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Concurrent Load and Construal on Planning

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Abstract

Planning for the future is a necessary activity which spans across all aspects of an individual's life. Concurrent cognitive load has been shown to hinder future planning, whereas concrete construal of events has been shown to increase planning efficacy. Interestingly, a limited literature speaks towards cognitive load inducing concrete construal. However, the two constructs predict differing outcomes on future planning therefore the interaction of cognitive load inducing a concrete construal is particularly interesting. The research study tested whether differing levels of concurrent cognitive load increase or decrease planning efficacy. The intention of the research was to elucidate whether cognitive load or construal is a greater predictor of planning as this will fill a gap in the literature. 693 participants were sampled and revealed significant main effects of cognitive load and task type on planning steps generated and enthusiasm. The predicted interactions between cognitive load and task type were not observed. Conclusions from the results are that cognitive load negatively impacts planning behavior and the results of this study did not confirm the induction of concrete construal under cognitive load.

Keywords: cognitive load, construal level, working memory, future planning, executive function

Table of Contents

Concurrent load and construal on planning

Cognitive load, often conceptualized as the utilization of executive resources, has been studied and implicated in its impacts on cognitive functioning. Most of this research has found detrimental or otherwise hindering effects of cognitive load on cognitive function. One area where the cognitive load literature is lacking is in understanding how these cognitive load effects present themselves or interact with behavior and cognition in a naturalistic (outside of the lab) setting. My conducted research focuses on furthering our understanding of how cognitive load impacts ubiquitous real-world activities - that every person engages in - but it also seeks to determine situations where cognitive load can lead to beneficial outcomes for individuals. I looked at future planning, as this is something that we all do both professionally and otherwise. For example, people may need to plan for a complex work project such as coordinating a new payroll system rollout across the company or a vacation in an exotic location. Both examples of future planning, from implementing a new payroll system to planning for a vacation require a multitude of future steps to be generated and executed. Furthermore, future planning can be a cognitively taxing process that requires the utilization of the same cognitive resources that make up cognitive load as a construct. Whereas the literature supports a general hinderance of cognitive ability as a function of cognitive load, I argue for and conducted a study that suggests that these hinderances of cognitive functioning can be adaptive and helpful in certain contexts.

The present research study investigated how cognitive load maps onto the effects predicted by construal level theory. Construal level has been shown to have impacts on cognitive functioning, including, but not limited to, future planning. To what extent does cognitive load mirror the effects of construal level, and to what extent do the two constructs differ? These research questions have not been thoroughly explored, and investigating them will further the understanding of how human cognitive functioning operates. The present study manipulated cognitive load via working memory, an often utilized and heavily implicated executive function in a wide variety of situations (Brunye et al., 2018; Klaus et al., 2017; Miyake et al., 2000). The impacts of cognitive load on planning will elucidate the relationship between construal level theory and cognitive load. If the observed results mirror those expected by construal level theory then this will suggest that the two constructs either heavily overlap or that perhaps cognitive load induces distal or proximal construal. While cognitive load has been shown to induce concrete construal, the specific predictions regarding planning differ slightly between the two constructs (Block et al., 2010; Ferrari, 2001; Hadar et al., 2019; Huijser et al., 2020; Koerner & Volk, 2014).

The primary focus of this study is to determine how concurrent working memory load impacts one's future planning capabilities. Cognitive load literature suggests that increasing amounts of concurrent cognitive load decrease judgements of prospective duration (perceived shorter amount of time to complete the task) and decrease the amount of preparation that one can perform, resulting in overall poorer planning or task performance (Block et al, 2010). Construal level theory also predicts future planning such that proximal construal induces concrete cognition, which leads to greater specificity (steps planned and generated) but also greater self-control failure on the task (Schmeichel et al., 2010). Distal construal induces abstract cognition that leads to lower specificity but greater self-control success on the task. The area where these two theories overlap, and the primary focus on this research proposal, is that further research has shown that moderate cognitive load appears to induce concrete construal that may *increase* effectiveness on a planning task (Hadar et al., 2019; Huijser et al., 2020; Kliegel et al., 2000; Strickland et al., 2019). The research findings therefore conflict: cognitive load literature suggests that, under cognitive load, fewer steps should be generated, but under cognitive load construal level theory suggests that more steps should generated. These overlapping but contradictory findings speak to the complex nature of cognitive load and its profound impacts on all manner of cognitive functioning.

Before methodology can be discussed, I believe it is important to discuss a sufficient background of the literature, which will serve as a framework for understanding cognitive load as a construct, the ways in that it can be measured or manipulated, and broadly the impacts that have been observed on a variety of behavioral and cognitive outcomes. Furthermore, a brief overview of the previous findings of cognitive load on planning will provide a knowledge base for understanding the present research. Lastly, understanding the effects of both construal level and perception of time are imperative towards setting the framework for the present study.

Overview of Key Literature

Cognitive Load

Cognitive load broadly describes the exertion of cognitive functioning such that ability to perform other tasks that require the same resource base are hindered. Most activities that we perform such as holding a conversation, driving a car, or completing simple arithmetic problems draw upon the cognitive resources that are implicated in cognitive load. Similar to a physical muscle group, like your bicep, utilizing the executive function muscle via cognitive load uses up some or all its potential output. . However, how cognitive load is operationalized, measured, and broken down is complex.

One of the earliest and most seminal theories that aimed to describe our cognitive capacity is Baddeley's working memory model (Baddeley, 1983). Baddeley's model posits that we have a limited resource base with that to perform cognitive tasks such as: arithmetic, manipulating objects spatially, and maintaining information in the forefront of our mind (Baddeley, 1983). Working memory theory builds upon previous memory research. A distinction between short term and long-term memory does not properly encapsulate all the functions that our short-term storage fulfills, namely findings that show that we actively manipulate information in the short term. Working memory accounts for more of the variance observed in our cognitive functioning relative to only short-term memory. The active manipulation of information is integral to human functioning and is the basis of Baddeley's working memory theory.

The theory is broken down into three major components: central executive, visuospatial sketchpad, and phonological loop. Working memory and by proxy cognitive resources are not a monolith; tasks recruit differential cognitive systems that govern specific cognitive functions. One could compare working memory to an internal combustion engine. Engines convert a fuel source into output, but this output is diverse, including horsepower and torque. These two measurements of engine output are relevant to converting energy into motion, much the same as Baddeley's working memory components are differing outputs of effortful cognition. The visuospatial sketchpad is responsible for the monitoring and manipulation of visual and spatial information, whereas the phonological loop is responsible for auditory information (including language as a whole). Baddeley later included a third component responsible for the active maintenance and governance of these two "slave" systems, this component being called the central executive (Baddeley, 2000).

The differing working memory systems have a fair amount of overlap with one another while still having distinct function and unique variance. When tasks demand a specific type of information to be manipulated, like spatial tasks or auditory language, it becomes harder to attend to information that similarly loads onto the slave system responsible for that functioning. A task that recruits the other slave system is comparatively less affected (Baddeley, 1983). Concretely, it is easier to perform a spatial task alongside a language task than it is to perform two language tasks concurrently. There is spill-over between the visuospatial sketchpad and the phonological loop (Baddeley, 1983). Spillover, or the functioning of one system impacting the other, suggests that there is an overall working memory storage space to pull from. However, there is a segmentation of these resources such that it would be easier for someone to complete concurrent tasks that recruit the visuospatial sketchpad and the phonological loop respectively, as opposed to tasks that simultaneously recruit only one of the slave systems.

Building upon working memory as an early construct with that to measure cognitive load, cognitive load has been further conceptualized as the utilization of executive functioning. Executive function describes the processes of mental set shifting, updating (working memory), and inhibition of response (Miyake et al., 2000). Set shifting is the ability to switch between differing rule sets or distinct processes relevant to completing a task. Updating is the ability to hold finite quantities of information in a readily available state with the intention of manipulating or recalling the information. Updating most closely resembles Baddeley's working memory model and is the primary focus of this paper. The ability to manipulate and maintain information in our cognition is a ubiquitous and important process. Lastly, inhibition is staying on task by diverting cognitive resources to blocking out distracting or off-task stimuli. Executive functions are said to exert control over cognitive processes and describe the ability to regulate complex mental processes and behaviors (Miyake et al., 2000).

There is significant overlap between all differing executive functions, but they each have unique variance associated with them. Research shows that there are measures and manipulations of executive function that best map onto specific executive functions (Miyake et al., 2000). In other words, executive functioning is a complex process that can be both measured and manipulated in a variety of ways.

Turning back to the earlier research on working memory, occupying working memory is often used to induce concurrent load. Working memory is frequently utilized when concurrent load is manipulated because many basic and complex tasks require working memory in some capacity; furthermore, working memory load is easily induced via a variety of differing tasks spanning multiple modalities (Benedek & Fink, 2019; Miyake & Friedman, 2012, Miyake et al., 2000). For these reasons, I plan to use a working memory manipulation in my study to induce and explore the downstream impacts of concurrent cognitive load.

Cognitive Load Measures and Manipulations

Cognitive load can be measured and manipulated in a variety of ways. Studies have specifically analyzed that executive functions map onto that measures and/or manipulations of cognitive load (Miyake et al., 2000).

One of the most straightforward ways in that cognitive load can be induced is via concurrent working memory tasks. *N*-back tasks operate such that a person is asked to remember a digit or item that is back *N* times; therefore, you can manipulate the difficulty of the task by the size of the *N*. The more items that someone is asked to remember, the greater the load on working memory by forcing more information to be held in a readily available state in working memory. *N*-back tasks are heavily used because they can use items that differ in modality (e.g., auditory, or visual stimulus) as well as content (e.g., numbers, shapes, letters)(Miyake & Friedman, 2012, Miyake et al., 2000). The active maintenance of information is a necessary process in all manner of human functions, from simple to complex. While *N*-back tasks are frequently utilized way to induce working memory load, there are a variety of other methods in that to induce or measure working memory.

