SECONDARY TASK INDUCED ENGAGEMENT AND DYNAMIC CHANGE OF ATTENTION - THE FACILITATING EFFECT OF SECONDARY STIMULI ON MEDIA TASK PERFORMANCE

BY

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DISSERTATION

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ABSTRACT

Media multitasking has become increasingly prevalent in recent years, with the proliferation of digital devices and the COVID-19 pandemic further accelerating this trend (Vargo et al., 2021). Recent research has shown that media multitasking is common across all age groups (Matthews et al., 2022) and has been studied from various perspectives, including its impact on cognitive control, academic performance, and socioemotional functioning (Beuckels et al., 2021). While previous research has largely focused on the detrimental effects of media multitasking on cognitive performance (e.g., Jeong & Hwang, 2016; Segijn & Eisend, 2019), this dissertation investigates the potential facilitation effects of introducing a secondary task or stimulus during media use on task engagement, performance, and attention management.

Three eye-tracking experiments provide converging evidence for the potential facilitation effects of secondary tasks on task engagement, performance, and attention management, depending on various factors. Study 1 demonstrates that while the presence of video stimuli does not directly enhance task engagement or performance, it serves a resource "corralling" function by reducing attention to task-irrelevant distractions. Study 2 explores the role of perceived task relationships (complementary vs. competitive), finding that competitive relationships can trigger heightened arousal and focus, leading to improved engagement and attention management. Study 3 investigates the optimal timing of secondary task introduction (simultaneous vs. delayed), showing that delaying introduction can help maintain performance by allowing individuals to establish a focused attentional state.

The dissertation contributes to a more nuanced understanding of media multitasking and cognitive performance by highlighting the need for a personalized approach that considers contextual, motivational, and individual factors. The findings have practical implications for the design of media environments and task management strategies across various domains, such as education, work, media consumption, and personal life. This research advances media multitasking theory by providing evidence for the potential facilitation effects of secondary tasks, emphasizing the role of subjective perceptions, temporal dynamics, and individual differences in shaping media multitasking outcomes. The dissertation provides suggestions for future research to further explore the complex mechanisms underlying media multitasking and inform the strategies for navigating the challenges and opportunities of media multitasking in an increasingly media-saturated world.

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CHAPTER 1: INTRODUCTION

1.1 The Rise of Media Multitasking

In recent years, media multitasking has become an increasingly common phenomenon, with individuals frequently engaging in multiple media-related tasks simultaneously. The proliferation of digital devices and platforms has made it easier than ever for people to consume and interact with media content while also engaging in other activities (Statista, 2021). Moreover, the COVID-19 pandemic has further accelerated this trend, with lockdowns and stay-at-home orders leading to a dramatic increase in media multitasking behaviors (Schmidt et al., 2020).

The prevalence of media multitasking has been observed across all age groups, with research showing that both younger and older individuals engage in this behavior (Matthews et al., 2022). This widespread adoption of media multitasking has led to increased research interest in its potential impacts on cognitive control, academic performance, and socioemotional functioning (Beuckels et al., 2021).

The prevalence of media multitasking has raised concerns among researchers, educators, and policymakers about its potential impact on cognitive abilities, such as attention, memory, and information processing (Jeong & Hwang, 2016; Segijn & Eisend, 2019). Much of the existing research has focused on the detrimental effects of media multitasking, drawing on theories such as the limited cognitive resources model (Kahneman, 1973; Lang, 2006) and the counterargument inhibition model (Jeong & Hwang, 2012). The limited cognitive resources model posits that individuals have a finite capacity for cognitive processing, and when multiple tasks compete for these resources, performance on one or both tasks may suffer (Kahneman, 1973; Lang, 2006). The counterargument inhibition model suggests that media multitasking can hinder an individual's ability to generate counterarguments to persuasive messages, leading to increased persuasion (Jeong & Hwang, 2012).

However, as highlighted by Beuckels et al. (2021), the research on media multitasking has been largely focused on specific subdomains, such as advertising effectiveness or cognitive control, and there is a need for a more comprehensive understanding of the phenomenon across different research fields. Additionally, the authors emphasize the importance of considering the role of age in moderating the relationship between media multitasking and cognitive performance, as demonstrated by Matthews et al. (2022).

1.2 Moving Beyond the Limited Capacity Perspective

While the limited capacity perspective has provided valuable insights into the challenges associated with media multitasking, it may not fully capture the complexity of this phenomenon. Research suggests that contextual, motivational, and individual factors can influence the outcomes of media multitasking, and that in some cases, the introduction of a secondary task or stimulus may actually facilitate task engagement and performance (e.g., Rosen et al., 2013; Chinchanachokchai et al., 2015; Fischer & Plessow, 2015).

For example, individuals may be motivated to multitask because it feels less mentally demanding and leads to more positive subjective experiences compared to single-tasking (Fischer & Plessow, 2015). Additionally, boredom with a primary task can lead individuals to introduce a secondary task to alleviate the perceived dullness (Rosen et al., 2013; Chinchanachokchai et al., 2015). These findings suggest that media multitasking may not always be detrimental and that a more nuanced understanding of the phenomenon is needed.

1.3 Research Focus and Objectives

This dissertation aims to contribute to a more comprehensive understanding of media multitasking by investigating the potential facilitation effects of introducing a secondary task or stimulus during media use on task engagement, performance, and attention management. The research focuses on three key aspects:

1. The role of contextual factors, such as the presence or absence of a secondary task, in shaping media multitasking outcomes.
2. The influence of motivational factors, such as the perceived relationship between tasks (complementary vs. competitive), on task engagement and performance.
3. The temporal dynamics of media multitasking, including the optimal timing of secondary task introduction and its impact on sustained attention over time.

By exploring these aspects, the dissertation seeks to provide insights into the complex mechanisms underlying media multitasking and to inform strategies for designing more effective and engaging media experiences.

1.4 Methodology and Contributions

To investigate the potential facilitation effects of secondary tasks on media multitasking outcomes, three experimental studies were conducted using eye-tracking technology. Study 1 assessed the role of a secondary task in enhancing task engagement and influencing performance, cognition, and subjective evaluations. Study 2 explored the impact of perceived task relationships (complementary vs. competitive) on engagement and performance levels. Study 3 examined the role of secondary task introduction timing on the dynamic change of sustained attention towards task completion over time. See Figure 1.1 for summary.

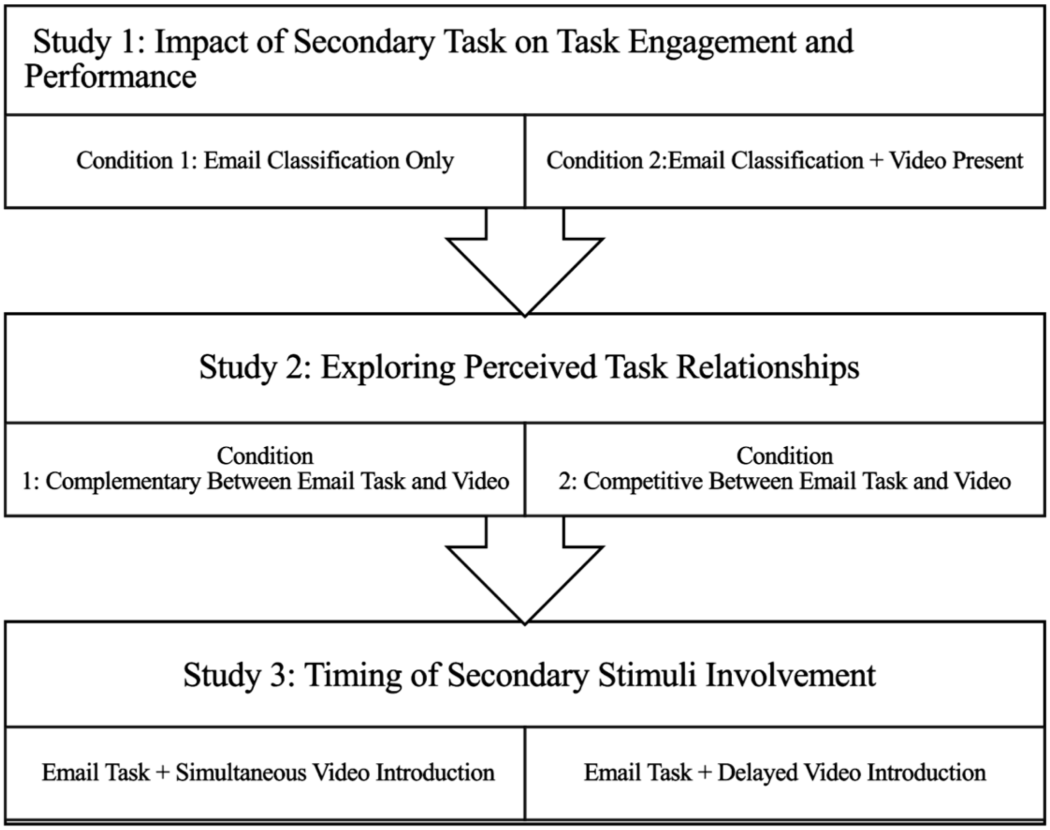

Figure 1.1 Dissertation Framework

The dissertation makes several significant contributions to the field of media multitasking research. Firstly, it challenges the dominant limited capacity perspective by providing evidence for the potential facilitation effects of secondary tasks on cognitive performance. Specifically, the study investigates the potential resource "corralling" function of secondary tasks, which refers to their ability to gather and focus an individual's cognitive resources on the current task(s), reducing the likelihood of distraction by task-irrelevant stimuli or mind wandering. This concept is like how a corral is used to keep animals contained within a specific area, preventing them from wandering off. In the context of cognitive resources, the secondary task acts as a boundary, helping to maintain attention on the main task by occupying available cognitive capacity and preventing it from being diverted elsewhere.

Secondly, it proposes a framework for understanding dual-task information processing that considers contextual and motivational factors. Thirdly, it offers insights into defining and evaluating successful media-related dual-task performance.

By investigating the interplay between motivational and contextual factors, this research aims to contribute to a more nuanced understanding of media multitasking and its influence on cognitive performance. The findings have practical implications for the design of media environments and task management strategies across various domains, such as education, work, media consumption, and personal life. This research advances media multitasking theory by emphasizing the role of subjective perceptions, temporal dynamics, and individual differences in shaping media multitasking outcomes.

