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An Analysis of the Ego-Depletion Effects of Emotion Versus Attention Draining Tasks: Even Emotionally Arousing Depletion Tasks Do Not Show an Ego-Depletion Effect

Savannah Binion
The College of Wooster, sbinion18@wooster.edu

The College of Wooster

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By Savannah Binion

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Supervised by Evan Wilhelms

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Abstract

The theory of ego-depletion has come under intense scrutiny within the past few years. Beginning around 2010, researchers conducted meta-analyses and large replication studies that have investigated this topic, and found a wide range of evidence for and against the existence of an ego-depletion effect. Although the goal has been to determine whether this effect exists or not, the research has proved that the answer may be more complicated than that. The purpose of the current research was to examine the different theories about self-control, and to test two specific depleting tasks against a control group. The depleting tasks were chosen by selecting one that has been shown to have a depleting effect in multiple studies, the emotion-suppression task, and one that has shown small or negligible ego-depletion effects, the attention video task. This study also used two dependent measures, the impossible version of the Euler tracing task and the Multi-Source Interference Task, which have been used in previous studies on ego-depletion. The results did not show an ego-depletion effect for either task, on either of the dependent measures. This supports recent research that has contradicted the ego-depletion theory, however, more studies need to be done to determine if there are certain conditions in which the ego-depletion effect is present, or if the effect is universally spurious.

Introduction

The ability to regulate our thoughts and actions, and to inhibit certain impulses and responses, are skills that we use every day. These skills are often referred to as self-control or willpower. Though it is an ability that we all have, some people are better able to resist temptations and suppress impulses than others. To that end, the same person might exhibit more self-control on one day versus another. A certain degree of what we call self-control can be described as a trait that varies among people, but there can also be variation within a single person's self-control abilities. The exhibition of self-control, or lack thereof, is partially context-dependent, such that different tasks can have varying effects on use and depletion of a person's self-control. The underlying causes and mechanisms of the variation in this skill are not completely understood, but many theories have been proposed. The purpose of this study is to examine the different theories about self-control, and attempt to clarify which characteristics of "depleting" tasks cause them to truly deplete an individual's ability to exhibit self-control.

Self-Control

Self-control is an ability that affects numerous aspects of everyday life. Low self-control has been linked to obesity, substance abuse, addiction, and criminality (Baumeister & Heatherton, 1996; De Ridder, Lensvelt-Mulders, Finkenauer, Stok, & Baumeister, 2012; Gottfredson & Hirschi, 1990; Vohs & Faber, 2007). In addition, low levels of self-control have been shown to be linked to increased aggressive behavior (Stucke & Baumeister, 2006), increased alcohol consumption (Christiansen, Cole, & Field, 2011), and poorer academic performance (Mischel et al., 1989). Conversely, people with high self-control are better at regulating their emotions, thoughts, and impulses (Baumeister, Bratslavsky, Muraven, & Tice, 1998; De Ridder et al., 2012). Individuals with high self-control are also less likely to be physically or verbally aggressive, and are willing to make more compromises in close relationships (Finkel & Campbell, 2001; Tangney, Baumeister, & Boone, 2004).

One illustrative example of this is the study conducted by Mischel, Shoda, and Peake in 1990. This longitudinal study followed up 10 years later with children who participated in a study on delay of gratification and self-control. Children who were able to delay gratification in preschool, by waiting for two marshmallows instead of eating one immediately, had higher SAT scores, and exhibited better coping competence (Mischel et al., 1990). In addition, a meta-analysis in 2012 found self-control to have an effect in four behavior domains: school and work, eating and weight, interpersonal functioning, and well-being (de Ridder et al.). The meta-analysis included all studies that used either the Tangey et al. (2004) Self-Control Scale, the Low Self-Control Scale (Grasmick et al., 1993), or the Barratt Impulsiveness Scale (Patton et al., 1995) and had some behavioral measure. The behavioral measures included in this analysis ranged from cognitive to overt behavior; the only type excluded was dispositional characteristics. The results for school and work domain showed the strongest relationship ($r = .36$), while the weakest relationship ($r = .17$) was found for eating behavior and weight control.

The concept of self-control stems from knowledge about how humans interact with their environment, and specifically, one of the types of control they engage in. Terms that are often used for two broad categories of control are “primary control” and “secondary control.” Primary control involves direct efforts to change our environment, whereas secondary control refers to actions we take to make ourselves fit well into the environment (Baumeister et al., 1994). This realm of secondary control involves self-control, as it refers to our efforts to monitor and change our behavior according to our environment.

In the circumstances of this study, self-control refers to the ability to override initial impulses to alter our own responses. Self-control is an example of an *executive function*, which are top-down processing mechanisms that include resisting temptations, focusing attention, remembering instructions, and inhibiting responses (Diamond, 2013). The act of self-regulation, which is involved in self-control, prevents the normal or natural responses from occurring, substituting a different response or reaction (Baumeister, Heatherton, & Tice, 1994). Executive function is closely tied to self-regulation, and both of these abilities require specific mental processes. Working memory is one such process, which allows us to retain and manipulate specific information over short periods of time. Mental flexibility is also necessary, as it helps us sustain or shift our attention depending on different situational demands (Center on the Developing Child, Harvard University). In the literature about self-control, executive control is used to describe the aspect of the self that is acting (Baumeister et al., 1998; Epstein, 1973).

Brain imaging has provided information about the areas of the brain that are involved in executive function tasks, and has shown how certain anatomical features are associated with executive function. As adolescents progress to adulthood, the connectivity in the prefrontal cortex improves. During this transition, executive function capabilities improve in a variety of ways. Young adults show improvement on tasks that activate the dorsolateral prefrontal cortex, such as challenging tests of response inhibition involving prosaccade vs antisaccade tasks (Luna et al., 2001). These tasks contain a target stimulus that is presented in one of two places that are in opposite hemi fields. Eye movement is tracked, and is supposed to either go towards or away from the target depending on the color of the target stimulus at that time. During the end of adolescence there is also an increase in connection between cortical areas and subcortical areas, which is correlated with increases in self-reported impulse control (Steinberg, 2008). The cortical brain regions are involved in higher thought processes, such as decision making, while the subcortical regions are evolutionarily older and are responsible for more basic functions. Research has shown that the prefrontal cortex in mice is involved in regulating instinctual behavior that is controlled by the brainstem (Franklin et al., 2017). This aligns with the correlation from the Steinberg study showing that the connection between these regions is implicated in ability to exhibit self-control. These findings give some neurological context to the concepts of self-regulation and self-control, showing that more connectivity within the prefrontal cortex, and between the cortical and subcortical regions, increases self-control abilities.

Theories of self-control.

There have been multiple theories proposed about the mechanisms of self-control. In 1975, Ainslie used the *discounting model of impulsiveness* to define self-control as the choice between a delayed, but more valuable outcome, and an immediate outcome that is less valuable. This is similar to the concept of delayed gratification, which Mischel illustrated in experiments with preschool children and marshmallows (1990). The children were given the option of having one marshmallow immediately, or waiting for the experimenter to return to get two marshmallows. In the delay of gratification experiments, the marshmallow served as an appetitive stimulus. An appetitive stimulus is a stimulus that evokes an automatic response relating to fundamental needs, such as food, water, and procreation. Having a desirable food as the reward in a test of self-control is an example of an appetitive stimulus, because it evokes an automatic response of wanting the food. Therefore, participants had to inhibit their initial responses to these provoking stimuli during the delay of gratification test. The parts of the brain that are involved in this type of response and self-control are in subcortical areas of the brain, such as the limbic system, and involve the dopaminergic system (Franklin et al., 2017; Mirenowicz & Schultz, 1996).