Working memory has been further assessed via operation and reading span tasks. In both tasks, participants are asked to remember a string of letters or other such stimuli, while intermittently having to complete math problems (OSPAN) or determine if sentences make sense (RSPAN) (Dokic et al., 2018). Both span tasks measure updating or working memory in that they require the active maintenance and repeated rehearsal of information. The information to be remembered at the end of the task is competing with distracting tasks that also utilize cognitive resources. Span tasks are often used to determine an individual’s working memory capacity because they map onto the complex nature of utilizing our working memory in real-world situations well. In day-to-day life, a person often finds themselves in situations where they need to remember a string of information (e.g., grocery list, new phone number, tasks to be completed) while also completing other tasks that might compete with some of our cognitive resources. This is essentially the same form that the span tasks take, but in a less controlled manner than within the lab.

Other measures of cognitive load instead focus on the inhibition component of executive function. Perhaps one of the most well-known examples of this type of measure is the Stroop task. In a classic Stroop task, participants are tasked with responding with what color a word is written as, but the words are written in varying colors that may differ from the physical color of the word. The rationale is that it is difficult for someone to say the word “red” when that word is displayed in blue. Good performance on this task therefore requires the inhibition of a predominant response or tendency of ours to want to respond to the color of the word and not the meaning of the word. Being able to inhibit responses or thoughts is an important component of executive functioning. For example, people might need to inhibit off-task thoughts when they are at work, and a test like the Stroop looks to measure how effective people are at this inhibition function.

Inhibition can be further tested via anti-saccade or go/no go tasks. Each task requires the inhibition of response, but the type of response to be inhibited differs by task. Anti-saccade tasks ask participants to fixate on a point. This point, normally in the center of the screen, will then have an object flash on a different portion of the screen. The natural human reaction to the sudden appearance of a new stimulus to direct gaze to the new stimulus. Instead, participants are instructed to shift their gaze *away* from the unexpected stimulus, therefore overriding their predominant and automatic response. The overriding of an automatic saccade, or eye-movement, requires inhibition. Go/no go tasks on the other hand ask participants to respond or “go” to a specific stimulus or stimuli and not to “go” (i.e., do not respond) to another stimulus or stimuli. The behavioral action measured is normally a button press. As has been the case with the previous examples, go/no go tasks require a participant to override a potentially automatic desire to “go” or press the button. Participants are judged on the amount of errors they commit and the speed with that they respond to the differing stimuli. On average, the expectation is that participants will respond slower on the “no go” trials that represents the cognitive mechanism of inhibition at work. Whereas both inhibition and updating are relatively straightforward executive functions to measure or manipulate, switching is significantly more difficult and complex.

An example of a popular measure that is said to test the task switching component of executive function is the Tower of Hanoi. The Tower of Hanoi is a rule-based logic game where one must move a series of sequentially sized rings from one peg all the way to a peg on the other side. A few rules constrain the moves you can make during this task; namely, rings can only ever sit on top of a ring that is larger. The Tower of Hanoi is suggested to test the switching component of executive function because a person needs to switch between differing strategies and cognitions throughout the process of coming to the correct solution. The Tower of Hanoi, and information processing approach, stress the importance of sometimes having to move away from an eventual solution out of necessity. Therefore, one must alternate between differing strategies, which might be counterintuitive, to reach the final solution. Switching as a construct is one of the more difficult executive function processes to measure. The complexity of tasks used to measure task switching therefore reflect this complexity. Each of the components of executive function can be used to either measure or manipulate cognitive load. Depending on the specifics of a research study, one might lean towards a component of executive function that best encapsulates a particular type of cognitive functioning utilized in a study.

Regarding the present study, I will utilize an updating cognitive load task that presents participants with pairs of exemplars to be remembered. These exemplars will be constantly updated and presented to participants. Participants will need to remember the most recent exemplar from a finite number of categories that were presented to them at the start. Participants will be given all possible categories and exemplars at the beginning of the study, and then will be later asked to remember the most recent exemplar presented. The purpose of this form of working memory manipulation is that prior knowledge or experience should have less of an impact on performance. With some of the aforementioned tasks, like operation span tasks, individual differences in arithmetic ability might have a profound impact on how difficult the task is and subsequently how well participants do on it. These subject related variables, along with others, that might impact cognitive load performance are the reason why I chose the updating task that I did.

For the purposes of this project, working memory and updating will be manipulated via a concurrent updating task. In part because this aspect of executive function is easy to manipulate, but furthermore because updating is integral in tasks and behaviors ranging from simple to complex. To build upon the ease of manipulation, updating is also easily taxed in everyday life. For these reasons, among others, updating will be manipulated and its effects on future planning will be tested.

Cognitive Load Effects

Having laid the groundwork with a variety of different ways in that cognitive load can be manipulated and tested, I will now delve into some of the downstream impacts of cognitive load on behavior and cognition. Cognitive load has impacts on all manner of activities, behaviors, and cognitions, because executive function is required for all tasks, from basic to complex. I will detail a variety of situations and activities that are significantly impacted by cognitive load. One area that is not sufficiently tested, however, is how cognitive load impacts future planning, and the few findings on the subject appear to be at odds with another significant body of literature in construal level theory. For those reasons, the impacts of cognitive load on future planning are the primary focus of this paper, but understanding the overall literature and the broad range of effects of cognitive load serve as a necessary background for this project.

Cognitive load research illustrates the importance of cognitive resources, such as working memory, in the consolidation of short-term memories (Vlassova & Pearson, 2013). In a random-dot-motion paradigm that measures decision making by presenting moving stimulus dots that the participant must indicate that direction of coherent motion, memory consolidation was shown to be hindered by concurrent working memory load (Vlassova & Pearson, 2013). When given a blank screen between stimulus onset and the response window, participants increased their accuracy relative to a masked delay screen. When cognitive load was induced via a high load concurrent digit span (10-number string), the effect was not present. Working memory load therefore seems to govern our ability to consolidate short term memories. The authors describe this research study as a proof of decision-relevant information in short term memory impacting decision accuracy on the dot-motion probe after delay (Vlassova & Pearson, 2013). Therefore, the authors support the idea that quicker processing that may be impacted by cognitive load has impacts on downstream decision-making processes. For a real-world example, concurrent cognitive load during a random-dot-motion paradigm may be analogous to attempting to consolidate a phone number to memory while having to hold a conversation with someone over the phone.

Cognitive load impacts assessment of risk (Allen et al., 2014; Deck, Jahedi, & Sheremeta, 2015; Harris et al., 2020; Whitney, Rinehart, & Hinson, 2008). In general, cognitive load increases conservative decision making. The actual mechanism of how decision making becomes more conservative under cognitive load is a complex discussion point. Conservative decision making is in part a product of concurrent cognitive load truncating the total amount of cognitive resources available to rigorously evaluate strategies and decisions that *can* be made in a particular situation. As such, when concurrent cognitive load is present, an individual is significantly more likely to settle with an initial decision and/or a strategy that has proven to work in the past. Even if this strategy is not optimal, such that a better strategy could be implemented, participants have been found to stick with the previous response. Cognitive load therefore generally impacts decision making capabilities when it comes to evaluating risk and formulating responses to that risk. These effects on risk evaluation show how concurrent cognitive load can not only hinder basic processes but also complex processes, such as choosing between a multitude of differing strategies or solutions to a problem.

Cognitive load slows down processing that can have profound impacts on complex and important activities that many people do on a day-to-day basis, such as driving (Flores, 2017; Wolfe et al., 2019). Cognitive load, manipulated concurrently via auditory and visual working memory load, slows down reaction times to typical driving responses (Flores, 2017); Wolfe et al., 2019). Typical driving responses include, but are not limited to, responding to brake lights and reacting to a driver merging into your lane. Higher concurrent working memory load increases the time that it takes to respond to brake lights and increases the proportion of brake lights missed entirely (Wolfe et al., 2019). Concurrent cognitive load causing significant detriments in reacting to hazards on the road like brake lights ahead of you demonstrates the far reaching and ecologically relevant impacts of cognitive load on functioning.

Driving is a complex task that requires attention to differing stimuli with significant consequences when the necessary attention and response is not exhibited. Research into visual working memory has shown that having to fixate on a visual stimulus and maintain it in working memory concurrently hinders functioning towards relevant stimuli, representing a bottleneck of working memory capacity. Visual information presented to drivers is presented rapidly and therefore requires a significant amount of attention to maintain proper vigilance. When a task like driving is therefore done concurrently with other tasks that also simultaneously recruit working memory resources, like receiving driving directions, the total amount of concurrent working memory load negatively impacts driving performance via reaction times and lane adherence (Hollands et al., 2019). Research into an ecologically valid behavior like driving is important because how people react to hazards on the road is necessary and potentially damaging to the driver and others. Concurrent cognitive load has therefore been shown to significantly impact driving performance in a multitude of studies, demonstrating the necessity for understanding how cognitive load interacts with complex everyday cognitive functioning. Many behaviors and cognitions, from simple to complex, recruit working memory resources.

Cognitive load impacts judgments of duration and stereotype activation (Block, Hancock, & Zakay, 2010; Gilbert & Hixon, 1991). Duration and stereotype judgments are both impacted by cognitive load and demonstrate how much cognitive load impacts a wide variety of functioning. Furthermore, cognitive load impacting duration judgements is directly relevant to discussing planning, as proper planning is contingent on assessing the amount of time or duration that a task has or will take.