1.5 Dissertation Structure

The remainder of this dissertation is structured as follows:

Chapter 2 provides a comprehensive literature review on media multitasking, covering theoretical perspectives, empirical findings, and research gaps. It also introduces the conceptual framework guiding the current research.

Chapters 3, 4, and 5 present the three experimental studies, detailing their objectives, methods, results, and implications.

Finally, Chapter 6 integrates the findings from the three studies and discusses their theoretical and practical implications, addresses the limitations of the research and provides suggestions for future work, and concludes the dissertation by summarizing the key contributions, highlighting the significance of the research, and outlining potential avenues for further investigation.

CHAPTER 2: LITERATURE REVIEW

2.1 Overview of Media Multitasking Research

Media multitasking, defined as the simultaneous use of multiple media (Jeong & Hwang, 2016), has become increasingly prevalent in recent years. The growing prevalence of media multitasking has led to increased research interest in its potential impact on cognitive processes, task performance, and overall well-being. Most research in this area has been conducted through experimental approaches, examining the effects of media multitasking on various outcomes such as attention, memory, and learning (Jeong & Hwang, 2016; Segijn & Eisend, 2019). These studies have generally found that media multitasking can have detrimental effects on cognitive performance, highlighting the need for a deeper understanding of the underlying mechanisms and boundary conditions of these effects.

One key aspect of media multitasking research is its relevance to advertising effectiveness. As individuals increasingly engage in media multitasking, the way they process and respond to advertising messages is likely to be affected. For example, media multitasking may lead to reduced attention and comprehension of advertising content, as cognitive resources are divided between multiple tasks (Angell et al., 2016). On the other hand, media multitasking could also create opportunities for advertisers to reach audiences across multiple platforms and enhance engagement with interactive or cross-media campaigns (Segijn et al., 2017). Therefore, understanding media multitasking effects on cognitive processes and task performance is crucial for optimizing strategies in various fields (e.g., advertising, workplace, learning, etc.) in the current media landscape.

The key concepts in media multitasking research, such as task engagement, sustained attention, divided attention, distraction filtering, resource allocation, and cognitive control, are essential for understanding the complex nature of media multitasking and its effects on cognitive performance. *Task engagement* reflects the level of cognitive and emotional involvement an individual has with a given task or medium, and it can influence the effectiveness of information processing and task performance (Christian et al., 2011). *Sustained attention* refers to the ability to maintain focus on a task over an extended period, while *divided attention* involves the allocation of cognitive resources between multiple tasks (Jeong & Hwang, 2016). Distraction filtering and cognitive control are critical for managing the allocation of cognitive resources and minimizing the interference of task-irrelevant stimuli (Lavie, 2004). Understanding how these concepts interact and are affected by media multitasking is crucial for optimizing strategies in various domains, such as advertising, education, and the workplace.

2.2 Task Engagement

2.2.1 Definition

The concept of engagement has various definitions depending on the context. In the workplace, Kahn (1990) defines it as the active investment of a person's preferred strengths and personality traits in tasks that connect them to the work, colleagues, or the task itself. This multifaceted concept includes three dimensions of self-expression and investment: physical, emotional, and cognitive (Kahn, 1990; Christian et al., 2011). Employing a person's "preferred self" involves channeling personal energy into physical, emotional, and cognitive efforts, while expressing it entails displaying one's genuine thoughts, feelings, and identity. In other contexts, engagement might refer to a state of complete absorption in stimuli, such as advertising (Kim et al., 2017), or a heightened level of mental focus that causes an individual to entirely disregard distractions (Buetti & Lleras, 2016).

While the specifics of engagement definitions may vary (e.g., work, personal, media), a central debate surrounds the concept's ambiguity. Researchers often mistake the consequences or precursors of engagement for the state itself (Calder et al., 2009). However, a consensus exists that engagement represents a "state" rather than an enduring "trait," subject to fluctuations around an average level (Sonnentag, 2003). Engagement influences the sustained intensity with which individuals approach tasks (Christian et al., 2011), differentiating it from motivation, which refers to the desire or drive to initiate or act in service of a goal or need.

The relationship between motivation and engagement can be either reciprocal or unidirectional. Engaged individuals may allocate more resources to a task, resulting in increased motivation for sustained concentration, effort, and arousal (Humphreys & Revelle, 1984). Conversely, motivation can determine the intensity and direction of engagement, with fluctuations in resource allocation depending on an individual's motivation levels. Therefore, task engagement fundamentally represents a motivational state characterized by the active allocation of resources towards tasks.

In the context of media multitasking, task engagement can be conceptualized as the level of cognitive and emotional involvement an individual has with each of the multiple tasks or media being simultaneously engaged with. For example, when watching television while browsing social media on a smartphone, an individual's task engagement would reflect their level of involvement with both the television content and the social media activity. It's important to note that the concepts of engagement and involvement are closely related and sometimes used interchangeably in the literature, which can lead to some ambiguity. High involvement typically leads to more thorough information processing and stronger task performance (Petty & Cacioppo, 1986). In media multitasking scenarios, the degree of task engagement can vary across different tasks or media, potentially influencing how attention and cognitive resources are allocated (Wang & Tchernev, 2012). This variability in engagement levels across tasks is a key focus of the current research and will be explored further in subsequent sections, particularly in relation to how perceived task relationships and individual differences in cognitive flexibility and multitasking propensity influence engagement patterns.

The overlapping nature of these concepts (engagement, involvement, attention) and their dynamic interplay in media multitasking contexts underscores the complexity of studying cognitive processes in multitasking environments. This dissertation will attempt to disentangle these concepts where possible, while acknowledging their interconnected nature.

2.2.2 Antecedents of Task Engagement

Research on workplace and media engagement has identified numerous factors influencing engagement levels and tendencies. According to the adjusted model of work engagement (Christian et al., 2011), task characteristics, leadership styles, and individual dispositional differences all play a role. Among task characteristics, task variety (the opportunity to perform different tasks concurrently or non-concurrently) and task significance (the extent to which a task affects others) are the strongest predictors of positive workplace engagement. This is because task variety facilitates the flexible transfer of information between tasks (e.g., Boh et al., 2007; Avgerinos & Gokpinar, 2018), allowing individuals to maintain a comprehensive view of tasks and make necessary adjustments when required. Furthermore, individual differences in cognitive and emotional control, such as conscientiousness and positive affect, are likely to correlate positively with engagement (e.g., Bandura, 2001; Hirschfeld & Thomans, 2008).

In media-related engagement research, contextual message relevance has been found to positively influence media engagement, subsequently affecting self-reported attitude, attention, and interest toward media messages (e.g., Kim et al., 2017). For instance, a study by Belanche et al. (2017) found that perceived relevance of online advertising content positively influenced users' engagement with the ads, leading to more favorable attitudes and higher click-through rates. Similarly, Angell et al. (2016) demonstrated that the contextual relevance of background television content to a primary task enhanced engagement with both the task and the background media.

2.2.3 Consequences of Task Engagement

Engagement's consequences can be grouped into task and contextual performance (e.g., Christian, Garza, & Slaughter, 2011), psychological and behavioral performance (e.g., Kim et al., 2017), or subjective perception and objective performance (e.g., Chinchanachokchai, Duff, & Sar, 2015). Previous research on engagement has demonstrated that task engagement is closely related to resource allocation, with engagement levels fluctuating dynamically as a state, positively correlating with the amount of resources allocated to the task or stimulus. This, in turn, may influence cognitive performance, which largely depends on the resources utilized.

Past research has also shown that within a person's effort limit, increased engagement enhances focal and sustained attention to the task, with sustained attention decreasing when engagement wanes (e.g., Christian, Garza, Slaughter, 2011; Spielmann & Richard, 2013). Moreover, task engagement has been found to correlate positively with eye gaze insensitivity to task-irrelevant distractors (e.g., Buetti & Lleras, 2016) and improved information learning (e.g., Celuch & Slama, 1998). These findings suggest that higher levels of task engagement can lead to more focused attention, better distractor filtering, and enhanced learning outcomes.

Engagement also fosters emotional or affective involvement with tasks or stimuli. For example, Kim et al. (2017) discovered that advertising engagement generally leads to positive attitudes toward both the advertisement and the advertised brand. Similarly, a study by Belanche et al. (2017) found that users who were more engaged with online advertising content reported more positive attitudes and higher purchase intentions for the advertised products. Phua et al. (2017) also demonstrated that engagement with brand-related content on social media positively influenced brand attitudes and loyalty.

Additionally, research has shown that when individuals are motivated to engage in tasks, they perceive the tasks as shorter in duration and consequently rate them as more enjoyable (Chinchanachokchai, Duff, and Sar, 2015; Hoffman and Novak, 2009). This suggests that engagement can alter subjective perceptions of time and enhance overall task enjoyment.

In the context of media multitasking, the consequences of task engagement may be more complex, as engagement must be considered for multiple tasks or media simultaneously. For example, a study by Poplawska et al (2021) found that media multitasking during lectures led to decreased engagement with the lecture content and poorer learning outcomes. However, the same study also noted that some students reported using media multitasking as a means of coping with boredom or maintaining engagement during less interesting parts of the lecture. This highlights the potential trade-offs between engagement with different tasks or media in a multitasking context.

Similarly, a study by Segijn et al. (2017) investigated the effects of media multitasking on advertising effectiveness and found that while multitasking generally led to reduced brand memory, it also resulted in more positive brand attitudes when the advertisements were perceived as relevant to the primary task. This suggests that the consequences of task engagement in media multitasking contexts may depend on factors such as the relatedness or perceived relevance of the multiple tasks or media being engaged with.

2.3 Sustained Attention and Distraction in Multitasking

2.3.1 Divided Attention and Resource Allocation between Tasks

Past research on divided attention suggests that adding a secondary task or stimulus impairs overall cognitive performance (e.g., Jeong & Hwang, 2016; Segijn & Eisend, 2019). Resource theories propose that people can divide their attention between tasks and manage multiple tasks simultaneously, as long as the total cognitive load does not exceed their cognitive resource capacity (e.g., Kahneman, 1973; Lang, 2006). However, media multitasking research has reported a range of effects, with negative cognitive outcomes—such as attention management failures, memory decrements, and weakened comprehension of information—being common themes (Lang & Chrzan, 2015).