Another system that was proposed to describe self-control was the *hot/cool system* (Metcalfe & Mischel, 1999). Metcalfe and Mischel describe the cool system as the slow, cognitive, reflective system. The hot system is the counterpart to the cool system; it is the quick, emotional, reflexive system that responds immediately (1999). Using this theory, self-control is the ability to inhibit responses from the hot system and engage the cool system. Metcalfe and Mischel found that as stress levels increase, the cool system is not able to function as well, so the hot system has more control (1999). This aligns with findings from Rutter in 1987; there was a correlation between living in a high-stress environment and having decreased ability to delay gratification. This characterization of self-control can be applied to the marshmallow task done by Mischel and colleagues. The hot system is responsible for the initial desire to eat the marshmallow, but the cold system is engaged when the children weigh that option with the option to wait for another marshmallow.

Delay of Gratification

One of the most well-known tests of self-control is the delay of gratification paradigm. The famous "marshmallow test" by Mischel and colleagues is an example of this. Through multiple studies, it has been shown that the task of delaying gratification is very difficult for children (Mischel et al., 1989; Mischel & Underwood, 1974). In these studies, the reward is either one marshmallow immediately, or two if the child waits. This task requires self-control, and there are certain strategies or manipulations that affect the child's ability to wait for a more valuable reward.

Children are able to wait longer when the waiting phase is less passive. In a similar study, with marshmallows and pretzels, children were allowed to choose between a less desirable reward (pretzel) immediately, or a more desirable reward (marshmallow) if they waited for the experimenter to come back (Mischel & Underwood, 1974). The children were either given the rewards or irrelevant objects to view. Then they were told to think about the objects in front of them; however, children in the "instrumentality" condition were told that the act of thinking about the objects would make the experimenter come back sooner. Children in the instrumentality condition were able to wait significantly longer than children who were not given that part of the instructions. In addition, children in the instrumentality condition were able to wait longer when they focused on the relevant objects versus the irrelevant items. These findings provide more information about variables that affect self-control in a delay of gratification task. Having a reward that is not appetitive, or having the ability to distract oneself from the reward, can both increase and decrease an individual's ability to resist the temptation of the reward.

The children that were participants in the initial experiments by Mischel and colleagues were contacted years later for many follow-up studies. One study by Mischel et al. followed up with children who had been participants in a delay of gratification study more than 10 years later (1990). This longitudinal study allowed for correlations to be drawn between self-control as a child and success in different realms as an adolescent. Individuals who were able to delay gratification longer as children were rated as more intelligent, and more able to cope with distraction, frustration, and temptation, as adolescents (Mischel et al., 1990). In one specific example, waiting longer during the test as a child was positively correlated with SAT scores later in life (Mischel et al., 1989). The amount that a child could delay gratification is also correlated with health later in life, such that children who waited longer had better overall physical health at age 30 (Mischel et al., 2011; Kubzansky et al., 2008). These studies put a great deal of importance on willpower. Showing that a trait such as self-control can impact success in multiple domains of life makes it a very relevant topic. These studies also naturally lead to a question about why certain people seemingly have more willpower than others, and what variables can affect an individual's ability to exert self-control.

The ability to delay gratification in tests such as the marshmallow task requires a certain amount of self-control to resist the tempting reward. From experience we know it can be difficult to exert self-control, and these studies showed just how agonizing the process of waiting for a second marshmallow could be for a child. This body of work provided a platform for the recently debated *self-regulatory strength model* to take shape, and has resulted in a specific term for the idea that self-control requires energy and can be depleted through use, namely, *ego-depletion* (Baumeister, 1994).

This model posits that self-control is a resource that is depleted through use. This is based on the idea that controlling one's emotion, thoughts, and reactions requires energy. Therefore, when someone exerts self-control to inhibit a response, they are using energy and will eventually run out of this type of mental energy (De Ridder et al., 2012). This theory was also built off the finding that participants who were required to ignore an irrelevant stimulus during a task, in which they had to make inferences about the author of a speech, performed worse than participants who were put in the same scenario, but weren't instructed to ignore the stimulus (Gilbert, Krull, & Pelham, 1988). This suggests that when the act of ignoring the stimulus was a task requiring self-control, it required mental effort.

The strength model includes six specific assumptions about self-control. The first is that challenging self-control tasks require some form of energy, which some experimenters believe is literal energy from glucose (Gailliot et al., 2007), while others refer to it as a metaphorical model of self-control (Baumeister et al., 1998). There is not a large enough body of evidence to say either opinion is correct, but with regards to the strength, or ego-depletion model, “depleting” tasks do not need to cause a literal glucose depletion for them to be psychologically depleting. The model says that this “energy” source must be limited, and all acts that require self-control will draw from the same source of energy. The amount of this energy that an individual has at any given time will determine their success or failure at exerting self-control. In addition, each time that a person must use self-control, some of this energy is expended. However, the model states that this depletion is not permanent and that the energy can be recovered over time or with a supply of glucose (Baumeister, 2002; Dvorak & Simons, 2009; Gailliot et al., 2007).

One of the original texts on the self-regulation strength theory describes ways in which people can fail at self-regulation. If a person has multiple, conflicting goals or standards, they lose the ability to manage themselves (Baumeister et al., 1994). For example, when participants have conflicting goals, they tend to ruminate rather than taking action, and fail to make progress towards any goal (Baumeister et al., 1994; Van Hook & Higgins, 1988). Another way in which people can fail to successfully exert self-control is when they are monitoring their behavior less. Loss of self-awareness, whether due to preoccupation or external factors, can decrease an individual’s ability to self-regulate. Lastly, this model asserts that self-control is a strength that works like a muscle. If there is chronic weakness, depletion through use, or a very strong impulse to overcome, a person’s ability to use self-control can decrease. This model has been demonstrated through a wide range of experiments, though with varying conclusions about the validity of the theory.

Arousal, Appetitive Stimuli, and Self-Control

Decision-making often involves self-control, such as deciding whether it is worth it to inhibit an impulse or resist a temptation. There are many different factors that can affect what decisions people make, but the one that is most relevant to self-control is level of arousal. Arousal is defined as a level of activation varying from calm to excited or agitated (Reyna, 1992). Level of arousal can affect how information is processed and stored, which can then influence decisions. Stimuli that cause more arousal are focused on more, and are remembered longer than neutral stimuli (Reyna, 1992). This high arousal can make it more difficult to inhibit responses to the stimulus, and therefore could cause more depletion of self-control, when using the strength-model of self-control as a framework.

In addition, the act of self-regulating can cause physiological arousal (Muraven, Tice, & Baumeister, 1998). When individuals must regulate their emotions, or inhibit facial expressions of emotion, they display increased physiological arousal (Adelmann & Zajonc, 1989; Gross & Levenson, 1993; Notarius, Wemple, Ingraham, Burns, & Kollar, 1982). In one case, when participants were told to suppress their emotions while watching videos of amputations and burn victims, they showed a greater increase in skin conductance compared to the control group. They also displayed a larger decrease in heart rate, which is a sign of greater sympathetic nervous system activation (Gross & Levenson, 1993). These results support the idea that emotional suppression leads to increased arousal. These findings are related to the ego-depletion model in cases when these arousing tasks cause participants to perform worse on subsequent tasks that also require some type of self-control. For example, participants who were asked to either suppress or increase their emotional responses performed significantly worse on a later hand-grip endurance test than a control group (Muraven et al., 1998). It has also been shown that attempts to regulate attention can cause similar changes in arousal (Kahneman, 1973; Muraven et al., 1998; Pribram & McGuinness, 1975). For example, the skin conductance of participants participating in the Stroop task increases as the task difficulty increases (Elliott, Bankart, & Light, 1970; Kahneman, 1973).