Judgments of duration are an applied way to measure cognitive load, as cognitive load has a direct impact on duration judgments (Block et al., 2010). Duration judgements are the amount of time that a person perceives a task will take or has taken. Judgments of prospective duration are shorter under concurrent cognitive load and judgments of retrospective duration are longer (Block et al., 2010). Loading working memory capacity via a variety of processing tasks that varied in difficulty, as well as tasks that placed demands on the attentional system, were both shown to impact duration judgments (Block et al., 2010). Anecdotally, we have all experienced this phenomenon. When under considerable cognitive load while completing a difficult activity, we tend judge that time as having passed by quickly. These findings further show the relative complexity of cognitive load and its effects. Entering a flow like state where time seems to pass more quickly under considerable cognitive load has aided a wide variety of people. Cognitive load therefore clearly has far reaching effects on our cognitions and the decisions that come as an outcome. For example, someone might delay getting started on an assignment only to complete it in one night because they know that, when under cognitive load, they will not only be able to get the assignment done, but it will temporally “fly by.” A simple judgment of duration, and the expectancy that it will occur under cognitive load, impacts a decision that a person makes.

Further evidence about the impacts of cognitive load shows changes in perceptions and eventual application of stereotypes (Gilbert & Hixon, 1991). Stereotype activation is inhibited by concurrent working memory load (Gilbert & Hixon, 1991). During concurrent working memory load (e.g., a digit span task), a person may therefore not make immediate stereotypic judgments that could change their behavior towards another individual. Interestingly, if a stereotype was first activated, and then cognitive load was induced via a visual search paradigm in that participants had to remember what letters were presented and respond accordingly, the participant was more likely to apply the stereotype under that concurrent load (Gilbert & Hixon, 1991). Cognitive load therefore appears to hinder the application of a stereotype but increase the likelihood of its usage if already activated. These findings have interesting conclusions that can be derived. First and foremost, the application and activation of stereotypes seem to draw upon the same cognitive resources as the cognitive load measures recruited. Furthermore, the application of these findings speaks towards a complicated relationship between cognitive load and stereotype activation. For example, if a police officer inherently holds stereotypic judgements, then under cognitive load they will be more likely to apply them. If instead that police officer does not explicitly hold these judgments, they may instead be less likely to apply them because they were never activated under high cognitive load.

Cognitive resources are clearly implicated in a wide variety of functioning, from complex decision making to more implicit judgements. The far-reaching impacts of cognitive load therefore speak to the necessity of properly understanding how concurrent cognitive load impacts other processes that apply to a wide variety of people in many contexts, such as future planning.

Cognitive Load on Planning

Cognitive load changes strategies that people employ when planning. Cognitive load has been shown to impact a variety of complex behaviors, not the least of that is the ability to plan. Planning for the future requires the recruitment of cognitive resources as planning requires someone to consider differing possibilities, what needs to be completed, and how to best approach that upcoming event. A common way that planning is conceptualized in the literature is the number of steps that a person generates that need to be completed towards eventual goal completion. The rationale behind this is that the more steps that are generated, the greater success that one will have on the task, with more steps being a metric of greater preparation.

People are generally quite poor at effectively planning (Forsyth & Burt, 2008; Francis-Smythe & Robertson, 1999; Wiese et al., 2016). When participants were asked to allocate time towards a necessary task and then asked to allocate time towards specific singular tasks that make up the aforementioned task, researchers found that when these individual tasks are summed together they are significantly longer than a prediction of the task as a whole (Forsyth & Burt, 2008). Participants in this study therefore show that people are generally bad at allocating the necessary time towards a task and in particular accounting for all the various steps that are necessary to properly complete a task. Judging the amount of time that a task or series of tasks take is paramount to planning and completing the task. The general finding that people are poor at judging task duration and that this is exacerbated under cognitive load is a significant finding worthy of further research (Block et al., 2010).

Research into the effects of cognitive load on planning is sparse, but findings suggest that planning is generally poorer under concurrent cognitive load with fewer to-be-completed items being completed (Ferrari, 2001). These findings specifically pertain to chronic procrastinators where the greatest detrimental effects of cognitive load are observed with chronic procrastinators being significantly worse at completing tasks under concurrent cognitive load relative to non-procrastinators. Individual differences in motivation or execution of plans, as referenced via findings on chronic procrastinators, shows impacts of cognitive load and suggest that cognitive load does have an impact on planning (Ferrari, 2001).

Working memory load has been implicated in concrete planning relative to abstract planning (Klaus et al., 2016). Research demonstrated that advance planning at the phonological level (concrete) is hindered by concurrent working memory load whereas advance planning at the abstract level is not hindered (Klaus et al., 2016). Advance planning at the phonological level was tested by using phonologically related distractor words whereas advance planning at the abstract level was tested via semantically related distractor words. Performance on the task was uniformly impacted with abstract distractors compared to performance being significantly worse under cognitive load when the distractor words were phonologically related (Klaus et al., 2016). Results that show that specifically working memory, more so than other executive function components, impacts planning; this is relevant to the questions of this paper. Under what circumstances does concurrent working memory load increase planning efficacy through the mechanism of concrete construal and how this is contrasted by limited findings that suggest that working memory load hinders concrete or proximal planning efficacy must be investigated. Research findings that differ in their predictions on planning efficacy depend on whether the researchers were more interested in cognitive load or construal as a predictor. For example, previous work suggests that working load hinders planning, which is at odds with the construal literature that finds concrete construal induced via working memory load increases planning efficacy (Huijser et al., 2020). The findings of construal level theory on planning will be discussed as they pertain to the direct question that the proposed research is attempting to answer.

Working memory resources have been shown to impact concurrent planning for future events (Huijser et al., 2020). Planning for a future event while also completing a current task occurs all throughout our daily life, such as discussing with your office when to schedule a meeting while also working on a spreadsheet. The ability to plan for a future event while performing a concurrent and cognitively taxing task is hindered as a product of how much our working memory capacity is utilized by the concurrent task (Huijser et al., 2020). Participants were asked to complete a task that varied in working memory utilization while also being able to look across the screen and prepare for the next task they will be asked to complete. Eye tracking data shows that participants reliably engaged with the second or future task, which acted as evidence that they were planning. Working memory is necessary for future planning and when working memory is utilized by the concurrent working memory tasks participants were significantly less likely to plan ahead and were worse at planning (Huijser et al., 2020).

A key outcome of planning is succeeding on the task and performing the steps that one has generated. Often, success on a given planning task is conceptualized as self-control failure or success, where self-control is the ability for one to sustain action towards the task and follow through with all the planning that they generated. This is an important application of the planning literature because planning for a task is somewhat irrelevant if it does not result in appreciable impacts on the task being completed. Construal level theory speaks to key differences in self-control failure or success as a function of construal type. As aforementioned, although the literature speaking towards the effects of cognitive load on planning is sparse, there is a much more robust literature regarding construal level and planning. The differing predictions on planning outcomes between the two theories will be tested. Before these differing predictions can be tested, and for the purposes of this paper, it is worth discussing some of the general findings of construal level theory that form the basis for the claims I am positing.

Construal Level Theory

Construal level theory discusses the differing ways in that a person can conceptualize events or concepts, primarily relating to the psychological distance (distal/abstract & proximal/concrete) (Trope & Liberman, 1998; 2000; 2010). Differing construal have an impact on the output of cognition and how an event is approached. An often-used example is that when one is far away (distal) they will view the forest and as they get closer (proximal) they will observe the trees, demonstrating the relative impact of real and/or imagined distance on our perception as well as our cognition. The farther away an event is the more abstract it is perceived, with a person focusing on the higher order (meta-level) aspects whereas as an event becomes closer either temporally or psychologically it is viewed as much more concretely or focusing on the specifics (micro-level) (Trope & Liberman, 2010). Specifically for this proposed research I will be talking about how construal impacts one’s ability to plan for events in the future, but construal level theory is a far reaching and heavily researched topic in social psychology.

Construal level highlights the aspects of a stimulus, event, or thought that most intrinsically associated with the event, with those aspects which are most intrinsically associated with the event being more salient distally (Trope & Liberman, 2010). Importantly, for the proposed research I believe that this means that a distal (abstract) view of vacation planning will focus on the positive experience of being on vacation whereas the distal view of work planning will focus on the task which needs to be completed. I conceptualize the core tenet of a vacation to be the fun we have while on it and the core tenet of a work task to be the necessity of completing it. Furthermore, when an event becomes more proximal the low-level aspects become more salient (Trope & Liberman, 2010). The low-level aspects of vacation planning are the details of what needs to be done, details which are not inherently positive.

Regarding the proposed research, construal level theory has been implicated in the qualities of a future event that a person finds relevant (Liberman & Trope, 1998; Trope & Liberman, 2010). Distal future events are judged on their desirability relative to their feasibility and the effect flips for proximal events (Liberman & Trope, 1998). Viewing a future event based on desirability relative to feasibility will necessarily increase the positive valence of that future event. Whereas viewing an event more proximally will highlight the negative valence (Liberman & Trope, 1998). The proposed research seeks to validate these findings through the measurement of enthusiasm as an outcome variable regarding planning for a work task or a vacation. Planning for a future vacation should lead to significantly more enthusiasm towards the task, particularly because with the vacation being perceived as temporally far away this will further predispose an individual to focus on the abstract thoughts of how fun the vacation will be relative to the concrete thoughts of how to plan for the vacation. Furthermore, the perceived emotionality of an event is more likely to be positive distally relative to proximally (Van Boven, et al., 2010). Whereas these effects are expected on average, the proposed study will test whether cognitive load pushes these findings around. In particular, the proposed study will seek to wash out the positive valence associated with distal vacation planning by inducing a concrete construal therefore increasing the salience of the more negative planning aspects of the positive future event.

To that end, I believe that construal level plays very well with the overall cognitive load literature because, at its core, construal level theory is very cognitive in nature. Construal level theory speaks to the differing ways that psychological distance, or a perception of how close or far an event or thought is from the individual, impacts outcome behaviors and thoughts (Fujita, 2008; McCrea et al., 2008). Distal construal induces abstract thinking while proximal construal induces concrete thinking.