For example, Srivastava (2013) conducted a study in which participants performed a reading comprehension task while simultaneously listening to a radio broadcast. The results showed that participants' reading comprehension scores were significantly lower in the dual-task condition compared to the single-task condition, indicating that the addition of the secondary listening task impaired performance on the primary reading task. A study by Cain et al. (2016) investigated the relationship between media multitasking and sustained attention in adolescents. Participants completed a questionnaire assessing their media multitasking habits and performed a sustained attention task. The results showed that higher levels of media multitasking were associated with poorer performance on the attention task, suggesting that frequent media multitasking may lead to difficulties in maintaining focused attention over time. Similarly, a meta-analysis by Jeong and Hwang (2016) examined the effects of media multitasking on cognitive outcomes such as attention, comprehension, and memory. The analysis included 49 studies and found a significant negative effect of media multitasking on cognitive performance, with an overall effect size of $r = -.15$.

The following paragraphs will introduce two prominent theoretical models used to explain the mechanisms and disrupted cognitive outcomes of divided attention between tasks or stimuli.

Response Selection Bottleneck Model (Pashler, 1994). This model proposes that task processing can be divided into distinct stages: perception, response selection, and motor activation. While certain stages, like perception and execution/activation, may allow for concurrent processing of two tasks, the central processing stage (response selection) cannot be performed simultaneously for both tasks. In this view, an individual must complete the response selection stage for one task before initiating or resuming the other task’s process. This perspective combines concurrent time-sharing and task switching definitions of dual-task performance, suggesting that the effectiveness of either approach depends on the task stage at that moment. According to this view, two tasks interfere with each other at the central processing stage, and reducing interference involves selecting a secondary task that can bypass the central processing channel (e.g., a task that only involves perception, like watching a video).

In the context of media multitasking, this model suggests that when an individual is engaged in two media-related tasks, such as watching a video and reading an article, the response selection stage for one task (e.g., processing the video content) must be completed before the individual can initiate or resume the response selection stage for the other task (e.g., comprehending the article). This sequential processing at the response selection stage can lead to performance decrements in both tasks, as the individual must constantly switch between the tasks and cannot process them simultaneously at this critical stage.

Capacity Sharing and Multiple Resource Theory (Kahneman, 1973; LC4MP, Lang, 2000, 2006). The capacity sharing view asserts that resources can be shared between tasks simultaneously, provided they are available. In this perspective, limited resource theories (Kahneman, 1973; LC4MP, Lang, 2000, 2006) are widely used examples. These theories argue that resources are limited, and adding a secondary task consumes resources that could potentially be allocated to the primary task, potentially resulting in performance deficits.

The Limited Capacity Model of Motivated Mediated Message Processing (LC4MP; Lang, 2000, 2006) is a widely used example of a limited resource theory. It assumes that individuals have a finite pool of cognitive resources that can be allocated to processing media messages, and that these resources are shared among various cognitive tasks, such as encoding, storage, and retrieval. When multiple tasks or media messages compete for these limited resources, performance on one or more of the tasks may suffer.

Furthermore, Kahneman contends that capacity is not fixed and can even change depending on an individual's arousal level. However, this view does not differentiate between the types of resources being used (e.g., perceptual or cognitive).

Adaptation and Evolving of the Theories. Another perspective incorporates elements from both models. For instance, multiple resource theories (e.g., Wickens, 1984) propose that capacity is limited at the central pool, but there are numerous modality-based resource pools in which resources may circulate and be allocated to different tasks simultaneously. The central pool refers to the main store of cognitive resources that can be flexibly allocated to various tasks, while modality-based resource pools are specific to certain sensory channels or processing pathways (e.g., visual, auditory, or spatial). While both within- and between-pool interference exist, within-pool interference is often higher due to increased competition within the same pool.

Lavie's load theory (2004) combines the capacity view and the bottleneck view, discussing resources from a perceptual and cognitive processing perspective. More details of the load theory will be discussed in the following section. The new LC4MP, developed by Fisher et al. (2018), further combines load theory with LC4MP, addressing load as a limited capacity resource available for allocation.

Wang et al. (2015) integrate the capacity view (limited capacity, multiple resource, threaded cognition) with the law of less work (Kool et al., 2010), which suggests that individuals perceive expending cognitive effort as more work than conserving effort. Consequently, people choose to multitask not to increase overall load, but to conserve cognitive resources with less effort by temporarily allocating these resources to another task. This is consistent with Clark's view (1998) that people sometimes use external resources to save mental representation effort. One possible explanation is that by engaging in a secondary task, they may feel that they are 'taking a break' from the primary task, which can help alleviate feelings of fatigue or boredom associated with the primary task (Kool et al., 2010; Wang et al., 2015). This insight is valuable for dual-task performance research as it may help explain why adding a secondary task doesn't always deplete a person's cognitive resources and can sometimes be beneficial.

Understanding the mechanisms of divided attention and resource allocation can provide valuable insights into how individuals manage multiple tasks and stimuli, as well as how these factors impact their cognitive performance. By examining the factors that contribute to successful multitasking and determining which types of tasks are more or less compatible, researchers can develop strategies and interventions to improve individual performance in multitasking situations, enhance comprehension of information, and ultimately optimize cognitive resource allocation.

2.3.2 Cognitive Control and Distraction Filtering

Previous media psychology research on divided attention has primarily focused on the negative consequences of allocating cognitive resources to different stimuli or tasks (e.g., Armstrong & Chung, 2000; Bergen et al., 2005; Brasel & Gips, 2011). For instance, a study by Segijn et al. (2017) found that media multitasking during a television program led to decreased brand memory and reduced counterarguing. Similarly, Kazakova et al. (2016) demonstrated that media multitasking while viewing an advertisement resulted in lower ad recall and recognition. These findings highlight the detrimental impact of media multitasking on cognitive performance, particularly in the context of processing media content and advertising messages.

Resource theories argue that individuals can handle multiple tasks as long as the combined tasks do not exceed their cognitive resource capacity. However, it seems that past multitasking research may have failed to create a context where adding a task can have an impact beyond disrupting information processing and primary task performance (see Lang & Chrzan, 2015 for an overview).

The theoretical explanations and study designs used in these studies might be responsible for this one-sided view. The design of multitasking stimuli can greatly influence the amount of cognitive resources individuals allocate to each stimulus (e.g., combination of media, content, and task; Segijn et al., 2018), making the task either cognitively demanding or manageable, distracting or facilitating, uninteresting or enjoyable. For example, studies have manipulated the media through which messages or stimuli are presented, sometimes giving people no control over their pacing (e.g., watching television or listening to radio that are externally paced, rather than reading a newspaper which is internally paced; Dijkstra et al., 2005). Adding an additional task indeed requires more resources, and resource limit and cognitive overload perspectives explain the extent to which multitasking can cause a scarcity of resources and disruption of information processing.

However, when there are both free resources and resources in use, individuals may simply use any available resource for the additional task rather than occupying resources that are already in use for the current task. For example, when watching a television show, an individual may choose to allocate spare cognitive resources to a secondary task (e.g., browsing social media on phones at their own pace) when he/she does not want to fully engage in that show, without necessarily interfering with their processing of the television content. In fact, limited capacity theories propose that people can process as many tasks as they want if the resources being used have not yet reached their limit (Kahneman, 1973; Lang, 2006). Nevertheless, most media studies tend to focus on the overload extreme of an individual's 'limited capacity', and rarely find any dual-task condition that does not reach the limit compared to when conducting a single task (for an overview, see Lang & Chrzan, 2015).

While we cannot ignore that excessive use of cognitive resources could dampen cognitive performance, we also need insights into the other side of the spectrum, where resources are not completely used up and people still have spare resources available. Motivational and contextual factors may provide a different perspective on the positive effects of adding a simultaneous secondary task to the original task. For example, individuals may be motivated to conduct two tasks concurrently during media usage because multitasking is associated with perceived less mental effort and more positive subjective ratings on effort compared to serial processing of the two tasks (Fischer and Plessow, 2015).

Additionally, the motivation to avoid boredom (e.g., being bored with homework) may prompt individuals to add an additional task and switch between the two tasks to reduce the perceived dullness of the original task (e.g., Rosen, Carrier, & Cheever, 2013; Chinchanachokchai, Duff, & Sar, 2015). Connecting the findings in cognitive performance and subjective evaluation, it seems that people may have a good subjective experience when adding a secondary task, even though this behavior may have a detrimental cognitive outcome. This suggests that people may not be fully aware of the potential detrimental effects of multitasking on their cognitive performance, or that the positive subjective experiences with media multitasking (e.g., reduced boredom, increased enjoyment) may outweigh the negative impacts on performance in their perception.

There are several potential explanations for this issue. One proposal is that previous multitasking research did not reveal the systematic influence of adding a secondary task on cognitive performance. Rather, prior studies (e.g., Sanbonmatsu et al., 2013; Uncapher et al., 2017) mainly focused on the speed and accuracy aspects of cognitive performance, using general cognitive performance measures to conclude the partial consequences of adding a secondary task. These aspects include, but are not limited to, reaction time, reaction accuracy, and memory accuracy. While accuracy and speed measures are crucial indicators of an individual's cognitive performance, a question arises regarding the use of only these measures to determine the advantages and disadvantages of divided attention: what kind of cognitive performance do people anticipate when choosing to divide their attention? Is their goal to achieve better accuracy? Or are they expecting their time spent on one task to reduce significantly by allocating part of their attention to another stimulus or task?

The answer to this question is likely "no." People probably add another task during media usage primarily because they feel unmotivated or bored and believe they still have spare cognitive resources to use. The question then becomes, why would they choose to add another task when they feel unmotivated or bored, and how would their cognitive performance outcome differ when they have a secondary task versus only a single task?

Lavie's load theory (2004) categorizes task load into two types: perceptual load and cognitive load. The two types have different processing mechanisms. Both loads increase with the complexity of the task; however, an increase in cognitive load can consume all cognitive resources, including those for cognitive control (e.g., determining what information to process and what to ignore, top-down strategy of processes), making individuals more susceptible to task-irrelevant distractor interference. On the other hand, an increase in perceptual load occupies free perceptual resources, leaving less room for individuals to process additional perceptual stimuli that are task-irrelevant. For example, in a media multitasking context, a cognitive load task could involve reading a complex article while simultaneously listening to a podcast that requires active processing and comprehension, leaving fewer resources available for cognitive control. According to Lavie's theory, this makes the individual more susceptible to distraction by task-irrelevant information. In contrast, watching an engaging video while passively listening to background music primarily involves a great amount of occupied resources for perceptual processing, leaving less capacity for processing newly popped task-irrelevant stimuli.