The type of stimulus used in an experiment affects how much, and what type of, arousal the participants experience. Resisting an appetitive stimuli requires a more autonomic form of self-control, as these stimuli elicit an instinctive response. The parts of the brain that are involved in this response and self-control are in areas of the brain that are evolutionarily old, exhibited by the fact that the limbic system is similar to the brain structures of other mammals (Franklin et al., 2017). Tasks that require intense focus or adherence to difficult rules do not require this type of self-control that inhibits natural responses. This difference has been noted in multiple areas of the ego-depletion literature (Dang, 2017; Mischel et al., 1989). Through delay of gratification studies, it has been shown that having participants focus on the abstract qualities of a stimulus, such as the shape, versus the appetitive qualities, increases the amount of time they are able to wait (Mischel et al., 2011. Mischel et al., 1989). When the children only had a picture of a marshmallow in front of them they were able to wait, on average, 18 minutes. When the marshmallow was sitting on the table in front of the child, but they were told to imagine that the reward was a picture, they were also able to wait almost 18 minutes. In contrast, when a picture of a marshmallow was in front of them, but they were told to imagine it was real, they were only able to wait about six minutes (Mischel et al., 1989). This supports the idea that tasks involving appetitive stimuli, and therefore more autonomic responses, are more difficult because these responses require more effort to override.

It could be that these types of tasks require more self-control, or that they require a different type of self-control that is more difficult to exert. There isn't conclusive research on the neural mechanisms of self-control tasks, however there is evidence that there may be different mechanisms for different types of tasks. A meta-analysis of over 40 neuroimaging studies, that looked at a range of cognitive control tasks, showed that there were non-overlapping patterns of brain activation for different types of cognitive control tasks, such as the Stroop and Go/no-go tasks (Mischel et al., 2011; Nee et al., 2007). In the Go/no-go task the most prominent cluster was in the right dorsolateral prefrontal cortex, however for the Stroop task the clusters were mostly left lateralized. There was a significant cluster in the left dorsolateral prefrontal cortex and in the medial frontal cortex for the Stroop task (Nee et al., 2007).

A longitudinal study that recruited participants who had been in a delay of gratification study as children compared "hot" and "cool" stimuli with regards to impulse control (Casey et al., 2011). This study occurred 40 years after the original study, which had taken place when the participants were in preschool. The participants in this study were divided based on whether they had been able to delay gratification for a long time or not as children (high-delay or low-delay). They were given a go/no-go impulse control task, which involves showing participants stimuli where one set of stimuli requires them to give a motor response, and the other set indicates that they should withhold their response. There were two versions of the task. One version contained neutral faces of men and women, and the other contained fearful and happy facial expressions. The version with the neutral faces was the "cool" condition because these pictures would not elicit an emotional reaction, whereas the condition with the expressive faces was the "hot" condition. The "cool" version of the task did not show a difference between the two groups of participants, however the "hot" version did. With the emotional cues the low-delayers had more difficulty suppressing their response than the high delayers. This shows that resistance to temptation and ability to exert self-control are relatively stable characteristics (Casey et al., 2011). These results also indicate that only certain types of tasks, in this study the condition with expressive faces, may require impulse control.

This study by Casey et al. included a second experiment that used fMRI to look at possible neural correlates of the delay of gratification and impulse control. This experiment showed that resisting temptation in the “hot” version relied on frontostriatal circuitry. The right inferior frontal gyrus was involved in correctly suppressing a response, and low delayers had less activation in this region compared to high delayers. They also looked at the ventral striatum, which is associated with processing positive and rewarding cues. The low delayers showed more activity in this area than the high delayers during the “no-go” trials with the expressive faces (Casey et al., 2011). These findings indicate that the characteristics of the stimulus can affect how much effort is required for people to resist them or suppress responses to them. This study also shows that there are identifiable regions of the brain that are associated with ability to delay gratification and control impulses (Casey et al., 2011).

Ego-Depletion

In 1998 a landmark study titled “Ego Depletion: Is the Active Self a Limited Resource?” was published (Baumeister et al., 1998). This study introduced the previously mentioned, controversial idea that self-control is a finite resource, which is depleted through use. Previous research had tested tasks in which self-control was necessary, and looked at different factors that could affect an individual’s ability to delay gratification (Mischel et al., 1989; Mischel et al., 1990). The findings of these studies showed that there were different techniques that children used to enable themselves to delay gratification, but that the process required effort (Mischel et al., 1989; Mischel et al., 1990). The strength model of self-control began to form, and Baumeister performed four different experiments to test the ego-depletion theory.

Experiments used to test the hypothesis of ego-depletion generally involve two phases; the initial phase is a depletion phase for the depletion group and a comparable activity without the depleting effect for the control group. The second phase is a testing phase for both the depletion and control groups. This second task is used as the dependent measure, to assess the participants' ability to exert self-control. The first experiment by Baumeister used appetitive stimuli, similar to the delayed gratification study by Mischel. Participants in the depletion condition were at a table that had a plate of cookies and a plate of radishes, and were told that they could only eat the radishes. This was used to deplete self-control, because resisting the temptation to eat the cookies is an action that requires exertion of self-control. In one type of control condition, both foods were on the table, but the participants were told to eat the cookies. There was also a control condition in which participants did not do this part of the experiment. All of the participants then had to attempt a tracing puzzle that, unbeknownst to them, was impossible to solve. The time that they spent on the puzzle was used as a dependent measure of self-control. This study found that the participants in the depletion condition spent less time trying to solve the puzzle than participants in the control conditions (Baumeister et al., 1998). The three other experiments were variations of this method, with different depleting tasks and measurement tests.

The second experiment had four conditions for the first task, three involved giving a persuasive speech about potential tuition increases. The participants in the experimental condition had to give a counter-attitudinal speech, arguing something contrary to their beliefs, under high or low choice conditions. In the high choice condition participants were told they could choose which speech to give, but were told that it would help the study if they chose the counter-attitudinal choice. In the low choice condition participants were assigned to give the counter attitudinal speech. As a control for the active choice making aspect the third group gave a pro-attitudinal speech, arguing something that aligned with their beliefs, under high choice conditions. In the low-choice condition participants were told that they had to give the counter-attitudinal speech. In the high-choice condition the participants were told that although they experimenters already had enough participants give the one of the speeches, and that it would be helpful if they gave the other one, that the choice was ultimately up to them. In this high-choice condition some participants were told that it would be helpful if they gave the counter-attitudinal speech, and some were told it would be helpful if they gave the pro-attitudinal speech. All the participants agreed to do the speech of the condition they were in, even though they were told they could choose. The fourth condition did not have participants give any speech, as a control. After this phase, all participants were asked to do the impossible tracing task that was used in the first experiment. The results showed that participants in both conditions involving an active choice spent a shorter amount of time on the impossible task. The authors concluded that the act of making the choice depleted the participants' self-control.

The third experiment used emotion-suppression as the depleting task. In the depletion group, participants were instructed not to show or feel any emotion during the video, while the control group was told to let their emotions flow. Half of the participants in each condition watched a funny video, while the other half watched a sad video. The second task, used as the dependent measure, was an anagram task. Participants were given 13 sets of letters, and six minutes to try to make words out of them. The participants in the suppression condition performed significantly worse than those in the control condition. In the last experiment, the first task involved crossing out the letter e on a paper with meaningless text. Participants in the control condition were just told to cross out every “e” they saw. In the depletion condition, participants were told to only cross out an e if it was not next to, or one letter away from, another vowel. In the next phase, participants were shown an intentionally dull movie, and were told that they could choose when to stop watching but that they should watch it long enough that they could understand what happened and answer questions about it. Half of the participants had to press a button to stop the movie, and the other half had to hold down a button for the whole time they were watching, and release it when they decided to stop watching. The results showed that participants in the depletion condition watched for a longer time when quitting required pressing the button versus releasing the button. In the control condition, there was no difference in time spent watching the movie between the two button conditions. Among participants who were in the condition where they had to press the button, those from the depletion group watched the movie longer than those in the control group.

In all four of these experiments, the results supported the hypothesis that self-control is depleted through use. The magnitude of the differences found between the experimental and control groups varied though, with the first experiment showing the largest difference. In the second experiment the overall difference between groups was significant, but some of the pairwise comparisons were only marginally significant. The third and fourth experiments had significant results however the effects for these results were smaller than that of the first experiment.