Construal level predicts self-control performance (Fujita, 2008; Schmeichel et al., 2010). Broadly speaking concrete construal has been conceptualized as increasing self-control failure (Fujita, 2008; Schmeichel et al., 2010). Concrete construal increases the perceived immediacy and necessity of a to-be-completed task therefore increasing the likelihood that a person becomes overwhelmed, deciding to not complete the task thereby counting as self-control failure.

Regarding planning for future events, construal level theory has been used to predict procrastination such that events that are viewed more concretely are less likely to be procrastinated (McCrea, et al., 2008). Intuitively, when an event is viewed as occurring more proximally this forces a person to stop procrastinating it and make progress. What this research does speak to is the powerful nature of construal and furthermore the fact that the concreteness of construal is a significant predictor even when the difficulty, attractiveness, and importance of the task were varied (McCrea, et al., 2008). The significant impact of construal level underscores the behavioral impact of a relatively simple cognitive mechanism and the enduring need to understand how everyday cognitions impact meaningful behavioral outcomes such as future planning.

Construal level has not only been shown to impact procrastination and starting of tasks, but, as is pertinent to this paper, construal level is directly tied to executive functioning. Specifically, concrete construal induced via a mindset manipulation (describing how to complete a task) has been shown to increase filtering accuracy and working memory capacity relative to an abstract construal (describing why to complete a task) (Hadar, Luria, & Liberman, 2019). In other words concrete construal appears to induce greater working memory efficiency. Therefore, evidence shows that construal level is more than just a change in perceived psychological distance and instead has significant impacts on cognitive functioning as measured via executive function. Furthermore, concrete construal is typically thought to be a significant predictor of self-control failure but aids in inhibitory performance in the short term (Fujita, 2008; Schmeichel et al., 2010). By manipulating the task to be delayed and introducing a goal maintenance (working memory) component, abstract construal was found to increase relative performance on the delayed task therefore showing that the construal level and its effects on cognitive load are dynamic (Schmeichel et al., 2010). Construal level appears to have differential effects on executive functioning depending on whether the task is immediate or delayed. The primary conclusion here is that concrete construal is better for immediate tasks and increases working memory efficiency (Schmeichel et al., 2010). Executive function and its relationship to construal level is intricate and warrants further study, this paper will look towards the specific outcome of future planning.

Perceived Time and Planning

Perception of time has a fundamental impact on planning. Anecdotally, perceiving a to-be-completed task as being temporally closer induces greater amount of stress and immediate need to plan for and complete the task, whereas perceiving a to-be-completed task as temporally farther away induces comparatively less stress and a lesser need to immediately plan for and complete the task. When the present is perceived as shorter, it causes people to be much more likely to make future-oriented plans (Hershfield & Maglio, 2019). For these reasons, the relationship between perception of time and planning is pertinent to this paper. Furthermore, as is directly cogent to this paper, cognitive load has been shown to induce concrete construal that impacts the perception of time (Huijser et al., 2020; Klaus et al., 2016).

One way in that people tend to systematically bias their decision making regarding future planning is such that people plan for optimistic scenarios and disregard pessimistic scenarios (Newby-Clark et al., 2000). The tendency when planning for personal events to disregard pessimistic scenarios and potential eventualities biases the average person towards shorter or more optimistic plans and timetables (Newby-Clark et al., 2000). Furthermore, people are generally overly optimistic in their predictions in their future planning and how long the task will take (Buehler, Griffin, & Ross,1994).

Further research into the relationship between time perception and planning has illuminated that people are very poor at judging the total time that a task will take (Forsyth & Burt, 2008). The task segmentation effect describes people's tendency to underestimate the time required to complete a global task relative to estimating the time that each subtask would take and summing them together (Forsyth & Burt, 2008). In other words, when people are asked to predict how much time a complex task will take, they tend to underestimate how long it will take. When people are instead asked to plan for all the individual tasks that make up the complex task, the summed total is much larger than when participants were asked to plan for the task as a whole. Segmenting and planning for the individual tasks is also more accurate (Forsyth & Burt, 2008).

The mechanisms at play as to why people are so poor at judging how long a task will take and biasing themselves towards optimistic predictions are not well understood. One interesting finding is that when participants are asked to plan backwards, that is start with the last thing that will need to be completed and then work towards the first, their estimation of how long the task will take is significantly longer and more accurate relative to a regular planning condition (Wiese et al., 2016). Showing that temporally how we think about a task that needs to be completed, even something so simple as which steps we plan from, has a fundamental impact on planning efficacy. Planning therefore is behavioral outcome which is easily shifted around, a proof of concept for the proposed study and the necessity of understanding the mechanism at play.

Overall, how people perceive the passage of time needed to complete tasks has a substantial impact on effectively planning for the task. Perception of time is impacted by construal level and construal level ca be induced via cognitive load manipulation (Hadar et al., 2019; Huijser et al., 2020; Klaus et al., 2016; Schmeichel et al., 2010).

Attractiveness of Task

I believe that the attractiveness or desirability of a to-be-completed task impacts a person’s intention to engage with the task, assuming there are not other factors which prioritize the need to plan for a future task. For example, people often look forward to planning for future vacations or other such leisure activities at the expense of preparing for a work assignment. Therefore I believe the attractiveness of a task has a non-zero impact on whether people decide to actually plan for a future event and how much they prioritize it. Regarding the present proposal, construal level theory posits that distal events are judged on their desirability and proximal events are judged on their feasibility (Liberman & Trope, 1998). Furthermore, distal events are primarily conceptualized for their beneficial aspects and as events become more proximal the downsides of the event become more salient (Eval et al., 2004). The construal research supports our tendency to daydream and take time to plan for vacations or other positive events and why some might therefore choose to devote time to thes positive aspects of distal events over proximal events. Furthermore, the perceived emotionality of events reduces as a function of increasing construal level (Boven et al., 2010). If the perceived emotionality of an event increases as it is more proximal and we view proximal events more concretely and therefore less positively, then people should prefer to plan for positive future events at the expense of negative proximal events. But, as a positive future event (such as vacation planning) becomes more proximal as a product of time or cognitive load a person might be *more* likely to avoid engaging in the planning process because there are no extrinsic motivators that often exist with negatively valanced work tasks that we must complete.

How Cognitive Load and Construal Interact

Concretely, the present study proposal is a novel contribution to the literature because it explores the alternative explanations of cognitive load and construal level theory on the outcome of future planning. Under cognitive load planning is thought to be hindered (Ferrari, 2001; Huijser et al., 2020). In contrast, as concrete construal increases beneficial outcomes of planning behavior also increase. Why this is interesting is because cognitive load has been shown to induce concrete construal; therefore, the two constructs appear to interact with one another but seemingly lead to opposing planning outcomes. The present proposal will seek to test whether cognitive load or construal level theory will be the primary driving force behind planning behavior, as this has not been tested sufficiently up until this point. The outcome of the research could side completely with one theory or be more nuanced where increasing levels of cognitive load will have negative impacts on planning behavior, but that a “goldilocks” zone of cognitive load may exist where it confers the benefit of inducing concrete construal without exceeding a threshold of cognitive load that overall hinders cognitive functions (e.g. planning). Understanding whether cognitive load or construal level theory drive the expected results in the proposed study will provide a novel contribution and will elucidate how the average person's cognition works under concurrent cognitive load. If the predictions of construal theory on planning win out over those of cognitive load theory then this supposes that cognitive load does not necessarily hinder our ability to plan, and that instead our cognition simply changes to manage the current load in an efficient way. On the other hand, if cognitive load significantly hinders planning behavior and washes out any benefits conferred by inducing concrete construal then this supposes that cognitive load needs to be managed or considered because it clearly has significant downstream consequences on outcomes of cognition. Several different outcomes can be rationalized based on the literature. My present proposal will include not only my own personal predictions based on the read of the literature, but also predictions that are driven by each theory.

Study Rationale: Cognitive Load and Construal Level on Planning

A common theme throughout the literature on planning is that how one perceives their time, namely looking towards the future or in the past, has an impact on how much time people think a task will/has taken and the impacts that those judgements have on planning. These findings have striking resemblance to construal level theory. Construal level theory is also conceptualized as the way one perceives time in relationship to themselves and the impacts on downstream behaviors and thoughts. Because both theories of cognitive load and construal level discuss the passage of time, one might expect that they lead to similar predictions on outcome variables like planning. The primary purpose of this paper and conducted research is to analyze the relationship between these two constructs because they *do not* predict the same outcomes on planning. It is therefore worth researching and uncovering why this might be the case and how these two theories overlap but also contrast with another on an ecologically relevant outcome variable of planning.

Cognitive load literature on planning is sparse but primarily suggests a hinderance or reduced ability to properly plan for a task when under cognitive load (Ferrari, 2001; Huijser et al., 2020), such that fewer steps will be generated, or the planning efficacy will be reduced. Construal level theory on the other hand has much more nuanced findings and predictions such that under a concrete construal people generate significantly more steps or items to be completed for a planning task. These two findings are at odds with one another because concrete construal is suggested to be induced via cognitive load. If this were the case then one would expect that under cognitive load a person will view a prospective event that must be planned for concretely, leading to a greater number of steps being generated. Parsing apart these findings will be a considerable contribution to the literature and will help to elucidate the relationship between cognitive load and construal level theory on the outcome of planning.

One suggestion worth considering is that the amount of cognitive load necessary to induce a concrete construal is relatively low. As such there may be a goldilocks zone of cognitive load that confers the benefits of concrete construal while not conferring the negative impacts of higher cognitive load. A goldilocks zone of cognitive load is analogous to the beneficial moderate level of stress, which aids in finishing an assignment, whereas lower stress might cause a person to not start the task and higher stress will prevent a person from focusing and completing the task.