Therefore, increasing perceptual load reduces individuals' sensitivity to distractions, whereas increasing cognitive load makes them more vulnerable to distractions. According to this theory, adding a cognitive or perceptual secondary task could trigger different processing mechanisms and result in different performance outcomes: adding a cognitive secondary task implies adding overall cognitive load to the processes and would impair one or more tasks' performance, while adding a perceptual secondary task implies adding overall perceptual load to the processes and would make subjects less sensitive to distractor interference.

Thus, Lavie's (2004) theory allows us to propose that engaging in additional tasks can help focus an individual's cognitive resources on the primary task by reducing the likelihood of external or internal distractions. It offers a potential function for additional tasks: an attention "corralling" function of gathering people's cognitive resources for the current task(s) rather than risking distraction and even changing the pre-determined goal (e.g., individuals might be distracted by inner mind wandering or a pop-up advertisement from the corner of a screen). This "corralling" function serves to maintain attention on the main task by occupying the available cognitive capacity and preventing it from being diverted to irrelevant stimuli or mind wandering. Consequently, the individual can remain more focused and attentive to the task at hand, potentially leading to improved performance and task completion.

2.4 Moving Beyond Limited Capacity

2.4.1 The Additional Task: Not Always a Source of Overwhelm

Task variety, encompassing concurrent and non-concurrent tasks, refers to the degree to which a task in volves various activities or subtasks (Christian et al., 2011). An individual can perform a single task, engage in multiple tasks concurrently, or complete tasks non-concurrently. Multitasking, or performing tasks simultaneously, does not always lead to feeling overwhelmed. From previous discussion, we can infer that in certain cases, adding a secondary task may actually enhance engagement and boost productivity. For example, adding a task to a dull primary task can reduce boredom and increase engagement. Boredom arises from a lack of motivation to focus on the current task or when sustained attention is required for repetitive tasks (van Tilburg & Igou, 2017; Thomson et al., 2015). Introducing a media-related task can decrease perceived dullness, boost enjoyment, and alter arousal levels (Rosen et al., 2013; Chinchanachokchai et al., 2015). For example, listening to music while completing a repetitive data entry task may help reduce feelings of boredom and increase overall enjoyment. Similarly, watching a short, entertaining video during a study break may help alleviate the perceived dullness of a lengthy study session and temporarily boost arousal levels. This change in arousal and enjoyment may increase motivation to maintain attention, reallocating resources to the original task and sustaining engagement.

Furthermore, adding a task may alter an individual's perception of time spent on the task. Attentional models of time perception suggest that when attention is diverted from a boring task, it can be allocated to processing time during a time judgment task (Thomas & Weaver, 1975). When attention is focused on additional tasks, people may perceive time as passing more quickly, leading to increased task enjoyment (Brown, 2008; Chinchanachokchai et al., 2015). However, more research is needed to determine if increased task enjoyment further motivates engagement.

Although Lavie's load theory demonstrates that adding a secondary task may facilitate cognitive control in certain cases, it remains unknown whether the theory applies to real situation attention management (e.g., sustained attention, distractor filtering), and task performance (e.g., accuracy, reasoning). Moreover, when tasks are unrelated (e.g., watching ads while monitoring another window), there has been no systematic exploration of whether and how an additional task could enhance engagement and cognitive performance.

Existing media effects research has primarily focused on improved subjective evaluations of task experiences, such as time perception and enjoyment, when an additional task is added to an original task. For instance, a study by Chinchanachokchai et al. (2015) found that participants who engaged in media multitasking while watching a video reported a more positive viewing experience and perceived the video as shorter in duration compared to those who watched the video without multitasking. Similarly, Rosen et al. (2013) demonstrated that students who were allowed to text during a lecture reported higher levels of enjoyment and perceived the lecture as less boring compared to those who were not permitted to text. However, it is unclear whether such improvements extend to the entire task process, including engagement and various performance indicators (e.g., cognitive, affective, etc.).

This dissertation aims to propose a systematic model and test the path and unexplored potentials of an additional task on enhancing task engagement and various aspects of performance (e.g., attention, distractor filtering, subjective experience, etc.) in a media use context. By examining these factors, this dissertation aims to gain a deeper understanding of the intricate relationship between multitasking and its effects on engagement, interference, and cognitive performance across different contexts. This knowledge can potentially help individuals and organizations to optimize task management strategies and make more informed decisions about multitasking in various settings. For media and advertising, understanding the conditions under which a secondary task can enhance engagement without impairing cognitive performance can inform the design of effective multimedia campaigns and cross-platform advertising strategies. For instance, advertisers could develop complementary content across different media platforms that maintains viewer engagement while minimizing distraction from the primary advertising message.

The premise of the study designs in this dissertation is that rather than *creating* overload, the two tasks in the study are within an individual's cognitive resource limit to avoid disruption of information processing caused by cognitive overload. Both perceived engagement via self-report and observed engagement via eye-gaze will be used to examine whether adding another media task could enhance- or at least not impair- an individual's task engagement and overall performance.

2.4.2 Individual Differences in Multitasking

Cognitive flexibility and multitasking propensity are two factors that can moderate an individual's multitasking experience. Cognitive flexibility refers to the ability to adapt cognitive processing strategies to new situations (Martin & Rubin, 1995). It encompasses skills like task switching, inhibiting irrelevant information, and adjusting problem-solving approaches. Studies on the relationship between cognitive flexibility and media multitasking have shown mixed results (Murphy & Shin, 2022; Alzahabi & Becker, 2013). Some studies have found that individuals with higher cognitive flexibility perform better in media multitasking environments (e.g., Alzahabi & Becker, 2013), while others have found no significant relationship or even a negative association between cognitive flexibility and media multitasking performance (e.g., Murphy & Shin, 2022).

This dissertation explores cognitive flexibility as a moderator to understand how it may influence task performance, sustained attention, and distractor filtering in media multitasking contexts. By examining this relationship, we can gain insights into individual differences in multitasking effectiveness.

Multitasking Propensity as a Moderator: Multitasking propensity refers to an individual's tendency to engage in multiple tasks simultaneously (Poposki & Oswald, 2010). Research suggests that this propensity can influence performance and engagement in media multitasking (Rosen et al., 2013). While some studies suggest a negative impact of high multitasking propensity on cognitive performance (Ophir et al., 2009), the influence on engagement remains unclear. This dissertation will explore how multitasking propensity influences engagement and attention allocation in media multitasking contexts.

In summary, Lavie's (2004) theory offers a potential function for additional tasks, which is the "corralling" function, that helps individuals focus their cognitive resources on the primary task by reducing the likelihood of distractions. Task variety, or in this dissertation, adding a secondary task to the primary task, should play a significant role in shaping an individual's engagement and productivity. This dissertation posits that multitasking, or performing tasks simultaneously, does not always lead to feeling overwhelmed. In some cases, introducing a secondary task can reduce boredom, increase engagement, and improve an individual's perception of time spent on it.

This dissertation will propose a systematic model (see Figure 2.1) to investigate the effects of adding an additional task on task engagement and various aspects of performance and attention management (e.g., sustained attention, distractor filtering) in a media use context.

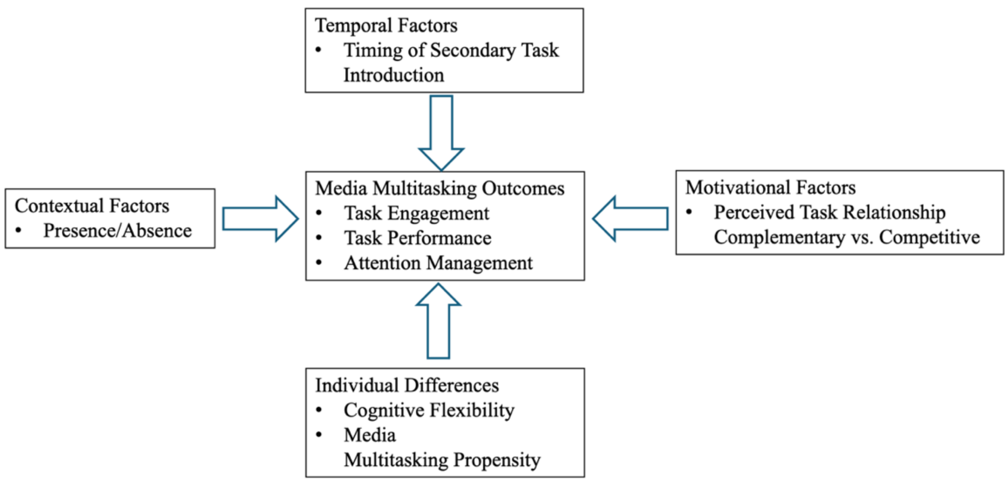

Figure 2.1 Proposed model for understanding media multitasking effects

The proposed model builds on load theory (Lavie, 2004) by considering the role of task characteristics and individual differences in shaping media multitasking outcomes. It differs from existing theories by exploring the potential facilitative effects of secondary tasks and investigating the temporal dynamics of media multitasking. This novel approach aims to provide a more comprehensive and nuanced understanding of media multitasking that goes beyond the limited resource perspective. Additionally, the research will explore how cognitive flexibility and multitasking propensity influence engagement and attention allocation in a media multitasking context, providing further insights into the complex interplay between dispositional factors, cognitive performance, and task engagement during media multitasking. This knowledge can help people optimize task management strategies and make more informed decisions about multitasking in various settings.

CHAPTER 3: STUDY 1 IMPACT OF SECONDARY TASKS ON TASK ENGAGEMENT AND PERFORMANCE

3.1 Overview

Study 1 aims to evaluate the impact of a secondary task (watching silent video clips) on individuals' engagement in a primary email classification task. The email classification task was chosen as the primary task because it represents a common, repetitive work-related task that people often perform (Bailey & Iqbal, 2008). Silent video clips were selected as the secondary task to provide a perceptual media task that could potentially influence engagement and performance in the primary task. Study 1 will directly assess the secondary task's influence on task engagement and indirectly examine its effect on task performance, cognitive control, and subjective task experience. Additionally, the study will investigate the moderating role of dispositional factors, specifically cognitive flexibility and multitasking propensity, in these relationships. The research protocol was approved by the Illinois Institutional Research Board (IRB20810).

3.2 Research Questions and Hypotheses

3.2.1 Task Engagement, Performance, and Attention Management

Research Question: How does a secondary perceptual media task influence task engagement, performance, and attention management in a primary email classification task?

