comparisons between means. No other significant effects were observed for WMI or PSI scores. Group means were recalculated and are presented in Table 3 and Figures 1 and 2.

Table 2

Univariate Type II Repeated-Measures ANOVA Assuming Sphericity of PSI Scores (Excluding Low Effort)

	Sum Sq	num DF	Error SS	den DF	F
(Intercept)	20325.50	1	622.56	76	2481.12***
Mood	55.00	2	622.56	76	3.36*
Time	0.10	1	288.77	76	0.03
Mood:Time	3.10	2	288.77	76	0.41

*p < .05. **p < .01. ***p < .001

Table 3

Mean Scaled Scores of WAIS-IV Tests (Excluding Low Effort)

		WMI				PSI			
		T1		T2		T1		T2	
Condition	Total Sample	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Positive	27	9.74	2.78	9.00	2.29	11.74	2.38	11.81	2.45
Negative	26	8.42	2.53	8.58	3.82	11.54	2.44	11.92	2.56
Neutral	26	8.42	2.55	8.38	2.52	10.65	2.21	10.35	2.64

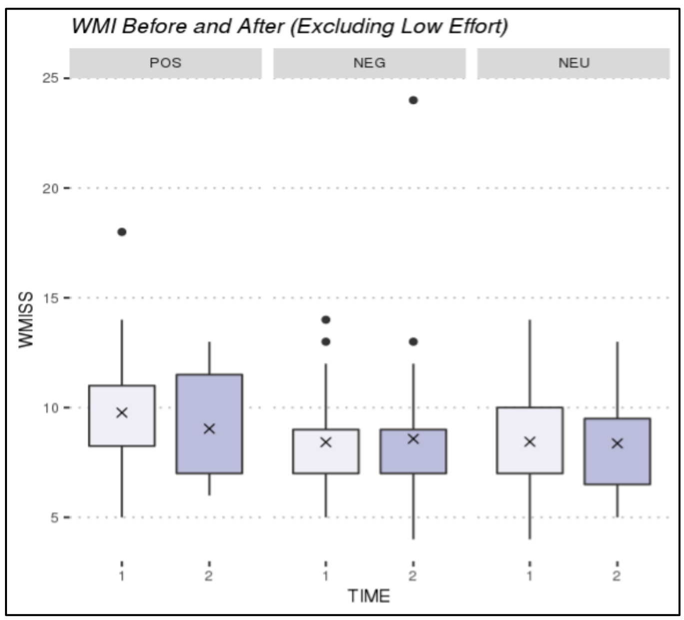

Figure 1. Distributions of scaled WMI scores between time 1 and time 2 across different groups

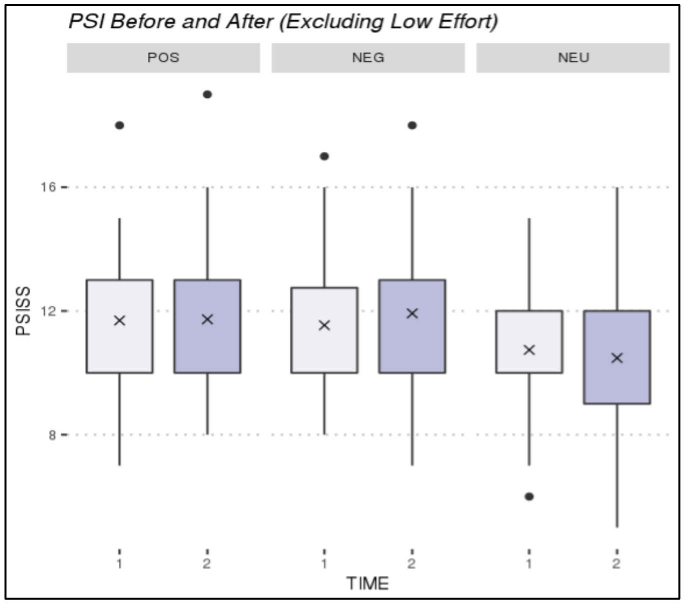

Figure 2. Distributions of scaled PSI scores between time 1 and time 2 across different groups

Manipulation

To assess whether our manipulation was successful, scores of positive and negative affect were averaged and compared between time 1 and time 2 (Table 4 and Figures 3 and 4). Afterwards, paired sample t-tests were run on affect scores for all 3 conditions to compare means (Table 5). Two-thirds through data collection, two 7-point Likert scales for overall positive feelings (OPF) and overall negative feelings (ONF) were added to the procedure. In addition to that, participants were asked “Was the video you watched earlier successful in changing your mood?” The results from these assessments can be found in Table 6.