The research study tested the effects of concurrent working memory load on planning towards both a negative (preparing for a work presentation) and positive (preparing for a vacation) event, while subsequently assessing the specificity with which participants plan for these events as well as their enthusiasm towards them. Concurrent working memory load was induced via a modified updating task (Miyake et al., 2000; Yntema, 1963) whereby participants were asked to maintain the last exemplar from a particular category throughout the study, these categories were constantly updated with new exemplars. Cognitive load level was manipulated by how many pairs back participants must maintain: high load = 5 categories, low load = 2 categories, no load = 0 categories. This updating task is similar to a *N-back* task insofar as it requires participants to remember a set number of items that were previously presented but differs such that all possible words which participants see will be presented on the front end to allow for participants to familiarize themselves with the words and prevent any individual differences as a product of prior experience. The updating task ran concurrently with a planning task whereby participants were asked to list out the steps that must be completed ahead of an event three weeks in the future, either: 1) a presentation to your supervisor 2) a vacation to a location which requires travel from your current location. Lastly, participants were assessed on outcome variables of the number of steps they generate for the task they are planning for as well as their enthusiasm towards the task.

Predicted Results by Theory

I predicted that there will be a main effect of cognitive load on the planning task such that significantly more steps will be generated in the moderate load condition, because it will induce a concrete construal which has been shown to benefit planning. On the other hand, the high load condition will not confer the benefits of concrete construal do to an over-taxing of the working memory system thereby hindering processing capacity. I further predicted an interaction of cognitive load and task type such that enthusiasm towards the work task will hold steady or increase under high cognitive load, but enthusiasm for the vacation task will decrease under high cognitive load.

I predicted that the amount of time predicted to complete both individual tasks and the total sum of all tasks required to complete a task will decrease as a function of cognitive load, such that the high cognitive load condition will display significantly shorter predictions of task time. Lastly, cognitive load will increase to intention to participate for the work task but decrease intention to participate for the vacation planning task.

My predicted hypotheses:

1: Moderate cognitive load (2 to-be-remembered categories) will induce a concrete construal that will increase the steps generated on the planning tasks relative to no cognitive load condition and high cognitive load (5 to-be-remembered categories). Moderate cognitive load will induce concrete construal without overloading the working memory system to the extent that detriments are observed. High cognitive load will utilize so many cognitive resources that no benefits will be observed in planning if anything detriments in planning will be observed. Lastly, no load will have no impact on planning, namely no increase in planning efficacy as a product of concrete construal.

2: Cognitive load will impact enthusiasm towards the task such that in the work task condition enthusiasm towards the task will increase or stay the same but enthusiasm towards the vacation task will decrease under cognitive load, the greatest difference observed in high cognitive load. The decrease in enthusiasm towards the vacation task is predicted to a function of induced concrete construal through concurrent working memory load. Concrete construal predicts higher emotionality, primarily negative and focuses on the perceived feasibility of a task rather than its attractiveness.

3: Predicted completion time for individual tasks as well as the sum will decrease as a function of cognitive load, with high cognitive load having the lowest predicted completion time.

Cognitive load theory hypotheses:

1b: Moderate cognitive load (2-to-be-remembered categories) and high cognitive load (5 to-be-remembered categories) will both decrease steps generated on either planning task relative to the no cognitive load condition.

2b: Both high and moderate cognitive load will impact enthusiasm towards the planning task. High cognitive load will cause the greatest reduction in enthusiasm relative to no load, with moderate cognitive load leading to a moderate if perhaps unsignificant reduction in enthusiasm.

3b: Predicted completion time for individual tasks as well as the sum will decrease as a function of cognitive load.

Construal level theory hypotheses:

1c: Moderate cognitive load (2 to-be-remembered categories) and high cognitive load (5 to-be-remembered categories) will induce a concrete construal leading to more steps being generated on the planning tasks relative to the no load condition.

2c: Cognitive load will impact enthusiasm towards the task such that in the work task condition enthusiasm towards the task will increase or stay the same but enthusiasm towards the vacation task will decrease under cognitive load, the greatest effect should be observed under high load. The decrease in enthusiasm towards the vacation task is predicted to a function of induced concrete construal through concurrent working memory load. Concrete construal predicts higher emotionality, primarily negative and focuses on the perceived feasibility of a task rather than its attractiveness.

3c: Both high and moderate cognitive load will induce a concrete construal, reducing expected completion times individually and in sum.

Method

Participants

Participants for this study were 693 participants sampled through an online sampling platform called Prolific. The sample identified as: 339 female, 273 male, 11 non-binary, and 3 non-specific. The sample indicated the following ethnicity breakdown: 495 White (37 identified as Hispanic/LatinX), 58 Asian, 47 Black, 3 Alaskan native/ Native American, and 24 selected other. The sample had a mean age of 38 (*SD* = 13.92).

Instrument

This study was conducted with a single online session administered through Qualtrics. Participants were recruited through prolific. The study took an average of 12 minutes and participants were compensated at a rate of 10 USD/hr. Participants were first asked to read and sign an informed consent. Participants were then randomly assigned in accordance with a 3 (Cognitive load: No load, Low, High) X 2 (Planning: Vacation, Work) design, such that four conditions existed: low load/vacation planning, low load/work planning, high load/vacation planning, and high load/work planning.

The participants were first familiarized with the updating cognitive load task (Wilhelm et al., 2013; Yntema, 1963)(See Figure 1 & 2). During this initial familiarization and practice period participants were presented with all possible exemplars from six possible categories (relatives, distances, metals, animals, colors, countries) and told that these categories and the exemplars within are all the possible words that they will be asked to remember throughout the study. Then pairs of categories and exemplars were serially presented for 1500ms each. The task was to remember the last word presented in each of the target categories.

For example, if given the words (Dog, Sophia) and then prompted to recall the last exemplar from the animal category, a participant would answer: Dog. These to-be-remembered exemplars were constantly updated and the amount of categories which participants were asked to update functioned as the method of manipulating cognitive load level. This same updating task ran concurrently throughout the study: high load participants were asked to remember the last exemplar encountered from 5 categories and low load participants were asked to remember the last exemplar encountered from 2 categories. The exemplars from each category to be remembered as well as prompts asking participants what the last exemplar from a particular category they encountered was were interspersed throughout the planning task.

The planning task, which occurred after the familiarization period with the updating cognitive load task, asked participants to plan for either a hypothetical presentation they have been asked to create for work or a hypothetical vacation they are taking from work. Participants were told either “your supervisor has asked you to give a presentation on all the work you have done in the past sixth months. You have three weeks to prepare for this presentation. What are all the steps needed to complete this task?” or “Your supervisor has granted your vacation request. You have three weeks to prepare for this vacation out of town. What are all the steps needed to complete these task?” Participants were given a table whereby they listed out all possible steps necessary to plan for the given task they were assigned to plan for. Participants were instructed that these steps need not be in chronological order, simply listing all possible steps they think would be needed to sufficiently plan for the task.

Participants were then given a Likert scale assessing their general enthusiasm towards the task they were asked to complete (work / vacation planning): *not at all enthused (1), (2), (3), (4), very much so enthused (5)*. Participants were then asked to estimate the total time required to complete the task as well as an estimate of how long each step will take individually. These participant generated steps were piped back to the participant so they can see what they wrote, subsequently being asked how long each step will take. Then participants will completed Likert type scale measures of enthusiasm towards each step: *not at all enthused (1), (2), (3), (4), very much so enthused (5)*. Finally, demographics were assessed.

Exclusion Criteria

Seven-hundred and forty-seven responses were collected on Qualtrics. Eighty-two participants were immediately excluded from further consideration for not completing the survey, as noted by Qualtrics. Sixty-five participants were further excluded if they did not engage with the cognitive load manipulation correctly and via a questionnaire at the end of the study assessing their: attention, effort, and honesty throughout the study (See Figure 3) as well as participants who did not engage with other aspects of the study. Each item in this questionnaire is presented on a Likert scale and if participants score poorly on this brief assessment their data will be excluded. The questionnaire includes items such as, “I paid extremely close attention”: *not at all (1), (2), (3), (4), very much so (5)*. Twenty-two participants were removed because they scored below the mid-point of the effort assessment (14). A final twenty-four participants were excluded for not completing the effort questionnaire, or other aspects of the study that were required. Furthermore, participant responses on the planning task were qualitatively assessed. If there was significant evidence that a participant did not put forward responses in good faith, then participant response was excluded. Nineteen participants were removed for not properly engaging with the load manipulation. Lastly, participants needed to demonstrate an ability to understand and properly complete the example of the cognitive load manipulation. Whether or not they did well on the cognitive load manipulation during the test is irrelevant, but participants must demonstrate an understanding and willingness to engage with this manipulation.

Results

Analyses conducted were a 3 (Cognitive load: No load, Low, High) X 2 (Planning: Vacation, Work) ANOVA assessing the impact of cognitive load level and planning task condition on outcome variables: number of planning steps generated, estimated time to complete task: total & first two steps respectively, and enthusiasm. Interactions were assessed via Tukey HSD pairwise comparisons. Individual dependent variables are presented below.

Dependent Variable: Planning Steps Generated

The hypothesized results are as follows. Moderate cognitive load (2 to-be-remembered categories) will induce a concrete construal that will increase the steps generated on the planning tasks relative to the no cognitive load condition and high cognitive load (5 to-be-remembered categories). Moderate cognitive load will induce concrete construal without overloading the working memory system to the extent that detriments are observed. High cognitive load will utilize so many cognitive resources that no benefits will be observed in planning if anything detriments in planning will be observed. Lastly, no load will have no impact on planning, namely no increase in planning efficacy as a product of concrete construal.