Task Engagement. Research suggests that adding a task can reduce boredom (Chinchanachokchai, Duff, & Sar, 2015). Therefore, it is proposed that when individuals engage in a repetitive and boring media task, introducing an additional media task on the same screen can motivate them to engage with the tasks compared to a condition without an additional task. This leads to the following hypothesis:

Hypothesis 1.1. Individuals will exhibit higher overall engagement when a media task is added to an initially boring media task, compared to a condition with only the primary task.

Attention Management. Previous research showed that the more engaged people are with the primary task, the fewer eye movements they make towards task-irrelevant distractions and the more fixations they make towards the task-related area (e.g., Buetti & Lleras, 2016). The eye gaze measures provide an objective assessment of visual attention allocation, which is a key component of attention management (Orquin & Loose, 2013). By examining the proportion of gazes on task-relevant versus task-irrelevant areas, it can be inferred how effectively participants are managing their attention in the presence or absence of the secondary task. Based on this, the current study proposes the following hypotheses:

Hypothesis 1.2a. The higher engagement induced by the secondary task will result in more attention (eye gaze) towards the designated primary task area.

Hypothesis 1.2b. The higher engagement induced by the secondary task will result in fewer eye gazes towards the primary task-irrelevant distractions.

Task Performance. According to Lavie's (2004) load theory, introducing a secondary perceptual task creates a constraint on cognitive resources. This limited capacity can have a two-fold effect on task performance: (1) Potential Benefit: Reduced processing of task-irrelevant stimuli due to attention being directed towards the primary task and the secondary task. This could lead to improved accuracy on the primary task (assuming less interference from irrelevant information). (2) Potential Cost: Competition for limited cognitive resources between the primary and secondary tasks. This could lead to slower reaction times on the primary task. Based on this theory, the current study proposes the following hypothesis:

Hypothesis 1.3: The introduction of a secondary perceptual media task may improve email task accuracy by reducing attention to distractors.

3.2.2 Moderating Role of Dispositional Factors

This study will also delve into the moderating role of dispositional factors, such as cognitive flexibility and multitasking propensity, on the impact of a secondary task on task engagement, performance, and attention management.

Research Question 1.1: How might individual differences in cognitive flexibility and media multitasking propensity moderate these relationships?

Cognitive Flexibility

Cognitive flexibility, defined as the ability to adapt cognitive processing strategies to new or changing circumstances, presents two potential scenarios in relation to the secondary task effect:

Scenario 1: Individuals with higher cognitive flexibility may be less reliant on a secondary task to suppress distractions and maintain engagement, as they can flexibly adjust to the environment.

Scenario 2: Alternatively, those with better cognitive flexibility may effectively utilize the secondary task's "corralling" function, leading to enhanced attention management and potentially improved performance compared to individuals with lower cognitive flexibility.

Media Multitasking Propensity

The influence of the propensity to engage in media multitasking on the secondary task effect can be explained in two ways. One direction is the positive effect: Media multitaskers may intentionally or unintentionally use additional tasks to motivate engagement or "corral" attentional resources. This could lead to increased comfort and potentially improved performance when conducting primary tasks in preferred settings. Another direction is the negative effect: Media multitaskers may also be less proficient at task switching, distractor inhibition (as suggested by Ophir et al., 2009), and other cognitive control processes. This vulnerability may prevent them from effectively using secondary tasks as facilitators, leading to compromised primary task performance due to distractions.

Therefore, the effect of video on performance for individuals with varying levels of cognitive flexibility remains an open question. Based on the above analysis, the current study proposes the following hypothesis:

Hypothesis 1.4: Individuals with a lower propensity to multitask will benefit more from adding a secondary task - the video's potential "corralling" function, enhancing engagement. Conversely, frequent multitaskers might find the video distracting, hindering engagement.

See Figure 3.1 for summary.

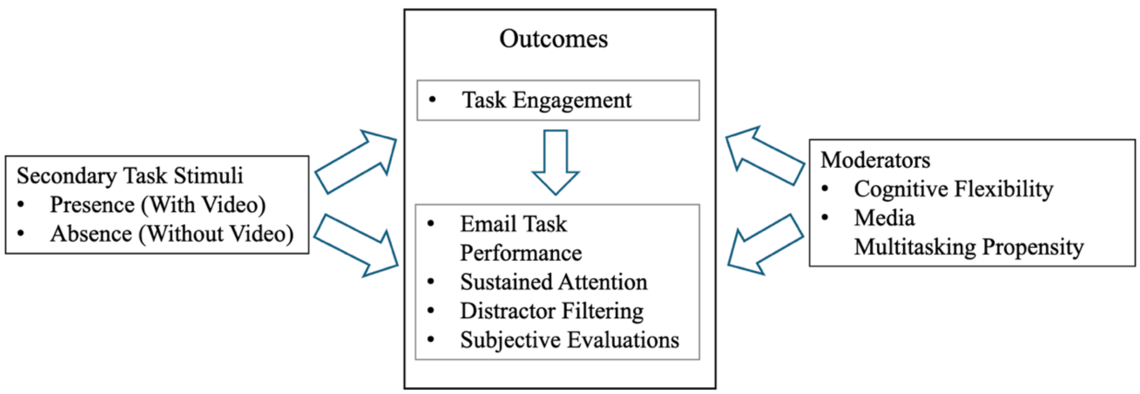

Figure 3.1 Study 1 Framework

3.3 Method

3.3.1 Participants

Seventy-six undergraduate students from a large Midwestern university participated in this study to earn course credit. The sample size was determined a priori using G Power, with a power of .80 and an effect size (eta-squared) of .40. This analysis indicated that a sample size of 65 would be sufficient. Two participants who experienced server connection errors during the study were excluded from the analyses.

3.3.2 Task and Stimuli Design

A between-subject design with two groups (email task without video vs. email task with video) was employed to examine the impact of adding a secondary task on task engagement, performance, and attention management. Each condition consisted of 38 participants.

Primary Task: Email Classification. In the email task-only condition, participants were required to complete an email classification task displayed on the left two-thirds of their PC screen. Drawing inspiration from Bailey and Iqbal (2008), this task involves categorizing emails (including all elements such as sender, recipient, subject title, content, and signature) into one of five predefined categories: medication, electronics, space science, sports, or for sale. This task simulates a common but often tedious work-related activity that employees encounter in various office settings, making it a suitable choice for studying interruptions and task performance in a controlled experimental environment. After selecting a category, participants proceeded to the next page to classify another email. This sequence was repeated for all remaining emails (89 in total), with the order of emails randomized. Participants were instructed to accurately classify as many emails as possible. The task had a maximum time limit of 25 minutes, and automatically terminated and redirected to the post-experiment questionnaire when either all emails were classified or the hidden time limit was reached, whichever came first. This undisclosed time limit significantly exceeds the average task completion time by two standard deviations. Refer to Appendix A.1 for a demonstration of the email task.

A pretest of the primary email classification task was conducted to assess whether each email was previously encountered by a participant, determine the difficulty level of classifying each email, and to identify emails that could potentially be classified into multiple categories. A total of 112 emails were selected for pretesting from five categories in the scikit-learn newsgroups text dataset (Dua & Graff, 2019). This dataset is a collection of approximately 18,000 newsgroup documents, partitioned evenly across 20 different newsgroups, and is commonly used for text classification as it provides a diverse set of pre-categorized text data. None of these email materials had been previously exposed to any of the pretest participants. Ultimately, 89 emails that met two criteria were chosen as the final email task stimuli: 1) classification accuracy of 95% or higher, and 2) clear category boundaries, allowing for unambiguous classification into one of the five categories.

While the email classification task may appear simple, potentially leading to high accuracy across conditions, this design choice was deliberate and aligns with our research objectives. The task mimics common, repetitive work activities that often prompt individuals to engage in media multitasking, representing scenarios where people have spare cognitive resources and choose to multitask. This simplicity ensures that participants have cognitive resources available for potential allocation to a secondary task, allowing us to study the dynamics of voluntary resource allocation in multitasking contexts. By using a task that doesn't heavily tax cognitive resources, we can more clearly observe how the introduction of a secondary task influences engagement and attention management, rather than task performance alone. The task's repetitive nature provides a consistent cognitive load across participants, reducing variability due to individual differences in task difficulty perception. While the task may not show large performance differences, it can still be sensitive to subtle changes in engagement, attention allocation, and cognitive strategies employed by participants. This approach allows us to focus on how individuals manage their attention and engage with multiple stimuli when they have the cognitive capacity to do so, rather than studying performance decrements under high cognitive load.

Secondary Task: Silent Video Stimuli. In the email task (primary task) plus silent video task (secondary task) condition, participants completed the primary email task while watching silent videos displayed alongside the task area on the screen. The videos played automatically upon loading the first email task page, and participants were notified of their presence during the pre-task instructions. The video consisted of four distinct clips featuring tranquil scenic and nature views.

This dissertation chose video stimuli as the secondary task based in part on the recent popularity of video-based productivity aids. For example, "study with me" videos, which feature footage of people studying for hours without social interaction or instructional content, have become increasingly popular on video-sharing platforms (Lee et al., 2021). While the current study did not use these specific types of videos, their widespread appeal suggests that video stimuli can play a role in shaping media multitasking environments. This emerging trend in video use for productivity influenced our decision to explore video stimuli, rather than other potential secondary tasks like background music or static images, in the current study experimental design.

To select the video clips, a pretest was conducted. The role of arousal in motivating allocation change has been discussed by several theorists. For instance, Lang (2006) described the “spill over” effect of arousal from one item to the target item being processed simultaneously. This “spill over” of arousal aids in maintaining goals and allocating resources to the target item. Furthermore, according to Kahneman (1973) and prior research findings, increased arousal may enhance the resources available for a task because when individuals are aroused, the heightened arousal reduces the cost of resource allocation, freeing up more resources for the task (e.g., Matthews, Davies, Holley, 1990). Therefore, it is hypothesized that video stimuli with a moderate interest level and arousal level would provide an appropriate amount of cognitive resource engagement and facilitation without causing excessive attention “spill over” to the video itself.

Based on the above theory, to select suitable video stimuli, only scenic nature video clips were chosen, ensuring a single camera position and no editing. Pre-test participants were instructed to provide two ratings for 20 silent nature video clips: 1) interest level on a scale from 1 (not interesting at all) to 7 (very interesting), and 2) arousal level on a scale from 1 (calm) to 7 (extremely arousing). After careful evaluation, only four video clips met the criteria: average interest ratings between 3.5 and 4.5, and average arousal ratings below 3. These selected video clips served as the secondary task video stimuli. Refer to Appendix A.2 for selected video clip links.