Table 4

Mean Affect Scores (Excluding Low Effort)

		PA				NA			
		T1		T2		T1		T2	
Condition	Total Sample	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Positive	27	29.74	6.44	28.78	7.56	13.89	4.96	12.00	2.00
Negative	26	29.26	8.19	25.15	9.58	14.04	3.79	15.08	4.71
Neutral	26	28.88	7.54	24.27	8.48	15.35	5.07	14.81	5.30

Table 5

Results from Paired T-tests of Change in Affect (Excluding Low Effort)

		PA		NA	
Condition	df	t	Difference	t	Difference
Positive	26	1.12	0.96	2.21*	1.89
Negative	25	3.68***	4.12	-1.37	-1.04
Neutral	25	4.66***	4.62	1.04	0.65

*p < .05. **p < .01. ***p < .001

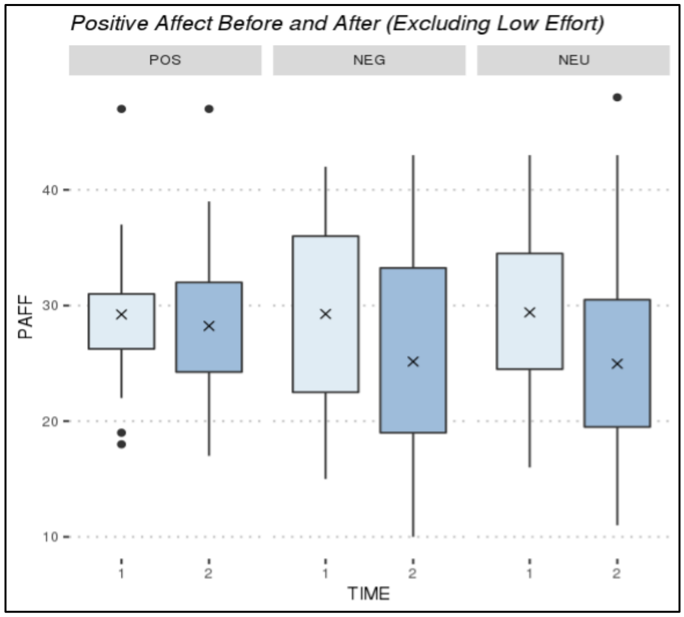

Figure 3. Distributions of positive affect between time 1 and time 2 across different groups.

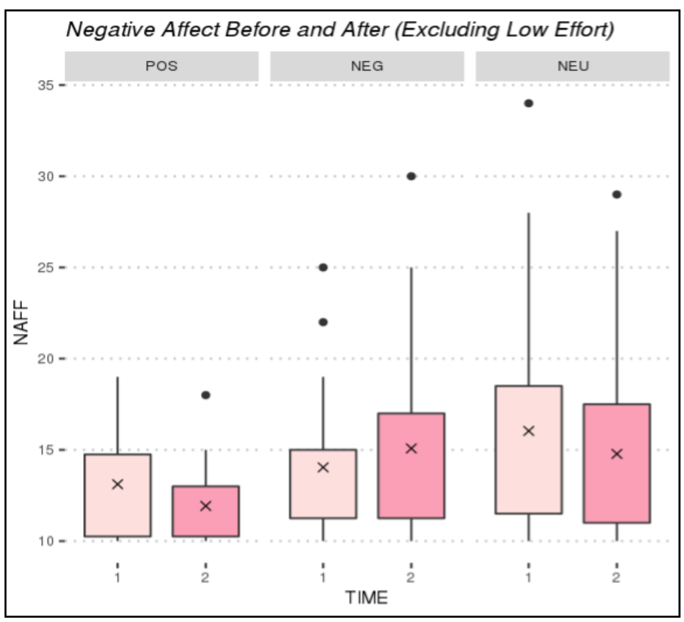

Figure 4. Distributions of negative affect between time 1 and time 2 across different groups.

Table 6

Additional Manipulation Statistics

		Mean OPF			Mean ONF			Did video change mood?	
Condition	Total Sample	T1	T2	T1-T2	T1	T2	T1-T2	Yes	No
Positive	13	5.08	5.46	-0.38	2.23	2.07	0.15	7	6
Negative	13	5.46	4.23	1.23	1.77	3.15	-1.54	9	4
Neutral	9	5.60	4.67	0.88	2.44	2.67	-0.22	5	4

V. DISCUSSION

Mood Manipulation

Results from our manipulation were different from what we expected. We originally assumed that manipulation would result in at least subtle increases in either positive or negative affect depending on whether the participant underwent positive or negative mood induction. However, it appears that over the course of testing, all levels of affect tend to flatten, and our manipulation was not able to overcome this effect. For example, over the course of testing, positive affect decreased by 4.12 in the negative condition and 4.62 in the neutral condition. However, the decrease was only 0.86 in the positive condition. This begs the question, why weren't we able to increase positive affect from time 1 to time 2? After all, the literature has already established that we used the most potent method for inducing positive mood experimentally (Westerman, 1996). Perhaps we can speculate that the videos used for MIPs are outdated and fail to reach the current college-age population. Even in the negative condition, we suspect the same issue could be present. In both positive and neutral conditions, there was a decrease in negative affect from time 1 to time 2, though this decrease was much less than what was observed with positive affect (perhaps because of floor effects, as the minimum score was 10). However, we at least saw an increase in affect between time 1 and time 2 in the negative condition. Regardless, this was a major limitation of our study.