A main effect of cognitive load on steps generated was observed, F (2,622) = 5.34, p <.01, η^2 = .02. The specifics of the analysis are presented in (Table 1, Figure 4). The main effect of cognitive load was further qualified by post hoc Tukey's HSD comparisons showing that there was a significant difference between the high load (M = 5.09, SE = .17) and no load (M = 5.84, SE = .16) such that significantly more steps were generated in no load. There was no significant difference between the high and low load or low and no load.

A main effect of task was observed, F (1,622) = 41.77, p <.01, η^2 = .06. The main effect is qualified such that the participants in the vacation task (M = 6.04, SE = .14) had significantly more steps generated than the work task (M = 4.81, SE = .14).

The interaction of load and task was not significant, F (2,622) = .63, p =.59, η^2 < .00. The predicted results on planning steps generated were not observed. Results and implications will be further discussed.

Dependent Variable: Estimated Time to Complete Task

The hypothesized results are as follows. Predicted completion time for individual tasks as well as the sum will decrease as a function of cognitive load, with high cognitive load having the lowest predicted completion time.

The main effect of load on estimated time was not significant, F (2,622) = 2.64, p =.12, η^2 < .00. The high load condition (M = 551.02, SE = 313.01) was not significantly different from the low load condition (M = 1333.15, SE = 301.81) and no load condition (M = 1049.61, SE = 306.28). The main effect of task was not significant, F (1,622) = 1.10, p =.30, η^2 < .00. The vacation task (M = 791.43, SE = 250.70) was not significantly different from the work task (M = 1164.43, SE = 252.35). Furthermore, the interaction was not significant, F (2,622) = .70, p =.49, η^2 < .00. Adding in the number of steps generated as a covariate did not change the observed results, with all *p*'s greater than .18 and not significant.

Further independent ANOVA analyses were run on the estimated time that participants predicted for their first and second planned step. For the first planned step the main effect of task on estimated time not significant, F (1,622) = 2.91, p =.08, η^2 < .00. The main effect of load on estimated time was not significant, F (2,622) = .28, p =.76, η^2 < .00. Lastly, the interaction of task and load was not significant for the first planned step, F (2,622) = .09, p =.91, η^2 < .00. For the second planned step the main effect of task was not significant, F (1,622) = .69, p =.41, η^2 < .00. The main effect of load was not significant, F (2,622) = .13, p =.88, η^2 < .00. Lastly, the interaction of load and task was not significant for the second planned step, F (2,622) = 1.69, p =.19, η^2 < .00.

Overall, none of the expected results were found. The results of the current study reveal no significant differences in estimated time for planned tasks across task type, cognitive load manipulation level, and the interaction of the two. Results and implications will be further discussed.

Dependent Variable: Enthusiasm

The hypothesized results are as follows. Cognitive load will impact enthusiasm towards the task such that in the work task condition enthusiasm towards the task will increase or stay the same but enthusiasm towards the vacation task will decrease under cognitive load, the greatest difference observed in high cognitive load. The decrease in enthusiasm towards the vacation task is predicted to a function of induced concrete construal through concurrent working memory load. Concrete construal predicts higher emotionality, primarily negative and focuses on the perceived feasibility of a task rather than its attractiveness.

A main effect of cognitive load on enthusiasm was observed, F (2,622) = 4.13, p =.02, η^2 = .01. The differences observed in the main effect of cognitive load are qualified by a Tukey's HSD comparison revealing that high load (M = 16.63, SE = .67) and no load (M = 18.87, SE = .66) were significantly different; furthermore, low load (M = 16.46, SE = .65) and no load (M = 18.87, SE = .66) were significantly different. Adding in number of steps generated as a covariate in the analysis reduced the size of the main effect below the level of significance, F (2,622) = 1.82, p =.16, η^2 = .00. A main effect of task type on enthusiasm was also observed, F (1,622) = 58.49, p <.01, η^2 = .09. The main effect of task type is such that the vacation task (M = 10.25, SE = .54) was rated significantly higher than the work task (M = 14.40, SE = .54). The interaction of load and task was not significant, F (2,622) = .19, p =.82, η^2 < .00. The specifics of the analysis are presented in (Table 2, Figure 5).

Overall, none of the hypothesized results were found. As with the previous dependent variables the hypothesized interactions were not observed. The implications of all these findings will be discussed.

Dependent Variable: Mood

Overall mood was also assessed after participants had completed the planning task. This analysis was exploratory; therefore, no predictions are stated. Results revealed a significant main effect of cognitive load on mood, F (2,622) = 16.94, p < .01, η^2 = .05. The main effect of cognitive load was qualified by Tukey's HSD post hoc tests which show that the high load condition (M = 50.95, SE = 1.72) was significantly lower relative to the low load (M = 60.29, SE = 1.67) and no load (M = 64.71, SE = 1.69) conditions on overall mood. There was no significant difference between low cognitive load and no load.

A main effect of task type on mood was also observed, F (1,622) = 15.00, p < .01, η^2 < .02. Participants had significantly higher mood when planning for the vacation task (M = 62.44, SE = 1.38) relative to the work task (M = 54.87, SE = 1.39). An interaction of cognitive load and task type was not observed, F (2,622) = 1.13, p =.32, η^2 < .00.

Dependent Variable: Experience with the Task

Experience with the assigned planning task was assessed. This analysis was exploratory; therefore, no predictions are stated. A main effect of load was observed, F (2,622) = 12.79, $p <$ .01, $\eta^2 < .04$. Tukey's HSD post hoc analyses reveal a significant difference such that high load (M = 2.81, SE = .08) was significantly lower than no load (M = 3.30, SE = .08) and low load (M = 2.82, SE = .08) was significantly lower than no load.

A main effect of task type was observed, F (1,622) = 53.18, $p < .01$, $\eta^2 < .08$. Such that participants had significantly more experience planning for the vacation task (M = 3.31, SE = .06) compared to the work task (M = 2.65, SE = .07). The interaction of cognitive load and task type was not significant, F (2,622) = .51, p =.59, $\eta^2 < .00$.

Dependent Variable: Task Prioritization

Participants were further assessed on whether they prioritized the cognitive load or planning task. This analysis was exploratory; therefore, no predictions are stated. Higher scores on the Likert scale measure indicating prioritization of the cognitive load task. A main effect of load on prioritization was not observed, F (1,412) = .13, p =.72, $\eta^2 < .00$. There was no significant difference between the high (M = 3.38, SE = .07) and low load (M = 3.35, SE = .06) conditions in which task they prioritized.

A main effect of task on prioritization was not observed, F (1,412) = 1.94, p =.17, $\eta^2 <$ .00. There was no significant difference between the vacation planning (M = 3.30, SE = .06) and work planning (M = 3.30, SE = .06) tasks in which task they prioritized. Lastly, the interaction of load and task was not significant, F (1,412) = .25, p =..62, $\eta^2 < .00$.

Discussion

Overall, while main effects of cognitive load and task type were observed for planning steps generated and enthusiasm towards planned steps, the predicted interactions of cognitive load and task type on enthusiasm were not observed. Furthermore, the predicted results of cognitive load on planning efficacy were not observed. The specifics of these findings will be discussed, including the rationale for why the predicted findings may not have been observed. Future directions and limitations will also be discussed.

Planning Steps Generated

Planning steps generated was the dependent variable which encapsulated the detail and efficacy with which participants planned. The more steps that are generated the better downstream outcomes are observed, namely the task being completed (Ferrari, 2001; Klaus et al., 2016). In this research study I hypothesized that the cognitive load task would result in the greatest number of steps being generated in the moderate cognitive load condition relative to the high load and no load conditions, regardless of what task the participants were asked to plan for. The rationale for this hypothesis was that moderate cognitive load would induce a concrete construal which would fundamentally change participants perceptions of the event that they were planning for (Huijser et al., 2020). Inducing a concrete construal via moderate cognitive load was theorized increase the specificity with which participants thought about the event they were planning for as well as truncating the amount of time they felt that they had to plan for it (Huijser et al., 2020). Unfortunately, the relationship between cognitive load and planning efficacy did not yield the hypothesized results. Overall, the findings support the cognitive load literature that suggests as cognitive load increases planning efficacy decreases (Ferrari, 2001).

The cognitive load literature was supported by the results found in this study with a main effect of cognitive load on planning steps generated (Klaus et al, 2016). Participants produced significantly more planned steps for both the work and vacation tasks when they were under no concurrent cognitive load, with the fewest steps being generated under high concurrent cognitive load. The observed results mirror what the limited cognitive load literature on planning efficacy has found to this point, as cognitive load increases fewer working memory resources are available with which to properly consider all the necessary steps that might be required to complete a task (Klaus et al., 2016). As working memory becomes taxed this has downstream impacts on a variety of cognitive functions and in the context of this study it hinders participants planning capabilities.

The importance of finding that cognitive load hinders planning efficacy is that it builds upon the existing literature and demonstrates how reliably cognitive load can be induced leading to considerable downstream impacts (Huijser et al., 2020). If cognitive load can be quickly induced via the induction used in this study then it is reasonable to assume that cognitive load can also be reliably induced via a multitude of real world situations. Knowing that cognitive load negatively impacts planning behavior implies that for the most effective planning a person should be put in a situation where they can focus on the planning task at hand. Freeing up cognitive resources from other work tasks as well as other external factors which might induce cognitive load.

A further finding elucidated by this study was that task type had a significant main effect on planning steps generated. The findings are not particularly surprising, that the vacation planning task had significantly more steps than the work planning task. Participants were more detailed in their planning for an objectively positive future event relative to a work presentation which is objectively less attractive. The main takeaway from this finding is that people are more likely to engage with planning for a positive future event. The applications of this finding are that employers could try to make work tasks more appealing and fulfilling for employees. Anecdotally, many people are extremely unhappy with their work and dread having to do it. The findings of my study suggest that if people looked forward to work they would plan more effectively.