Distracting Stimuli. In both dual-task and single-task conditions, a distracting area was present on the empty white spaces at the bottom right third of the screen. These images were not part of the experimental instructions or goals communicated to participants, distinguishing them from the email classification task and video stimuli. Thirty-five task-irrelevant distracting images appeared in this area one at a time, in a randomized order. Each image was displayed for seven seconds. The images were selected from the previously validated International Affective Picture System (IAPS) database (Lang, Bradley, & Cuthbert, 2008). All chosen images showed moderate arousal and neutral valence, with a rating score between 4 and 6. The original ratings are scored on a scale from 1 to 9, where 9 represents a high rating and 1 represents a low rating on each dimension. Refer to Appendix A.3 for folder link of IAPS images used in the current study.

3.3.3 Task Completion Environment and Procedure

The experiment was conducted in an eye-tracking lab setting, ensuring controlled conditions. Each participant was individually welcomed to the lab. Due to the COVID-19 pandemic's limited in-person contact policy, participants were taught to use an intercom to communicate with the researcher in the monitoring room. After providing informed consent, each participant was seated at a specific distance (55-66 cm) from the computer screen. They were then given instructions and underwent calibration for the iMotions eye tracking screen recording settings. This setup ensured accurate data collection and a smooth experimental process.

In the email-only condition, participants were instructed to accurately classify as many emails as possible. In the email task with silent video condition, participants were informed that there would be videos playing on the side, similar to having an extra window open for watching videos. The locations of the email task area and the video window area were displayed along with the text instructions. Refer to Appendix A.1 for a visual illustration of the task window(s) for Email-only vs. Email+Video conditions. Importantly, in both conditions, participants were not explicitly informed about the presence of distracting images to prevent any undue attention to task-irrelevant elements.

Upon completion of all email classifications or after a 25-minute time limit, whichever occurred first, participants were directed to a post-experiment questionnaire. This questionnaire assessed various aspects, including self-reported emotions, engagement levels, task experiences, distractions, attention experiences, general cognitive flexibility, and propensity for multitasking. The full questionnaire can be found in Appendix D.

3.3.4 Dependent Variables

The current study used the following metrics to gauge the participants' task performance and experiences:

Task Performance: Calculated as the proportion of accurately categorized emails to the total number of emails. This metric reflected participants' reasoning abilities as they analyzed message content and decided on appropriate categories.

Sustained Attention: Measured as the proportion of eye gaze on the email task area relative to the total area. The total area includes four regions: (a) task-relevant area, (b) distracting image area, (c) video display area, and (d) blank empty region (Buetti & Lleras, 2016).

Engagement: Measured using a 13-item task engagement scale (Cronbach's $\alpha = .85$) developed by May, Gilson, and Harter (2004). This scale assessed self-reported physical, emotional, and cognitive engagement during the task. Note that for the email-only condition, the task was solely focused on email classification. In contrast, for the email plus video condition, participants were instructed to classify emails while videos played alongside, with both activities considered part of the overall task. This distinction in task definition allows us to examine how the addition of a secondary stimulus (video) influences engagement, performance, and attention management in a media multitasking context.

Distractor Filtering: Calculated as the proportion of eye location (oculomotor capture) on the distracting image area versus the entire eye gaze shortly after the onset of a new distracting image (Buetti & Lleras, 2016).

Perceived Task Experience: Adapted from Chinchanachokchai, Duff, and Sar (2015), this measure included a time perception question (1 = very slowly, 7 = very fast) and a task enjoyment question (1 = not at all, 7 = very much). The Cronbach's $\alpha = .81$.

3.3.5 Moderators

Cognitive Flexibility: Measured using a 12-item, 7-point general cognitive flexibility scale developed by Martin and Rubin (1995). The Cronbach's $\alpha = .83$.

Propensity to Media Multitasking: Assessed through a 2-item, 7-point Likert scale (Cronbach's $\alpha = .75$) that asks participants about their frequency of multitasking in general and their simultaneous use of multiple media. The scale ranges from "never" to "all the time" (Duff, Yoon, Wang, & Anghelcev, 2014). Note that there is currently no standardized approach to measuring the self-reported level of media multitasking. While some studies (e.g., Ophir, Nass, & Wagner, 2009) have used measures that assess the use of a combination of 12 media, others (e.g., Jeong & Fishbein, 2007; Sanbonmatsu et al., 2013) have employed different combinations of media. However, these exhaustive lists of questions containing over 100 items may be less suitable for heavy multi taskers, who can have difficulty maintaining focus on single tasks. In contrast, the 2-item multitasking behaviors assessment measurement used by Duff et al. (2014) is short in length and captures the variance in media multitasking behaviors without causing attention focus issues for multitaskers. Refer to Appendix A.4 for a full list of measures.

3.4 Results

3.4.1 Task Engagement

Task engagement was assessed across three dimensions: physical, emotional, and cognitive (May, Gilson, & Harter, 2004), and were averaged to create an overall engagement score (Cronbach's $\alpha = .89$). An analysis of variance (ANOVA) was conducted with the video stimuli condition as a between-subjects factor on task engagement. The results showed no significant effect of video stimuli on task engagement, $F(1, 72) = 0.029$, $p = 0.865$. Participants in the video condition ($M = 4.00$, $SD = 1.13$) and the non-video condition ($M = 4.03$, $SD = 1.13$) reported similar levels of engagement. This indicates that the presence or absence of video stimuli did not significantly impact task engagement.

Furthermore, the low R-squared value of 0.001 and the observed power of 0.053 suggest that the presence or absence of video stimuli explained less than 0.1% of the variance in task engagement, and our test had limited power to detect an effect, if one existed. Therefore, this study does not provide evidence supporting the impact of video stimuli on task engagement. Consequently, the hypothesis (H1.1) stating that higher engagement is associated with video presence is not supported. See Table 3.1.

Table 3.1 Test of Between-Subjects Effects Dependent Variable: Task Engagement

Source	df	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b^]
Corrected Model	1	0.029	0.865	0.001	0.029	0.053

3.4.2 Task Performance

The mean email performance accuracy for each participant in each condition was calculated to assess the participants' email performance. This accuracy metric was determined by computing the absolute difference between the perfect email performance and the participants' actual email performance. Consequently, a mean accuracy of zero indicates perfect performance, while a larger value signifies greater error.

To analyze the impact of video stimuli on email task accuracy, an ANOVA test was conducted with conditions (email task without video, email task with video) as a between-subject factor. The main effect of video stimuli on email task accuracy was not statistically significant, with $F(1, 72) = 0.533$, $p = 0.469$, and $p^2 = 0.011$. This suggests that the participants demonstrated relatively high accuracy in our task, and the manipulation of video stimuli did not significantly influence their email performance accuracy. Participants in the video condition (M = 97.5%, SD = 2.1%) and the non-video condition (M = 97.8%, SD = 2.1%) had similar accuracy levels.

3.4.3 Attention Management During the Task

(1) Attention to the email classification task: the proportion of time participants spent looking at the email classification task area was measured as the number of eye gazes on the task area divided by the total number of eye gazes captured during the task completion period. An analysis of variance (ANOVA) with condition as a between-subject factor revealed that the gaze ratio on the email area (Table 3.2) was significantly higher when no video was provided during the task period ($F(1, 72) = 9.10$, $p < 0.05$, $p^2 = 0.16$). This indicates that participants paid more attention to the email classification task when no video was present (M = 98.4%, SD = 4.0%) compared to when videos were displayed (M = 95.6%, SD = 5.0%), which does not support Hypothesis 1.2a (adding a perceptual task would positively influence attention to the task area). See Figure 3.2.

Table 3.2 Tests of Between-Subjects Effects Dependent Variable: Gaze Ratio on Email Task Area

Source	df	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power
Corrected Model	1	9.102	0.004	0.159	9.102	0.84

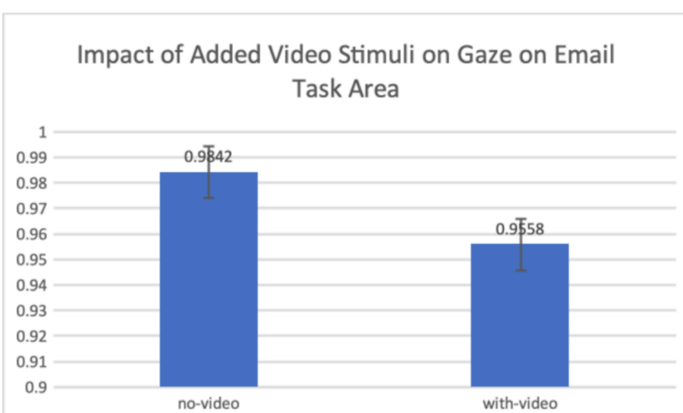

Figure 3.2 ANOVA Result for Ratio of Gaze on Email Task Area between Conditions

(2) Distractor filtering: The ANOVA test (Table 3.3) also showed a marginally significant difference in attention given to the distracting image, with participants noticing the distracting image more often when no video was present (M = 0.2%, SD = 0.1%) compared to when videos were displayed during the email task (M = 0.1%, SD = 0.1%; $F(1, 72) = 3.05$, $p = 0.08$, $p^2 = 0.10$). This finding aligns with Hypothesis 1.2b, which suggested that adding another perceptual media task would positively influence filtering of distracting information.