Ego-depletion has also been applied to the inhibition of aggressive behavior. An individual’s ability to inhibit aggressive behavior can be depleted through tasks that require self-control (Stucke & Baumeister, 2006). Though some factors that affect an individual’s self-control have been studied and discussed, there are many others that most likely play a role outside of the lab. More recent research has shown that motivation and personal beliefs can counteract the effects of ego-depletion (Schmeichel & Vohs, 2009; Vohs, Baumeister, & Schmeichel, 2012). In particular, when participants are encouraged to believe that they have unlimited willpower, they don't show ego-depletion effects in mild depletion conditions. This impact of motivation disappears, though, when the participants are in a severe depletion condition that involves more than two depleting tasks. In the severe depletion condition, the ego-depletion effect returns (Vohs et al., 2012). These studies highlight the fact that differences in individuals' mindsets can influence whether or not they display an ego-depletion effect in certain scenarios.

Controversy of ego-depletion theory.

The self-control strength model assumes that acts of self-control draw from a single resource, no matter what the task is. It also assumes this resource is limited, and can be depleted through use (Hagger et al., 2010; T.D. de Ridder et al., 2012). Multiple meta-analyses have been performed in the past decade analyzing the effect of ego-depletion (Baumeister et al., 1998; Carter et al., 2015; Dang 2017; Hagger et al., 2010; Hagger et al., 2016). One such analysis included 83 studies that used some variation of the dual-task paradigm to test for ego-depletion effects. The results showed an effect of ego-depletion on self-control task performance. Furthermore, this effect was moderated by depleting task duration, dependent task complexity, and intertask interim period, among other variables (Hagger et al., 2010).

In response to this, another meta-analysis was conducted with different inclusion criteria (Carter et al., 2015). The more stringent criteria ensured that only experiments that involved frequently used depletion tasks and outcome tasks were included, versus experiments that used less clear operationalizations of variables. In addition, unpublished studies were included to reduce the publication bias that was present in the meta-analysis by Hagger et al. The analysis by Carter et al. included a total of 116 studies, and found ambiguous results. The estimates of the depletion effect, using a random-effects meta-analysis model, were statistically significant. However, there was a large amount of variation in the effects of different outcome tasks, and all data sets showed statistically significant heterogeneity (Carter et al., 2015). These results challenge the self-control strength model. The Carter et al. study concluded that their results do "not support the proposition (and popular belief) that self-control functions as if it relies on a limited resource, at least when measured as it typically is in the laboratory (2015)."

The meta-analysis by Carter et al. caused a debate over the validity of the ego-depletion concept to arise. In 2016, preregistered replication of the ego-depletion effect was conducted (Hagger et al., 2016). This replication involved 23 labs that were spread throughout 11 different countries including the United States. This large-scale replication of the ego-depletion effect was criticized for the choice of depleting task (Hagger et al., 2016). The protocol employed the "letter 'e' task" as the depleting task and the Multi-source interference task (MSIT) as the dependent measure (Hagger et al., 2016). The letter "e" task had two conditions: depletion and no depletion. In the no depletion condition, participants were asked to press a button whenever a word with the letter "e" was displayed. In the depletion condition, participants were asked to press a button when a word with the letter "e" was displayed, but to refrain from pressing the button if the "e" was next to or one letter away from another vowel. This task is similar to a go/no-go task, in that a certain stimulus elicits a motor response and a slightly different stimulus requires the participant to withhold a response.

However, the depletion condition of this task generally requires participants to do the easier version of the task first, then requires them to learn a new set of more difficult rules that contradict the first rules. This design requires the participants to inhibit a response, because they must refrain from following the first set of rules. However, in this large replication study the participants in both conditions were only given one set of rules to follow, with the depletion-condition rules being more difficult. The study was criticized because this change in experimental design did not require participants in the depletion condition to break a previously formed habit (Baumeister & Vohs, 2016; Dang, 2016). The critiques point to the fact that the element of the e-crossing task that requires self-control is the action of inhibiting the crossing-out response when the rules change. Without this aspect, the depletion-condition task is a difficult cognitive task, but it does not require participants to override an impulse (Baumeister & Vohs, 2016). Either way, this task does not use an appetitive stimulus, and does not require much autonomic self-control. The version that requires response inhibition incorporates this form of self-control more, but the task is still predominantly a learning task.

The dependent measure for this study was the MSIT task, which involved identifying the unique digit in a set of three numbers. The task included congruent and incongruent trials, such that in the congruent trials the position of the unique digit matched the position of that digit on the keyboard, and in the incongruent trials it did not. During the MSIT, reaction time and error data were recorded by the program. This replication study found a great amount of variability in the effect found across the labs. On average, the labs found a small effect size for the ego-depletion effect on reaction time and accuracy in the MSIT (Hagger et al., 2016). The authors of this replication concluded that if there was any effect of ego-depletion, it was close to zero. However, they reported that the letter “e” task may not have been sufficiently difficult or draining, and called for further research exploring possible explanations for the variability in the effect sizes found across labs.

Though this large replication study concluded that there is no ego-depletion effect, Baumeister and Vohs published an article criticizing the protocol used in this replication study (Baumeister & Vohs, 2016). They state that the letter “e” task is not an effective self-control task unless it involves the act of breaking a habit, which the task in the replication study did not include. The fact that the depletion task did not involve inhibiting an instinct may be a contributing factor to the findings that oppose much of the other literature. However, these results still call the validity of the ego-depletion effect into question.

In the most recent meta-analysis, the different types of frequently used depleting tasks were evaluated (Dang, 2017). This analysis also addressed concerns with the 2015 study by Carter and colleagues. First, Dang excluded some studies that Carter et al. had used, based on the grounds that the depleting tasks included were not frequently used tasks. Second, the most recent studies that were included in the 2015 meta-analysis were from 2013; in this 2017 analysis Dang included newly conducted studies. The analysis included experiments that used the following depleting tasks: attention essay, attention video, crossing out letters, emotional video, food temptation, stroop, though suppression, working memory, or a combination of tasks. This meta-analysis included 27 articles, and found a small-to-medium overall effect for ego-depletion, even after adjusting effect sizes for publication bias with the trim-and-fill method. When analyzing each task individually, they found insignificant results for the attention video, working memory, and multiple depletion tasks. The food temptation task showed the largest effect, however it had high heterogeneity, which signifies that the studies used in the meta-analysis for this category were not conducted in the same way. When the studies used in a meta-analysis don’t have the same experimental design, this can reduce the validity of the results. This analysis concluded that the three most reliable depleting tasks were the attention essay, in which participants must write an essay without using some set of common letters, the emotion video, which requires participants to suppress or exaggerate their emotions during an emotionally evocative video, and the Stroop test because these tasks showed significant results and low heterogeneity (Dang, 2017). The attention video, working memory, and multiple depletions tasks has no statistically significant effect on level of self-control exhibited. All other tasks (crossing out letters and thought suppression) showed significant results but also had high heterogeneity. This analysis lends more support to the theory of ego-depletion than the results of the analysis by Carter and colleagues, but shows that not all depleting tasks have the same effect. This study leads to a question about which tests are capable of "depleting" self-control, and why these tasks have differing effects on later measures of self-control.

Junhua Dang, author of this meta-analysis, also published a commentary on the 2016, large-scale replication by Hagger and colleagues (2017). The response to the replication echoes the article by Baumeister and Vohs. Dang supports the criticism of the letter "e" task used in the replication, confirming that the task should have required participants in the depletion condition form a habit first and then break it. In the study by Hagger and colleagues, the letter "e" task did not differ significantly from the control condition on one of the manipulation checks, fatigue, which supports the idea that this task may not have been depleting for participants. A closer investigation, by Dang, of the results from the Hagger replication showed an interesting interaction between condition and effort exerted. In the control condition, effort exerted did not predict reaction time on the dependent measure. However, in the depletion condition the more effort a participant exerted during the depleting task, the worse they performed on the dependent measure, the MSIT. This indicates that the letter "e" task wasn't depleting for all participants, but that there was an ego-depletion effect for participants who reported having to exert effort (Dang, 2017). For these reasons, the results of the Hagger et al. replication do not convincingly disprove the theory of ego-depletion.