Lastly, the main intention of my research study was to show differential outcomes of cognitive load on planning outcomes. What I expected to see was that moderate cognitive load would induce a concrete (proximal) construal that in turn would increase participants planning efficacy relative to high cognitive load or no load inductions (Hadar et al, 2019). The hypothesized result was not observed. The cognitive load induction utilized in my study did not have differential effects on planning efficacy at moderate cognitive load, suggesting that a concrete construal was not induced. Another interpretation of the results could be that even if a concrete construal was induced that it did not outcompete the effects observed by cognitive load. Either way, the predicted results confirm the cognitive load literature (Block et al., 2010). My hypothesis that a concrete construal could be induced via cognitive load leading to beneficial outcomes on planning was not confirmed, thereby suggesting that as my study is concerned that cognitive load did not have intended beneficial effects.

Alternative explanations for the observed findings center on the planning task itself and if the number of steps planned is an effective measure construal level. Furthermore, if generating fewer planned steps may paradoxically be a representation of a concrete construal. Addressing the first possibility, it may be the case that the number of steps generated on a planning task is not a particularly effective measure of construal level. The observed results could be caused by a variety of factors including the affective spillover of the cognitive load task. The concurrent cognitive load task was difficult and not enjoyable, because of this the participants that were in the cognitive load conditions may have not sufficiently engaged with the planning task. Furthermore, while the planning task was intended to be as ecologically valid as possible there are considerable individual differences in people's propensity to make detailed plans. It is possible that a larger than expected subset of participants were not comfortable with making plans as they were instructed. Having said that, I still observed a reduction in planned steps as cognitive load increased so even if participants were generally uncomfortable with the planning task a main effect of cognitive load was still observed.

Addressing the second possibility, it could be the case that for the planning task utilized in this study that fewer steps generated demonstrates a more concrete construal thereby confirming my hypotheses. Interpreting fewer steps generated as a concrete construal would be at odds with the literature, but one could conceptualize that cognitive load generating fewer steps is participants thinking of the planned for event in a way that can be achieved. Consolidating necessary steps into clusters because they are viewing the upcoming event more proximally and therefore planning fewer steps that can be acted upon and completed. Unfortunately, I don't have any way of confirming nor disconfirming this conceptualization, especially because it is at odds with the literature. Future research would need to determine whether fewer steps generated on a planning task like what was utilized in this study might represent a concrete construal.

Estimated Time to Complete Task

In this study it was hypothesized that estimated time to complete the task would decrease as a function of cognitive load. No effects of cognitive load, task type, or the interaction were observed in this study. The fact that no effects were observed makes any conclusions or interpretations difficult. Primarily the expected effects of cognitive load on estimated time to complete the task may be a representation of the cognitive load manipulation not being significant enough, although this is not a likely scenario. The cognitive load manipulation was quite difficult. Therefore, it may also be the case that lack of psychological realism of the study influenced participants to not properly consider how long the planning would take. It could be the case that because the participants were not extremely motivated to plan as they would be in real life, and therefore the lack of effect was observed in this study.

Enthusiasm

Finally, an interaction of cognitive load and task type was hypothesized such that enthusiasm towards the task would decrease as a function of cognitive load in the vacation planning task but not in the work planning task. The rationale for this hypothesis was that cognitively loading an individual makes them think more concretely and that increases the specificity of how an event is viewed (Klaus et al., 2016). In relation to planning for a vacation I predicted that as participants think about the specifics of planning for the event that they would feel more negatively about it, because they are not able to consider the more abstract or global thoughts that would be more positively valanced. These results were not observed, but main effects of cognitive load and task type were observed.

First and foremost a main effect of cognitive load was observed such that the high and moderate cognitive load conditions both had significantly less enthusiasm compared to the no load condition. This is contrary to the predictions that I made, but interestingly the means of both cognitive load conditions were very similar to one another. The means being extremely similar in both cognitive load conditions suggests that the manipulation had a similar effect regardless of the amount of cognitive load induced. Therefore, it appears as if there was a significant negative impact or affective spillover of the cognitive load manipulation (Hooff & Hooft, 2016). It is worth noting that when total steps planned was included as a covariate the main effect of cognitive load was no longer significant, suggest that enthusiasm per step was the same across levels of cognitive load. Overall mood was still impacted even if the main effect of load on enthusiasm was nullified by including the variance associated with total steps generated. Participants more than likely were so unenthused with the load task that they felt wholly negative about the other aspects of the study that they were asked to do. The overall mood measure presented in this study confirms suggestions of affective spillover. Participants who were placed in the high cognitive load condition were significantly lower in mood relative to the other conditions, particularly the no load condition, suggesting that the cognitive load task caused participants negative affect which can have impacts on perceptions of other aspects of the study (Hooff & Hooft, 2016). In the future, it is worth considering how negatively the concurrent load task made participants feel and a different task may need to be utilized if enthusiasm is an outcome variable of interest. It could also be possible that cognitive load broadly negatively impacts people's affective state, therefore decreasing enthusiasm regardless of the type of cognitive load induction utilized. Future research could compare differing cognitive load manipulations to see if there are differential impacts on enthusiasm for a planning (or other) task depending on the type of load induction.

The main effect of task type was relatively straightforward such that participants rated the vacation planning task with significantly more enthusiasm relative to the work planning task. I think the observed findings map onto typical anecdotal experience. Even those who enjoy the work that they do on average will have more enthusiasm planning for vacation, if for no other reason than the novelty of it. Planning for a work presentation is something that you can be evaluated on, requires a considerable amount of work, and is the summation of work that you one has done over a long period of time. Planning for vacation is something that one can usually only do one or two times a year and therefore produces significantly more enthusiasm.

Overall Take Aways

Broadly the results of this study show that cognitive load reduces planning efficacy and enthusiasm. Furthermore, the type of task that people plan for further impacts their planning efficacy and enthusiasm such that people are significantly better and more enthusiastic about planning for positively valanced events like a vacation than a systematic work review. Clearly cognitive load is a construct that needs to be considered in all facets of life. Truncating one's available cognitive resources has immediate impacts on cognition; therefore, employers and people should consider how cognitively loaded they or their employees are when it comes to assessing their performance, making plans, or attempting any of a variety of tasks. Cognitive load has been shown to have significant downstream impacts and the present study only confirms the importance of this construct (Allen et al, 2014; Wolfe et al., 2019). The broad implications of my findings are that all facets of our day-to-day life need to consider how cognitive load is currently affecting people. By considering how cognitively loaded people are and creating strategies to supplement their cognition if they are cognitively loaded, or finding ways to reduce cognitive load, this will lead to appreciable benefits in any domain.

Limitations and Future Directions

One of the primary limitations of the present study was the lack of psychological realism. Asking participants to plan for a work presentation or vacation is ecologically valid, but the way they were asked to do so all at once in the context of a Qualtrics survey was relatively different from how that would play out naturally. There are individual differences in participants likelihood to even plan in a detailed manner as well but all participants were asked to plan, therefore some of them may have found the task to be quite difficult. The concurrent load task was also low in psychological realism. In my opinion it is a significant issue with most cognitive load inductions in that asking participants to hold information in the forefront of their mind is similar to how cognitive load would manifest in day-to-day life but the content of what participants are being asked to keep in the forefront is not. People on average will be cognitively loaded by ruminative thoughts, chores that they need to do when they get home, upcoming work tasks, etc. In this study and others though it is necessary that participants are uniformly loaded, for internal validity, the consequence of this is a reduction in psychological realism. The relative lack of realism in the planning task and the cognitive load induction could have impacts on how seriously participants took the study and their subsequent outcome variables. In the future it would be beneficial to find a way to get participants to plan for something that is upcoming in their life, while I manipulate their cognitive load by having them think about things that are relevant to their own life. Differing results from what were observed in this study might be found.

A further limitation of my study was I was unable to qualitatively assess the planning steps that participants generated. Being able to assess the relative concreteness and abstractness of participants specific steps that they generated may have informed the conclusions that could be drawn. Unfortunately, timing and resources were not in our favor and the qualitative assessment of the responses was reasonable. It is a possibility that if the responses were qualitatively coded that a difference in construal may be observed, thereby confirming my hypotheses.

Another limitation of this study, which has been discussed throughout this section already, was the apparent difficulty and negatively valanced affective spillover of the cognitive load manipulation. The results of the study seem to suggest that the cognitive load manipulation was very difficult, thereby potentially loading participants working memory capacity too severely making the moderate cognitive load condition more severe than it was intended. Furthermore, the lack of effects seen on enthusiasm, and the fact that both the moderate and high cognitive load conditions had extremely similar enthusiasm suggests that the cognitive load manipulation was poorly received by participants. By having to do the cognitive load task participants may not have enjoyed or properly engaged with the other aspects of the study. A more appealing and less difficult cognitive load manipulation may show differential effects compared to those that were observed.

Future directions that should be pursued are increasing the ecological validity of the planning task and cognitive load induction. Furthermore, making the cognitive load induction less difficult or including an even lower loaded condition compared to what was utilized in the present study. I believe that under the correct circumstances cognitive load may have beneficial outcomes, but the present study was not able to confirm these suspicions. My primary assumption is that the moderate cognitive load condition was still too cognitively taxing and if it were easier for participants to attend to, and if the task itself was more compelling, differing results may have been observed. Future research could elucidate these findings. The results obtained by the present study can still be useful. Primarily, understanding that cognitive load negatively impacts enthusiasm and planning efficacy qualifies the relative downsides of multitasking or having to perform cognitively taxing cognitions while simultaneously performing another task. Employers and individuals alike can try to insure that if they want to properly plan for a future even that they need to devote as much of their available cognitive resources to the planning task as possible.