Overall, manipulating our independent variable proved to be a struggle. Results from the PANAS data imply that our manipulations were, in fact, successful. However, while we had originally hoped for significant affective changes from baseline, we were unsuccessful in this sense. We suspect that our manipulations were not able to overpower a greater affective flattening that could have resulted from testing.

WAIS-IV Results

The original goal of this study was to determine if positive and negative affect interact with cognition in a meaningful way. We hypothesized that because of the AAI model, induced affect would produce changes in the individual's processing speed and working memory. We suspected that negative mood would lead to more focused processing therefore resulting in better performance in working memory tasks. Additionally, we proposed that positive mood would lead to faster processing speed because of the AAI model, but also because of results from studies such as Grol and De Raedt (2018), and Yang and Yang (2014). However, the results we have presented would imply that this is not the case. Induced positive and negative affect produced no significant changes in either of these domains. Overall, group means were fairly similar for all groups. This is somewhat consistent with previous research, as Chepnik (2007) also found no significant change in many cognitive domains after negative mood induction.

The only significant statistic in this study was the main effect of mood condition in PSI scores. Overall, positive and negative groups scored roughly a full point higher than the neutral condition (Time 1: positive=11.74, negative=11.54, neutral=10.65. Time 2: positive=11.81, negative=11.92, neutral=10.35). However, this likely has no serious implications since those in the neutral condition also had the lowest score before any manipulation, and post-hoc analysis revealed no significant pairwise comparisons.

One final point of interest unrelated to our statistical analyses is the underwhelming WMI scores. The average score of all WMI groups was roughly 8.77.

This is noticeably lower than what we would have expected from a healthy, partially college-educated population. For reference, a score of 10 places an individual in the 50th percentile, while a score of 9 places an individual in the 37th percentile. Comparatively, the average PSI score in all groups was about 11.34 (around the 63rd percentile). This raises the question as to why our participants performed so poorly on working memory tasks. We could speculate that some undergraduate university students are less motivated to perform well on working memory tasks because they more closely resemble schoolwork (especially the arithmetic task). Therefore, these individuals may attempt the task with less effort. Another possibility is that students admitted defeat on the task early because of laziness, or to avoid feelings of inferiority. This was a suspected cause, as students frequently made excuses for their performance during this task, and many gave up without attempting to work through the questions.

Limitations

This study had numerous limitations, two of which have been described previously. A major limitation was that our mood induction was not as powerful as we had hoped, and another was that WMI scores showed a presumed lack of effort. However, another limitation is that our study was underpowered. Based on our literature search, we suspected that the effect we were looking for would be small to medium. Unfortunately, what we observed instead was very small (if it existed at all). Therefore, to have obtained a power of 0.80 for finding a small effect, we would have needed to recruit 957 participants (or 156 for a medium effect). Ultimately, if we were indeed searching for a small effect, our power was 0.121 (or 0.544 for a medium effect).

Implications of This Study

This study has shown that working memory and processing speed are robust against changes in mood. The unwavering nature of these abilities has been shown previously in studies such as Etherton & Tapscott (2014), which test its strength against physical ailments, and studies by Hamoa et al., (2018) and Leonard, & Abramovitch (2019) which demonstrate that it is robust even against severe psychological disorders. This study adds to the body of literature which highlights the stability of processing speed and working memory.

Directions for Future Research

Future research in mood cognition literature could focus more on the development of potent procedures for mood induction. The Mood literature does not appear to be especially active, so the most widely accepted MIPs have not been updated for decades. Especially for video MIP, it is entirely possible these MIPs have lost their potency over the years. Though, at least in our experiment, the issue could be more with the procedure we used for mood induction. Perhaps we would have seen different results if MIPs were presented more frequently to maintain appropriate levels of affect. Another method of improving our procedure would be increasing the power, as the current study was rather underpowered. Therefore, future research could improve upon all the areas mentioned previously.

Conclusions

We conducted an experiment in which participants were manipulated with positive, negative, or neutral mood induction after they completed tests of processing speed and working memory. Afterwards, further assessments of processing speed and working memory were conducted, and those results were compared to baseline. We did not notice any significant trends; therefore, we cannot conclude that there is any significant effect of induced affect on the cognitive domains we measured. We have identified several possibilities for the direction of future research which have been discussed previously.

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