Though results from this body of research show that different "depleting" tasks have different effects on self-control, this fact hasn't been incorporated very well into the debate over the validity of the ego-depletion theory. The debate has focused on a binary choice of whether or not the ego-depletion effect exists, rather than looking for factors about the tasks and dependent measures that might affect the presence of such an effect.

Present Research

The on-going debate in ego-depletion literature leads to the purpose of the present research. There is evidence for and against ego-depletion, but in most of the literature it appears that different depletion tasks can have differing effects (Baumeister et al., 1998; Dang, 2017; Hagger et al., 2016; Hagger et al., 2010). The tasks differ in whether they ask participants to resist appetitive stimuli, or complete a challenging mental task. In the category of mental tasks, some mental tasks simply require focused attention, while others require the suppression of an impulse or habit.

The current research aims to compare the effects of two different depleting tasks. The two tasks are both mental tasks, however one requires focused attention, and the other requires emotion suppression. The attention video is based on a video used in a study on helping behavior as a function of self-regulatory energy and genetic relatedness (DeWall, Baumeister, Gailliot, & Maner, 2008). This type of video showed insignificant results with regards to ego-depletion in the 2017 meta-analysis (Dang). However, it has been shown to cause an ego-depletion effect in other studies (Baumeister, 1998; Carter et al., 2015). The emotion video is modeled after similar videos used in various studies about ego-depletion and self-control (Baumeister et al., 1998; Finkel & Campbell, 2001; Muraven, 2008). This category of videos showed significant results and low heterogeneity in the same meta-analysis (Dang, 2017). I hypothesize that the depletion tasks will decrease performance on the dependent measure self-control tasks compared to the control condition tasks. I also hypothesize that the emotion-suppression condition will decrease performance on the subsequent self-control tasks more than the attention condition, which will show reduced or negligible effects.

The current research also uses two dependent measures of self-control. One of the dependent measures is the impossible tracing task. This task has been used in many self-control and ego-depletion studies (Baumeister et al., 1998; Glass, Singer, & Friedman, 1969). The second dependent measure is the MSIT. This task was used in the multilab replication study by Hagger and colleagues (2016). Though the different types of depleting tasks have been analyzed, not much research has looked at possible effects of the various dependent measures of self-control. The purpose of this manipulation is to identify if different dependent measures affect the results obtained from the two depletion conditions. The MSIT requires focus and accuracy, but does not measure endurance in the way that the impossible task does, so I hypothesize that the impossible task will show a depletion effect and the MSIT will not.

Method

Participants

Sixty students at the College of Wooster participated in this study. Participants ranged in age from 18 to 22 years old, ($M = 19.23$, $SD = 1.047$). There were 44 female, 14 male, and 2 non-binary participants. The ethnicities of the sample were as follows: 68% of participants identified as White, 18% as Asian, 8% as Black or African American, 3% as Hispanic or Latino, and 2% as “other.” Participants were recruited through the research participation system, SONA, and through email. Participants were compensated with course credit when applicable, or were entered in a drawing to win a $25 gift card.

Procedure

Participants were told, when they signed up for the study, that the purpose of the experiment was to see which personality traits make people more responsive to videos. They signed a consent form, and then were asked to first watch a video on the computer in the lab. They were randomly assigned to either the emotion depletion, attention depletion, or control condition. In the emotion condition, they watched a 7-minute-long video comprised of comedic clips from the Ellen DeGeneres show, and clips of babies reacting an unpleasant taste and making faces. The participants were asked to suppress their emotions, and were told that they were being recorded and should show no facial expression. There was a small video camera set up to make it seem as though they were being recorded, but the camera was not on.

In the attention condition, participants watched a 7-minute-long video of a woman talking (without sound). In the bottom corner of the screen, words (e.g., chair, tree, book) appeared every 10 seconds. Participants in the attention condition were asked to focus their attention only on the woman’s face, and to refrain from looking at the words. They were told that if they did look at the words, they should refocus their attention on the woman's face as quickly as possible. Participants were told that they were being recorded during this time.

In the control condition, participants watched the emotion condition video, but were not given instructions to suppress their emotions. These participants were also told that they were being recorded, but were not asked to do anything specific during the video. When participants finished watching the video they took a survey that asked for demographic information, and contained manipulation checks based on those used in a study on ego-depletion and aggressive behavior (Stucke & Baumeister, 2006). The manipulation check section of the survey aimed to ensure that the videos served their purposes, so participants were asked to rate the video with respect to three descriptors: *aggressive*, *funny*, and *boring*. Participants were also asked how *difficult* the video task was, and how much effort it took to follow the instructions they were given.

After watching the respective videos and completing the survey, participants were asked to complete two tasks that compromised the dependent measures. One task was an impossible tracing task, also known as a Euler puzzle; the participants were first given two geometric figures to practice on, and were told that they needed to trace the figures without lifting the pen from the paper or retracing any lines. After the two practice figures, they were given two figures that were, unbeknownst to the participants, impossible to solve. They were told that they should bring the figures out to the experimenter when they finished, or if they wanted to stop before they finished.

The other task was the Multi-source interference task (MSIT, Hagger et al., 2016). This task was administered on a computer using E-Prime, and required response inhibition. On the screen, three digits (0, 1, 2, or 3) would appear. The instructions told the participants that they needed to identify which digit was different from the other two (target digit) by pressing one of three keyboard keys. In the control, or congruent, sets of the task the target digit always matched its position on the response keys. In the interference, or incongruent, trials the target digit never matched its position on the response keys. Interference was also caused by varying thefont size of the digits in the set. Participants were given 20 practice sets, and then the main task which had 200 sets (100 of each condition) which lasted about 10 minutes. The order of the MSIT and tracing tasks was counterbalanced, with half of the participants receiving the geometric figures first and half receiving the MSIT first.

Once the participants completed both tasks, they were debriefed about the purpose of the study. During the debriefing, they were told that the tracing task was impossible and that they were not being recorded during any part of the study.

Results

The randomized groups did not differ on age, gender, or ethnicity (Appendix C). The manipulation checks for difficulty of the task and effort exerted during the task showed the expected differences between groups. There was a significant difference between the groups on both difficulty, $F(2, 59) = 9.46$, $p < .001$, and effort exerted, $F(2, 59) = 19.75$, $p < .001$ (Table 1). For both manipulation checks, there was a significant difference between the control group and the two test groups, but not between the emotion and attention test groups themselves. The emotion condition was significantly more difficult, $t(37) = 4.26$, $p < .001$, and required more effort, $t(37) = -5.97$, $p < .001$, than the control condition. Similarly, the attention condition was more difficult, $t(38) = 2.57$, $p < .001$, and required more effort, $t(38) = -4.82$, $p < .001$, than the control condition (Figure 1).

The manipulation checks for the qualities of “boring” and “funny” also showed the expected differences between groups. There was a significant difference between groups on both the boring scale, $F(2, 54) = 66.38$, $p < .001$, and the funny scale, $F(2, 57) = 50.84$, $p < .001$ (Table 1). Looking at a pairwise comparison between the two test conditions, the attention condition was significantly different from the emotion condition on both the boring scale $t(38) = 9.06$, $p < .001$ and the funny scale $t(39) = -8.35$, $p < .001$.

The three conditions did not significantly differ on the average time spent on the impossible drawing task $F(2, 57) = .83$, $p = .442$. They also did not differ on the other dependent variables from the MSIT: reaction times on congruent trials, $F(2, 57) = 1.01$, $p = .369$; reaction times on the incongruent trials, $F(2, 56) = .606$, $p = .549$; accuracy on congruent trials, $F(2, 57) = 1.24$, $p = .296$; and accuracy on incongruent trials, $F(2, 57) = 2.039$, $p = .14$ (Table 1).