Table 3.3 Tests of Between-Subjects Effects Dependent Variable: Attention to Images

Source	df	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power
Corrected Model	1	3.053	0.087	0.056	3.053	0.403

3.4.4 Moderator Effects: Cognitive Flexibility and Multitasking Propensity

Cognitive flexibility and media multitasking propensity were examined as moderators in the study. First, cognitive flexibility was analyzed as the moderator, with video conditions serving as the between-subject variable. The results revealed a marginally significant moderation effect on email task performance (Table 3.4). Specifically, in the with-video condition, higher cognitive flexibility was associated with decreased performance (from 0.98 to 0.96). In contrast, in the non-video condition, performance remained constant across all levels of cognitive flexibility $F(1, 66) = 3.52$, $p = 0.07$). This suggests that while video does not affect individuals with lower or medium cognitive flexibility, it may slightly hinder the performance of those with higher cognitive flexibility. See Figure 3.3

Table 3.4 Moderator Effects of Cognitive Flexibility on Email Performance Between Conditions

Cognitive Flexibility Moderates Email Performance Between Conditions

Condition	lower cognitive flexibility	medium cognitive flexibility	higher cognitive flexibility
no-video	0.98	0.98	0.98
with-video	0.98	0.97	0.96

Test(s) of highest order unconditional interaction(s):

	R2-chng	F	df1	df2	p
X*W	.07	3.52	1.00	46.00	.07

Focal predict: video conditions (X) Moderator: cognitive flexibility (W)

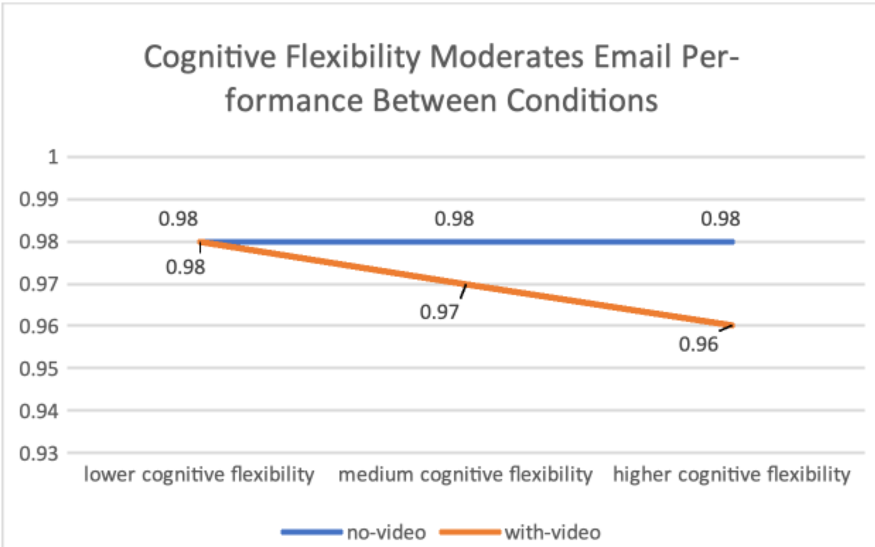

Figure 3.3 Moderating Effect of Cognitive Flexibility on Email Performance Between Conditions

Next, propensity to media multitask was analyzed as the moderator. The results (Table 3.5) indicated a significant moderation effect on overall engagement (F (1, 72) = 5.66, $p < 0.05$). Participants with lower multitask propensity benefited more from the presence of a video in terms of engagement compared to those with higher multitask propensity. As multitask propensity increased, the positive impact of video on engagement decreased, becoming detrimental for individuals with the highest propensity to multitask. This finding supports Hypothesis 1.4, which predicted that individuals with a lower propensity to multitask would benefit more from the video's potential "corralling" function, enhancing overall engagement. See Figure 3.4.

Table 3.5 Multitask Propensity Moderates Overall Engagement Between Conditions

Condition	lower mmt propensity	medium mmt propensity	higher mmt propensity
no-video	3.46	3.92	4.37
with-video	4.07	3.97	3.86

Test(s) of highest order unconditional interaction(s):

	R2-chng	F	df1	df2	p
X*W	.10	5.66	1.00	49.00	.02

Focal predict: video conditions (X) Moderator: multitask propensity (W)

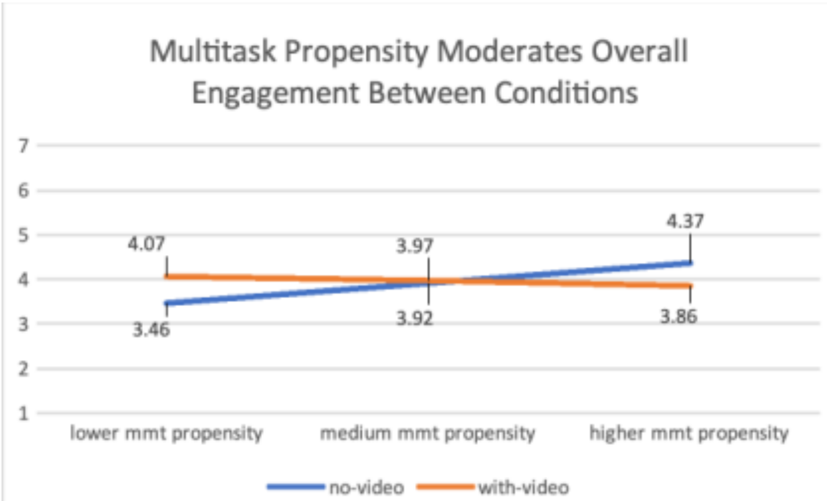

Figure 3.4 Moderating Effect of Multitask Propensity on Task Engagement Between Conditions

3.4.5 Subjective Experience

Subjective evaluations of the task experience were collected through self-reported measures of arousal, valence, task enjoyment, and time perception. However, no significant differences were found between the video and non-video conditions for any of these measures (see Table 3.6 for ANOVA results). This indicates that the presence or absence of video stimuli did not significantly influence participants' subjective experiences of the task.

Table 3.6 ANOVA Results for Self-reported Task Experience Measures

Measure	Source	Sum of Squares	df	Mean Square	F	Sig.
SAM	Between Groups	0	1	0	0	0.988
	Within Groups	66.272	51	1.299		
	Total	66.273	52			
task enjoyment	Between Groups	0.117	1	0.117	0.048	0.828
	Within Groups	125.128	51	2.453		
	Total	125.245	52			
time perception	Between Groups	2.168	1	2.168	0.672	0.416
	Within Groups	164.587	51	3.227		
	Total	166.755	52			
motivation to complete task	Between Groups	0.44	1	0.44	0.214	0.646
	Within Groups	105.031	51	2.059		
	Total	105.472	52			
feel of boredom	Between Groups	1.497	1	1.497	0.463	0.499
	Within Groups	165.031	51	3.236		
	Total	166.528	52			
feel of interestingness	Between Groups	0.269	1	0.269	0.113	0.738
	Within Groups	121.014	51	2.373		
	Total	121.283	52			

3.4.6 Results Summary

Study 1 investigated the impact of video stimuli on task engagement, performance, attention management, and subjective experience. The key findings are summarized in Table 3.7. Contrary to Hypothesis 1.1, a secondary task - video stimuli - did not significantly impact task engagement. Participants focused more on the email task without videos, failing to support Hypothesis 1.2a. However, participants were slightly more distracted by images without videos, supporting Hypothesis 1.2b. Video stimuli did not significantly affect task performance accuracy, contrary to Hypothesis 1.3.

The study also examined the moderating effects of cognitive flexibility and multitasking propensity. Supporting Hypothesis 1.4, participants with lower multitasking propensity benefited more from video presence for task engagement, while those with higher propensity found videos detrimental. Video presence had no effect on participants with lower cognitive flexibility but slightly hindered performance for those with higher flexibility. Subjective measures revealed no significant differences across conditions, indicating that video stimuli did not significantly impact task engagement or accuracy.

Refer to Appendix A.5 for a descriptives table with means and standard deviations for all variables.

Table 3.7 Summary of Hypotheses and Results for Study 1

Hypothesis	*Result*
H1.1: Video stimuli will increase task engagement.	Not supported
H1.2a: Video stimuli will increase attention to the email task.	Not supported
H1.2b: Video stimuli will reduce attention to distracting images.	Supported
H1.3: Video stimuli will have a positive effect on task performance accuracy.	Not supported
H1.4: Lower multitasking propensity will benefit more from video for engagement.	Supported
RQ Cognitive flexibility: Video will have no effect on low flexibility but hinder performance for high flexibility.	Supported

3.5 Discussion

3.5.1 Impact of Video Stimuli on Task Engagement & Performance

The present study revealed no significant influence of video stimuli on task engagement or task performance accuracy. The relationship between engagement and performance is not always straightforward. While it is intuitive to assume a positive correlation between task engagement and performance, other factors can intervene and affect this relationship. For instance, an individual may perform a task efficiently with minimal engagement if it is a routine task or requires minimal effort. Conversely, a person may be highly engaged but not perform well due to a lack of necessary knowledge or skills. Therefore, task engagement might act more as a moderator that alters the strength or direction of the relationship between video stimuli presence and task performance. In the context of the current study, the email classification task could be considered a repetitive operation that does not necessitate full engagement for task completion. This might explain why no significant effect was observed on task performance accuracy. The relatively high accuracy scores across all participants further support the notion that the email classification task was not particularly challenging and could be completed with minimal engagement.

3.5.2 Influence on Attention Management

The study did not find a direct increase in attention to the email task when video stimuli were present. However, the presence of video stimuli did moderate attention towards distractions, revealing an interesting effect on attention management.

Based on these findings, this dissertation proposes a novel concept that I term "attention corralling" to describe this observed phenomenon. The attention corralling function refers to how secondary tasks, in this case video stimuli, can gather and focus an individual's cognitive resources on the current task(s), reducing the likelihood of distraction by task-irrelevant stimuli or mind wandering. This concept, which was developed from the experimental results, is distinct from but complementary to existing theories on attention and multitasking.

For the general participants, video stimuli helped streamline focus and prevent potential interference from other task-irrelevant stimuli, such as distracting images. This aligns with Load Theory (Lavie, 1995), which suggests that when perceptual load is high (in this case, with the introduction of video stimuli), attentional resources are more fully occupied, leaving fewer resources available to process other irrelevant distractions.

While Load Theory explains how perceptual load can affect distractor processing, this attention corralling concept specifically addresses how secondary tasks can be strategically used to enhance focus on primary tasks. In the current study, the video stimuli seemed to serve this corralling function by helping participants resist distractions, even if it didn't directly increase attention to the email task.

Although the study did not directly observe improved engagement and performance with video presence, it highlights the attention corralling function of video stimuli in protecting participants from task-irrelevant distractions. This defensive role creates an attentional boundary that prioritizes the primary task over external distractions. As a result, while the perceptual media stimuli might not directly enhance engagement or performance, its role as a cognitive filter provides an indirect method to potentially improve task performance by minimizing disruptions.

This attention corralling effect represents a novel way of understanding how secondary tasks can be used to manage attention and potentially enhance performance in multitasking scenarios. Further research is needed to fully explore the implications and applications of this concept across various tasks and contexts.