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Tables

Table 1

ANOVA Results – Total Steps Generated

Predictor	*df*	MS	*F*	*p*	η^2
Load	2	30.40	5.34	$.00^{*}$	.02
Task	1	237.97	41.77	$.00^{**}$	.06
Load X Task	2	3.00	.53	.59	.00

Note. Total steps generated for planning task. ** p <.001 *p < .005

Table 2

ANOVA Results – Total Time Predicted

Predictor	*df*	MS	*F*	*p*	η^2
Load	2	3.24e7	1.63	.19	.00
Task	1	2.17e7	1.10	.29	.00
Load X Task	2	1.39e7	.70	.49	.00

Note. Total time predicted to complete planning task.

Table 3

ANOVA Results – Total Steps Generated

Predictor	*df*	MS	*F*	*p*	η^2
Step 1					
Load	2	9.98e6	.28	.76	8.95e-7
Task	1	1.05e7	2.91	.09	.00
Load X Task	2	3.22e6	.09	.92	2.89e-4
Step 2					
Load	2	3.54e5	5.34	.88	4.41e-4
Task	1	1.82e6	.69	.41	.00
Load X Task	2	4.49e6	1.69	.19	.00

Note. Time predicted for first and second step.

Table 4

ANOVA Results – Total Enthusiasm

Predictor	*df*	MS	*F*	*p*	η^2
Load	2	378.58	4.13	.02	.01
Task	1	5366.49	58.49	$.00^{**}$	.09
Load X Task	2	18.05	.19	.82	5.71e-4

Note. Total time predicted to complete planning task. ** p <.001

Figures

The categories and words are as follows. Please take a moment to read through the lists. You will need to know which category each word belongs to.

RELATIVES - Aunt, Uncle, Father, Mother, Brother, Sister

DISTANCES - Mile, Foot, Inch, Yard, Meter, Centimeter

METALS - Iron, Copper, Steel, Tin, Zinc, Platinum

ANIMALS - Dog, Cat, Horse, Cow, Lion, Tiger

COLORS - Blue, Red, Green, Yellow, Orange, Black

COUNTRIES - Mexico, France, England, Russia, Germany, Canada

Figure 1. Categories and exemplar list

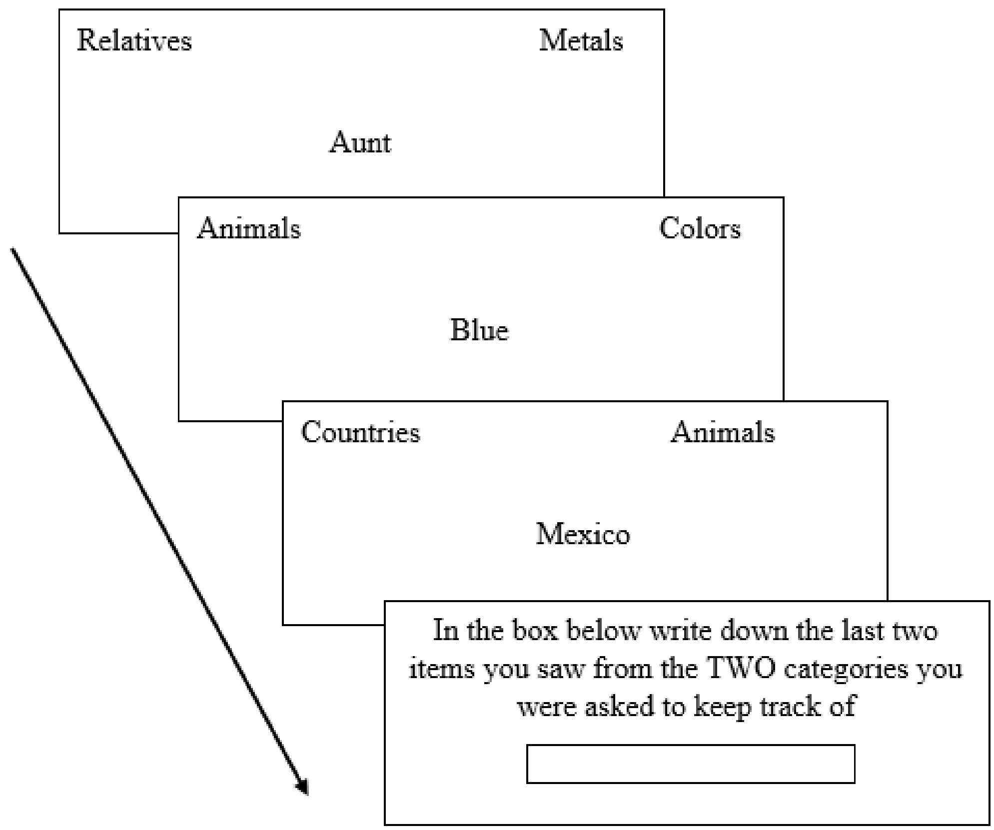

Figure 2. Example of updating task. Participants will be presented with categories, exemplars, and box to recall the last exemplar seen.

- **I paid extremely close attention**.

1 2 3 4 5
(Not at all) (Very much so)

- **I completed this study as fast as I could.**

1 2 3 4 5
(Not at all) (Very much so)

- **I am certain this is the first time I have done this survey.**

1 2 3 4 5
(Not at all) (Very much so)

- **My responses to this survey were real and honest.**

1 2 3 4 5
(Not at all) (Very much so)

- **You should not use my responses on this survey because I did not take it seriously.**

1 2 3 4 5
(Not at all) (Very much so)

Figure 3. Example ending questionnaire on effort. Used for exclusion purposes.

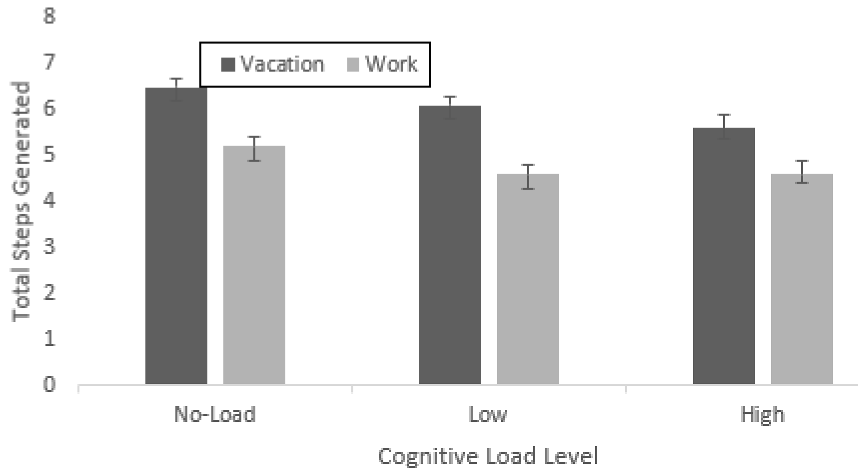

Figure 4. Cognitive load and task type on total steps generated.

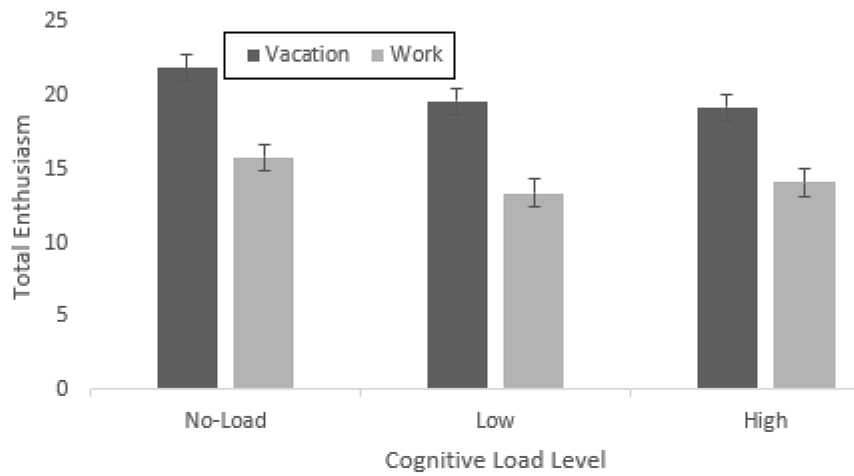

Figure 5. Cognitive load and task type on total enthusiasm.

Your supervisor has asked you to give a presentation on all the work you have done in the past six months. You have three weeks to prepare for this presentation. What are all the steps necessary to complete this task?

1	
2	
3	
4	
5	
6	
7	

Figure 6. Example planning task.

- What is your overall enthusiasm towards the work planning task?

1	2	3	4	5
(Not at all)		(Indifferent)		(Very much so)

- How much total time will it take you to plan for the work planning task?

- How much time will it take for the first step *(pipe in response)* you noted for your planning task?

- How much time will it take for the next step *(pipe in response)* you noted for your planning task?

- What is your enthusiasm towards the first step you indicated (*pipe in*) in the planning task?

1	2	3	4	5
(Not at all)		(Indifferent)		(Very much so)

- What is your enthusiasm towards the next step you indicated (*pipe in*) in the planning task?

1	2	3	4	5
(Not at all)		(Indifferent)		(Very much so)

Figure 7. Example general and specific measure of time / enthusiasm for the work planning task.

Appendix

UNIVERSITY OF ARKANSAS

To:	Denise R Beike
From:	Justin R Chimka, Chair IRB Expedited Review
Date:	12/14/2021
Action:	**Exemption Granted**
Action Date:	12/14/2021
Protocol #:	2111372079
Study Title:	Cognitive load and construal on planning

The above-referenced protocol has been determined to be exempt.

If you wish to make any modifications in the approved protocol that may affect the level of risk to your participants, you must seek approval prior to implementing those changes. All modifications must provide sufficient detail to assess the impact of the change.

If you have any questions or need any assistance from the IRB, please contact the IRB Coordinator at 109 MLKG Building, 5-2208, or irb@uark.edu.

cc: Maximilian V Fey, Investigator

Figure 8. IRB approval letter.