Overall, the two manipulation conditions were more difficult for participants than the control condition, however the three conditions did not have different results with regards to the dependent measures. In addition, the manipulation conditions did not differ from each other in difficult or effort required.

The difficulty of the task, and the amount of effort required, did not correlate with any of the dependent measures (Table 2). Similarly, the ratings of the video on the funny and boring scales did not correlate with the dependent variables. Interestingly, performance on the MSIT did not correlate with time spent on the impossible tracing task. There was internal validity though, as the different measures on the MSIT correlated with each other. The scores of “boring” and “funny” were negatively correlated, as were the scores of difficulty and effort because they were coded oppositely. One unexpected correlation was the relationship between effort required during the task, and the rating of how boring the task was. The more boring something was rated, the more effort participants reported exerting. This may be due to the fact that during a more engaging task, participants aren't thinking about how difficult the task is while doing it.

Discussion

The manipulation in this study of creating conditions of varying difficulty and levels of arousal worked, however the hypotheses were not supported. It is important that the manipulation checks showed significant differences, because this confirms that the participants did experience the feelings that the conditions were designed to induce. The results from this study did not support the hypothesis that participants in the depletion conditions would spend less time on the impossible task, have longer reaction times for the MSIT, and have reduced accuracy on the MSIT. The second hypothesis, that the emotion-suppression condition would have a significantly larger depleting effect than the attention condition, was also not supported by this study. Since the manipulations worked, we can conclude that the different depleting tasks did not affect performance on any of the dependent measures. In addition, self-reported effort exerted, and perceived difficulty, did not correlate with performance on any of the dependent measures. This proves that even if some participants did not find the tasks difficult, those that did exert a lot of effort did not perform worse on the dependent measures.

Completing tasks that require a great deal of focus or emotion suppression both cause an increase in physiological arousal, however they activate different areas of the brain (Elliott, Bankart, & Light, 1970; Gross & Levenson, 1993; Kahneman, 1973; Mischel et al., 2011). The emotion-suppression condition was expected to be more depleting than the attention and control conditions because it has been shown that suppressing emotional responses involves areas of the brain, such as the limbic system, that are also involved when resisting appetitive stimuli (Franklin et al., 2017; Mirenowicz & Schultz, 1996). Tasks that require participants to resist appetitive stimuli have been shown to have strong depleting effects, so it was hypothesized that tasks that involve similar brain regions would have similar effects (Baumeister et al., 1998).

The findings from this study support the study by Carter and colleagues in 2015, which concluded that self-control does not function as if it relies on a limited resource, when tested in the lab. These results also align with the findings from the study by Hagger and colleagues, which was the inspiration for using the MSIT as one of the dependent measures (2016). This 2016 study concluded that if there was any ego-depletion effect, it was close to zero. The study used the letter “e” task as the depleting task though, which differs from the depleting tasks used in the present study. The present study aimed to determine if the dependent measures, MSIT versus the impossible tracing task, gave different results with regard to the ego-depletion effect. The MSIT requires focus and accuracy, but does not measure endurance in the way that the impossible task does, so it was hypothesized that the impossible task would show a depletion effect and the MSIT would not. However, neither dependent measure showed the presence of an ego-depletion effect, so this study was not able to determine whether these measures differ in ability to detect a depletion effect. Although both tasks in this study did not detect an effect, when the MSIT was previously used in a large replication study it also showed no effect, so it may not be a good dependent measure of self-control (Hagger et al., 2016). Additionally, in the current study performance on the MSIT did not correlate with performance on the impossible tracing task, showing that these variables are not measuring the same thing (Table 2).

The results of the current study both conflict with, and align with, certain results from the 2017 meta-analysis by Dang. This meta-analysis found a significant depletion effect for the emotion video task, Stroop test, and attention essay. It did not find an ego-depletion effect for the attention video, working memory, or multiple depletion tasks. The results from the current study for the attention video task align with this meta-analysis, in that there was no ego-depletion effect found. However, the present study did not find an ego-depletion effect for the emotion video task either, which conflicts with the results of the Dang meta-analysis. It is difficult to determine what might have caused this difference in results. The meta-analysis does not describe procedural details for the various labs, so the current study can't be compared on that aspect. In any case, this difference in results highlights the variance in this field of research that has become problematic.

The current research somewhat contradicts the main study that the ego-depletion theory stems from (Baumeister et al., 1998), and a meta-analysis by Hagger and colleagues in 2010. These studies both found an effect of ego-depletion on self-control task performance. The 1998 study by Baumeister and colleagues included four different experiments, one of which used an emotion video. They found an ego-depletion effect in all the experiments, including the one with the emotion video and one that used the version of the letter "e" task that requires breaking a habit (Baumeister et al., 1998). This study is therefore in line with the results that Dang obtained about the emotion video, however the results from the study by Dang for the letter "e" task showed such high heterogeneity that they were not considered reliable (Dang, 2017). The study by Hagger and colleagues also did not find an effect of ego-depletion for the letter "e" task, however the version of the task that they used was less difficult than the one used by Baumeister (Baumeister, 1998; Hagger et al., 2016). This mixture of agreement and discord among the results of three large studies, plus the current study, indicates a lack of validity and generalizability for the tasks and measures being used to test ego-depletion.

The literature on ego-depletion has debated the existence of this theory, and come to differing conclusions. The experiments on this topic vary widely; many different tasks have been used in the depletion phase, and many other tasks have been used as the dependent measure of self-control. Given this range of tasks, the debate has been unsuitably two-sided. The research has focused on whether or not ego-depletion exists, instead of looking at which specific settings might cause an ego-depletion effect and why. Though the current research did not find an effect of ego-depletion, it only tested two "depleting" tasks and two dependent measures. Future research should continue to compare different depleting tasks, and should also strive to find agreed upon dependent measures of self-control for these experiments. It might be the case that only certain tasks deplete self-control, and that only certain dependent measures accurately quantify self-control exertion.

There were some limiting factors in the study that may have affected the results found. The sample size for this study was small, with about 20 participants in each condition. If there is a true effect, a larger sample might be able to detect it. However, there was a significant difference between conditions for all the manipulation effects, so if there is an ego-depletion effect it must be smaller than those effects. In that case, if a true ego-depletion effect exists but can't be detected with the current sample size, the importance of the effect could be debated. Another factor that may have affected the results is the fact that although one of the conditions involved an emotional task and one did not, both dependent measures were attention and endurance oriented. It may be the case that certain tasks only have a depleting effect for subsequent tasks that involve similar brain regions. The study by Baumeister and colleagues found an ego-depletion effect for similar situation, in which the depleting task required emotion suppression and the dependent measure involved solving anagrams, however the relationship between the two tasks has not been well-studied.

One example that does look at performance on tasks of similar natures, although not in an ego-depletion context, is the 40-year longitudinal study that followed up with participants from the delay of gratification study by Mischel and colleagues. In this study, ability to delay gratification at age four predicted ability to suppress responses in the emotion condition 40 years later (Casey et al., 2011). Though these were not studies of ego-depletion, they did look at self-control across a long span of time, and found that performance on one type of task correlated with later performance on a different task. The original task involved an appetitive stimulus, a marshmallow, while the later study involved an emotional condition where participants looked at expressive faces. These tasks both involve aspects of the limbic and dopaminergic systems in the brain, and in this way are comparable even though they are not the exact same type of task (Casey et al., 2011; Franklin et al., 2017). Specifically, the follow-up experiment showed that resisting temptation in the “hot” version relied on frontostriatal circuitry. It also looked at the ventral striatum, which is associated with processing positive and rewarding cues. The people who had not be able to delay gratification as a child showed more activity in this area than the people who were, during the “no-go” trials with the expressive faces (Casey et al., 2011). The fact that performance on one task was predicted by performance on the other 40 years previously, indicates a strong relationship between the type of self-control needed for these tasks. This relationship between performance on tasks involving similar, or different, parts of the brain should be studied in the realm of ego-depletion. Future work should look at whether or not having the initial depleting task and dependent measure be of the same variety affects results.

To come to a clear understanding of the possible effects of ego-depletion, future studies should continue to compare different depleting tasks and dependent measures. The conflicting results from the current literature on this topic imply that there is more nuance to the ego-depletion theory than what we currently understand. To understand the limitations of this theory, more work needs to be done to understand the neural mechanisms of different tasks, and examine why some may be depleting while others are not. Scientists in this field have also called for more research on different operationalizations of self-control and moderating variables of the sequential task paradigm (Carter et al., 2015; Hagger et al., 2016).

The ego-depletion theory has broad implications for how we think about self-control. As mentioned previously, the level of self-control that a person exhibits has been linked to obesity, substance abuse, addiction, aggressive behavior, academic performance and criminality (Baumeister & Heatherton, 1996; De Ridder, Lensvelt-Mulders, Finkenauer, Stok, & Baumeister, 2012; Gottfredson & Hirschi, 1990; Mischel et al., 1989; Stucke & Baumeister, 2006; Vohs & Faber, 2007). With self-control having effects on such a range of aspects of success and well-being, it is important to understand what factors can influence a person's ability to exert self-control. These factors are not yet understood, but the debate on the theory of ego-depletion has the potential to provide a wealth of information. Further research in this area may lead to discoveries about what factors can reduce one's ability to exert self-control, and whether or not self-control truly can be depleted. Though this study did not find an effect of ego-depletion, future work should continue to investigate the details of this theory.

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Tables and Figures

Table 1

Mean, Standard Deviation, and Standard Error for Variables by Condition

Variables	**Condition**	**Mean**	**Std. Deviation**	**Std. Error**
Effort (1=most effort, 5=least effort)	Attention	3	1.049	0.229
	Emotion	2.55	1.099	0.246
	Control	4.58	1.017	0.233
	Total	3.35	1.351	0.174
Difficulty (1=least difficult, 5=most difficult)	Attention	2.81	1.123	0.245
	Emotion	3.45	1.099	0.246
	Control	1.84	1.259	0.289
	Total	2.72	1.316	0.17
Boring (1=least, 5=most)	Attention	3.95	1.024	0.223
	Emotion	1.42	0.692	0.159
	Control	1.35	0.606	0.147
	Total	2.33	1.48	0.196
Funny (1=least, 5=most)	Attention	1.81	0.602	0.131
	Emotion	3.9	0.968	0.216
	Control	4.05	0.78	0.179
	Total	3.22	1.303	0.168
Time spent on impossible task (sec)	Attention	972.95	513.054	111.958
	Emotion	779.3	528.274	118.126
	Control	937.21	483.572	110.939
	Total	897.08	507.653	65.538
Accuracy (congruent)	Attention	99.05	2.376	0.519
	Emotion	97.65	6.722	1.503
	Control	99.68	0.478	0.11
	Total	98.78	4.154	0.536
Accuracy (incongruent)	Attention	77.9	30.135	6.576
	Emotion	79.3	24.385	5.453
	Control	91.42	6.336	1.454
	Total	82.65	23.413	3.023
Mean Reaction Time (ms; congruent)	Attention	743.4724	205.00625	44.73603
	Emotion	668.143	125.59108	28.08302
	Control	714.2479	168.95564	38.76108
	Total	709.1082	170.39	21.99725
Mean Reaction Time (ms; incongruent)	Attention	1003.6005	266.2888	59.54398
	Emotion	985.5665	215.94536	48.28685
	Control	1061.0068	173.7377	39.85816
	Total	1015.9741	221.15341	28.79172

Table 2

Pearson Correlations among Variables

Variables	1	2	3	4	5	6	7	8	9
1. Effort (1=most effort, 5=least effort)	1								
2. Difficulty (1=least difficult, 5=most difficult)	-.773**	1							
3. Boring (1=least, 5=most)	-.269*	0.158	1						
4. Funny (1=least, 5=most)	0.13	-0.023	-.786**	1					
5. Seconds spent on impossible task	-0.005	0.069	0.104	-0.026	1				
6. Accuracy (Congruent)	0.15	-0.111	0.051	-0.029	0.034	1			
7. Accuracy (Incongruent)	0.114	-0.064	-0.151	0.244	-0.163	.309*	1		
8. Reaction Time (ms; Congruent)	0.047	-0.044	0.118	0.026	0.005	0.213	.367**	1	
9. Reaction Time (ms; Incongruent)	0.066	-0.067	0.017	0.202	-0.202	.348**	.613**	.795**	1

Note. ** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

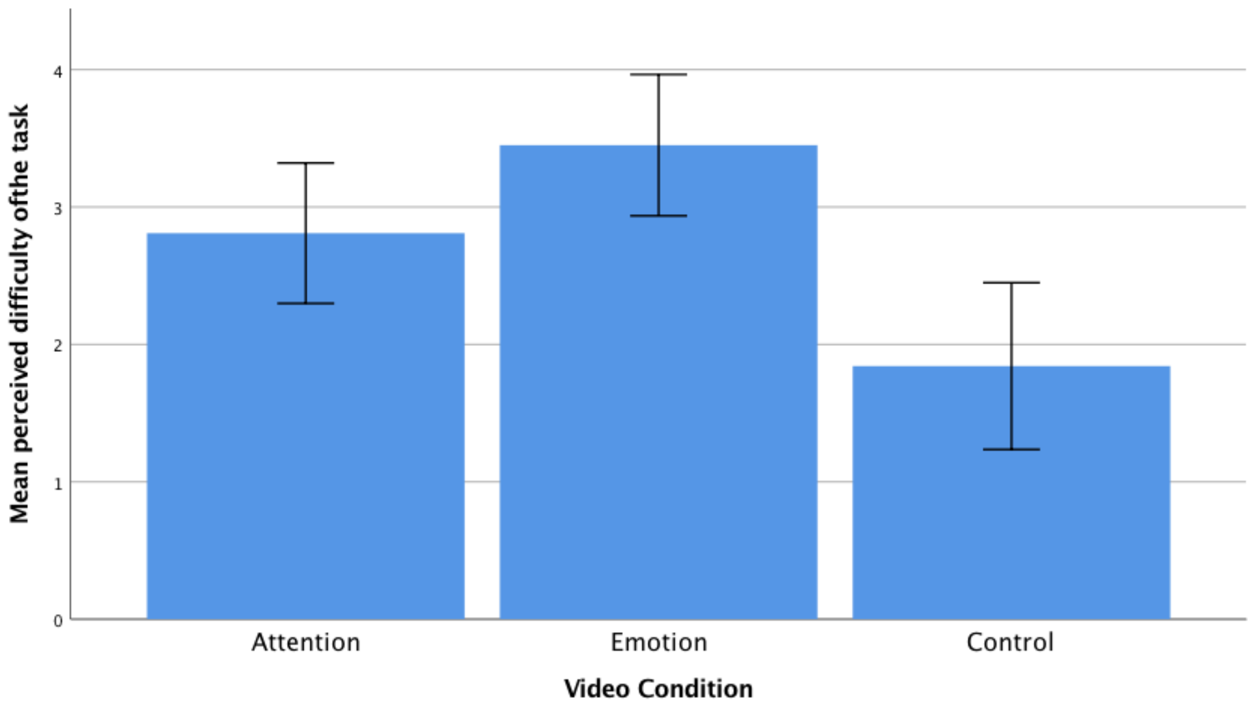


Figure 1. Perceived difficulty of the video task by condition (1 = least difficult).

Note. Error bars represent a 95% confidence interval.

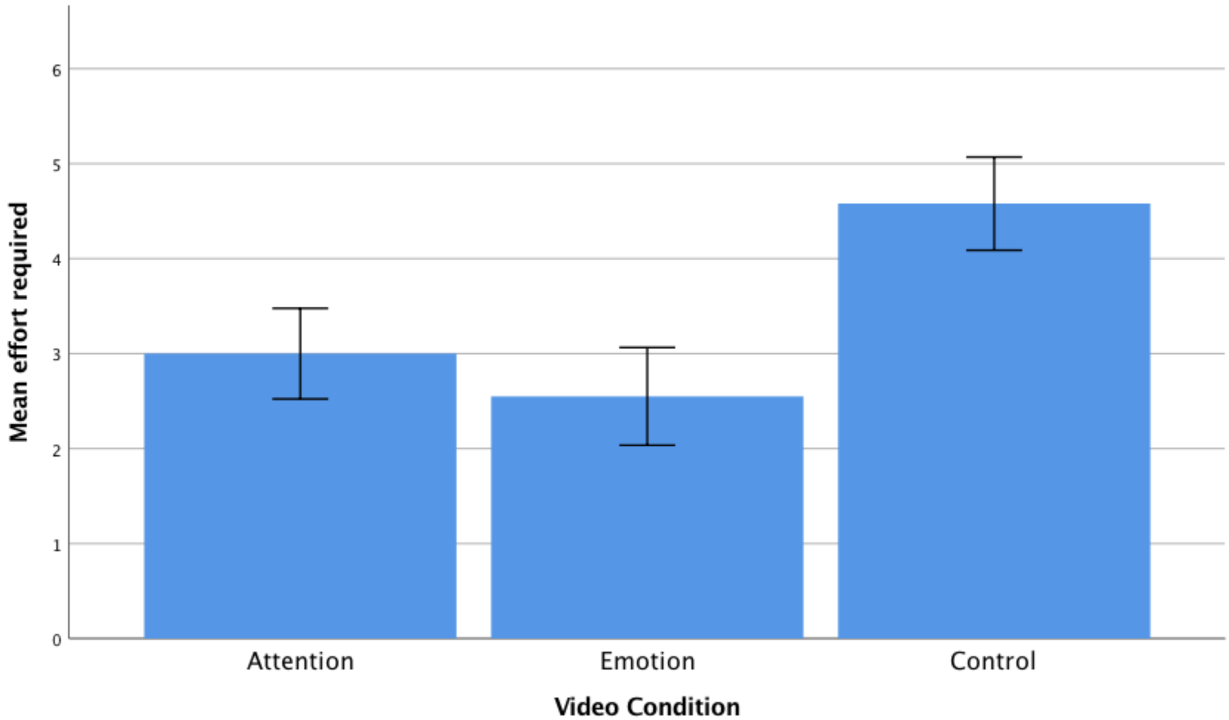
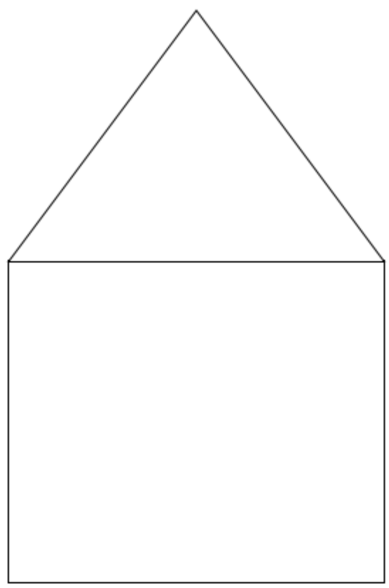


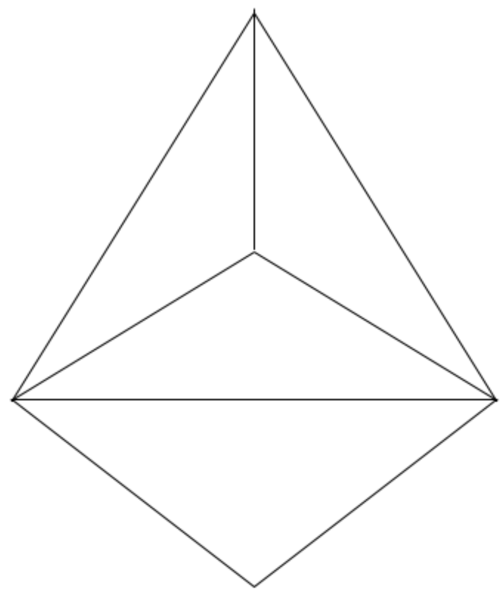
Figure 2. Perceived effort exerted during the video task by condition (1 = most effort).

Note. Error bars represent a 95% confidence interval.

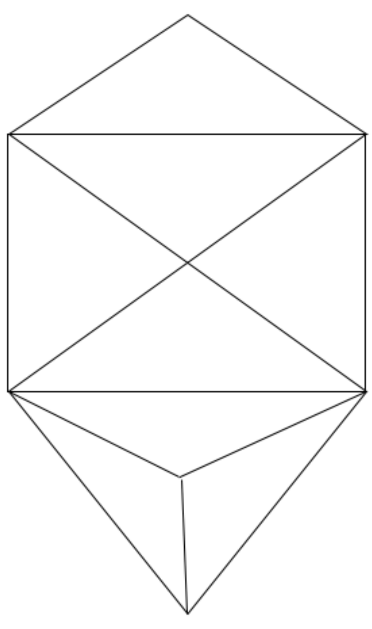
Appendix A: Euler Tracing Tasks

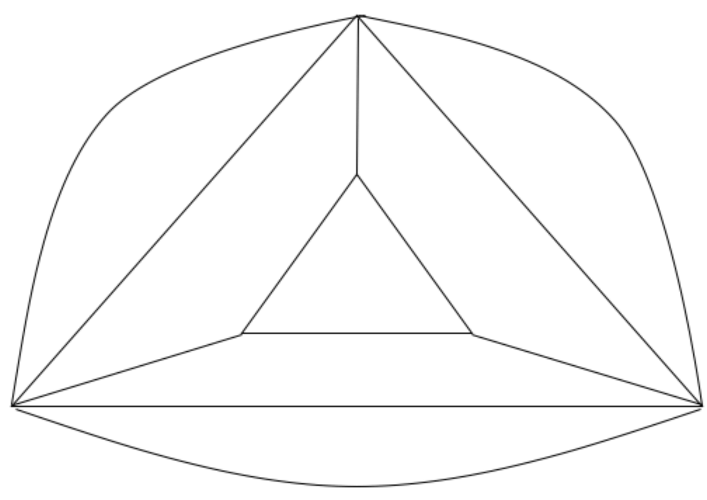
Possible Figures





Impossible Figures





Appendix B: Instructions to Participants

Investigator to Participant:

The purpose of the study is to see which personality traits make people more responsive to videos.

Video 1 (Attention):

Please focus your attention only on the woman's face during this video, try to refrain from looking at words that come on the screen. If you do look at the words, you should refocus your attention on the woman's face as quickly as possible. You will be recorded during this task, so please try to keep your gaze focused on the woman.

Video 2 (Emotion):

Please suppress your emotions while watching this. Try not to smile or laugh at any point. You will be recorded during this task and should show no facial expression.

Video 3 (Control):

Please watch this video, you will be recorded during it, but please just watch the video as you normally would.

Euler Tracing Task:

These two figures are for practice; you need to trace the figures without lifting the pencil from the paper or retracing any lines. When you feel comfortable with the task, let me know, and I will bring in the other figures.

These are the test figures, but the rules of the task are the same as the practice. Please bring the figures out when you're done, or if you'd like to stop before you finish.

Appendix C: Statistics of Randomization

There was not a significant difference between the groups with regards to age, $F(2, 59) = .26$, $p = .772$, gender $F(2, 59) = .77$, $p = .469$, or ethnicity $F(2, 59) = .414$, $p = .663$.