3.5.3 Individual Differences and Multitasking Propensity

The study's findings reveal an intriguing dynamic between individual cognitive traits, multitasking propensity, and the impact of video stimuli on task engagement. Participants with higher cognitive flexibility and a tendency to multitask were negatively affected by the presence of video stimuli, while those with lower flexibility and a lower propensity to multitask benefited from it. It appears as though the video stimuli acted as an "attentional shield," influencing participants' performance in different ways. For individuals with lower cognitive flexibility, the presence of video stimuli had no significant impact on their task performance. However, those with higher flexibility experienced a slight decline in performance when videos were present. Interestingly, participants who were less inclined to multitask actually benefited from video presence in terms of task engagement. On the other hand, those who tended to multitask found video stimuli detrimental to their task focus. One possible explanation for this finding is that the video stimuli used in the study were not sufficiently arousing or engaging for frequent multitaskers, who may require more stimulating content to maintain their interest and engagement. In contrast, for individuals with a lower propensity to multitask, the tranquil nature scenes provided a pleasant background that helped maintain their focus on the primary task without causing excessive distraction.

For individuals with higher cognitive flexibility, the video stimuli may have had an unintended consequence. While they may excel at rapidly switching between tasks or stimuli, the presence of video stimuli occupied a significant portion of their attentional resources. This made it challenging for them to perform optimally on their primary email classification task, especially when the video content did not offer transferable knowledge or insights to facilitate the task.

In contrast, for participants with lower cognitive flexibility or a lower propensity to multitask, the video stimuli proved beneficial. These individuals tend to focus on one task or stimulus at a time, and the video stimuli helped channel their attention away from other potential distractions, allowing them to concentrate better on the primary task.

3.5.4 Limitations

The current study had several limitations in its design. Firstly, the nature of the video stimuli used may not have provided transferable insights or knowledge that could benefit participants, especially those with high cognitive flexibility. Previous research (Wang et al., 2014) suggests that the relevance of stimuli plays a crucial role in influencing task performance. Another consideration is the absence of clear instructions regarding the expected function of the video stimuli. Without a predetermined expectation, participants might have had varying perceptions of the video's role, leading to differences in engagement and task performance. Some participants may have considered the video a secondary distractor, while others may have treated it as an equally significant task.

Given these considerations, a subsequent study investigated the interplay between primary tasks and secondary stimuli, to delve deeper into the intricacies of attention management in mediated environments. For Study 2, participants were guided to perceive the video stimuli either as complementary resources that augment the primary task experience or as competing resources that vie for their attention. This approach not only aims to elucidate the role of the secondary stimuli but also seeks to uncover strategies for effective attention management. While Study 1 provided valuable insights into the impact of video stimuli on task performance, engagement, and attention allocation, a more refined examination of stimulus relevance and participant perception is crucial for a comprehensive understanding of this phenomenon.

CHAPTER 4: STUDY 2 COMPLEMENTARY VS. COMPETITIVE: HOW PERCEIVED TASK RELATIONSHIPS INFLUENCE TASK PERFORMANCE AND ENGAGEMENT

4.1 Overview

Prior research indicates that introducing an additional stimulus or task can enhance an individual's subjective satisfaction (e.g., Rosen, Carrier, & Cheever, 2013; Chinchanachokchai, Duff, & Sar, 2015). Study 1 provided initial evidence that even when resources are shared, a secondary task can improve the filtering of distracting stimuli. Expanding on this, Study 2 explores how our perception of the relationship between tasks (complementary versus competitive) influences performance, attention, and engagement during multitasking.

4.2 Background and Research Question

Study 1 explored the influence of adding a task motivated by psychological satisfaction on objective performance and attention management in a digital environment. It examined how adding video stimuli interacted with task execution and attention control. While the expected correlation between video and task engagement wasn't observed, video stimuli did reduce attention towards peripheral distractions. This suggests that video can act as a filter, focusing attention on the primary task and the video itself.

These findings align with Lavie's (2004) load theory, implying that a secondary task or stimulus can capture attention if it shares resources with the primary task. However, previous media multitasking research often shows that a secondary element can impair overall performance. Our explanation for this discrepancy is twofold. For example, Segijn et al. (2017) found that media multitasking during a television program led to decreased brand memory and reduced counterarguing. Similarly, Kazakova et al. (2016) demonstrated that media multitasking while viewing an advertisement resulted in lower ad recall and recognition. The explanation for this discrepancy is twofold.

Studies like Srivastava (2013) and Cain et al. (2016) employed cognitively demanding secondary tasks that intentionally competed for resources with the primary tasks, leading to disruption in performance on measures like reading comprehension and sustained attention. Secondly, the experimental setting itself might have influenced participants' perception, creating the mindset that both tasks compete for resources and need equal focus. For instance, in a study by Srivastava (2013), participants were asked to read an article while simultaneously listening to a radio broadcast, with both tasks being framed as equally important. This framing might have led participants to perceive the tasks as competing for their attention and cognitive resources.

4.2.1 Complementary Vs. Competitive Tasks: Objective Resource Allocation

Prior research has categorized tasks based on their compatibility, differentiating between complementary and competitive tasks. *Complementary tasks* minimally interfere with each other's performance, while *competitive tasks* require overlapping cognitive resources and cause interference. Traditionally, tasks requiring different resources (e.g., listening to music while reading) are considered complementary, while those requiring similar resources (e.g., watching TV while doing homework) are competitive and prone to interference (Multiple Resource Theory, MRT: Wickens, 2002). The multiple resource theory posits that performance is better for complementary tasks due to several reasons:

1. Modality effects: Tasks using the same modality (e.g., visual) compete for resources within that channel, limiting availability for each task.

2. Limited central resources: When both tasks require central processing (e.g., memorizing information), the limited resources must be divided, potentially hindering performance.

3. Cognitive cost of switching: Switching between tasks consumes additional central resources for execution. The switch itself and the time to resume the prior task can lead to performance decrements in both tasks.

Wickens (2002) suggests that optimal multitasking performance occurs with complementary tasks that don't compete for the same resources.

While the Multiple Resource Theory focuses on the cognitive aspects of task competition and complementarity, another important factor to consider is the role of arousal in task performance. The relationship between arousal and performance is described by the Yerkes-Dodson law, which states that performance increases with physiological or mental arousal, but only up to a point. When levels of arousal become too high, performance decreases (Yerkes & Dodson, 1908). This inverted-U relationship suggests that moderate levels of arousal induced by a competitive framing may improve task engagement and performance.

In the context of complementary versus competitive tasks, the perceived relationship between tasks may influence arousal levels, which in turn affects performance. A competitive framing might increase arousal, potentially leading to improved engagement and performance if the arousal level remains moderate. However, if the competitive framing induces too much arousal, it could lead to decreased performance. This theoretical framework provides an additional perspective for understanding how different task relationships might influence study outcomes through changes in arousal levels.

4.2.2 Modality Switching in Multitasking

The interplay between competition and complementarity in multitasking is complex. While the modality effect suggests reduced interference for tasks using distinct channels (e.g., listening to music while reading), research by Helleberg and Wickens (2003) presents a different perspective. Their study found that visual communication displays were less disruptive to pilots performing a flight simulation task compared to auditory instructions. This is because pilots rely heavily on vision for flight control, and visual communication minimizes the need to switch attention between the cockpit and external sources. Conversely, auditory instructions require a shift in attention, leading to performance decline. A more recent study by Wiradhany and Koerts (2019) investigated the effects of media multitasking on learning performance in a lecture setting. In their experiment, participants watched a video lecture while either taking notes (single task) or taking notes and reading text on a tablet (multitasking). The results showed that participants in the multitasking condition performed worse on a comprehension test compared to those in the single task condition. The authors argued that the need to switch attention between the lecture and the additional reading task led to increased cognitive load and decreased learning performance. These examples highlight an interesting trade-off: using separate channels can reduce interference, but switching between modalities can incur a cost that outweighs the benefit.

4.2.3 Beyond Objective Resource Competition: Subjective Evaluation in Multitasking

Several studies have explored the subjective experiences associated with media multitasking, such as enjoyment, boredom, and time perception. For instance, Chinchanachokchai et al. (2015) found that media multitasking was positively correlated with enjoyment. Similarly, Kononova and Chiang (2015) showed that individuals engage in media multitasking to satisfy various needs, including information seeking, social interaction, and enjoyment. These studies suggest that people's subjective experiences play a role in their media multitasking behavior.

However, these studies have some limitations. First, they primarily focus on the outcomes of media multitasking rather than how subjective perceptions influence the multitasking process itself. Second, they do not directly compare the effects of subjective perceptions on different types of media multitasking scenarios (e.g., complementary vs. competitive tasks). As Poplawska et al. (2021) point out in their review, there is a need for more research on the role of subjective factors, such as motivation and task relevance, in shaping media multitasking behaviors and outcomes.

The current study addresses these limitations by directly manipulating participants' perceptions of task relationships (complementary vs. competitive) and examining how these perceptions influence their engagement, performance, and attention management in a media multitasking context. This approach allows us to better understand the role of subjective factors in the media multitasking process, beyond just the outcomes.

Study 1 demonstrated that even tasks sharing the same resource channel (e.g., visual processing) can still be somewhat beneficial under certain conditions. This raises the following questions: Which factors determine whether a complementary relationship between tasks simply avoids hindering performance, or actually facilitates it? Is there a tipping point where tasks transition from interfering to complementary, regardless of their objective nature? These questions lead to the following research question in our Study 2:

Research Question: How does subjective perception of task relationship (complementary vs. competitive) influence performance, attention, and engagement during multitasking?

4.3 Hypotheses

Previous research demonstrates that objectively competitive tasks (those causing executive control conflicts, sharing a modality, or requiring irrelevant information processing) lead to performance impairment due to resource allocation challenges (e.g., Wiradhany & Nieuwenstein, 2017; Scharinger et analysis., 2017). However, despite this objective decline, multitasking often provides users with a sense of subjective satisfaction (e.g., Kononova & Chiang, 2015). Furthermore, this subjective experience may even alter perceptions, such as time perception (e.g., Chinchanachokchai, Duff, & Sar, 2015).

The current study posits that the subjective perception of task competitiveness might influence how individuals allocate attentional resources, ultimately affecting performance. Limited research has explored this concept from a subjective perspective. Specifically, how an individual's perception of tasks being related or independent influences their resource allocation strategies remain under-investigated. For instance, if individuals perceive two visually demanding tasks as highly related (e.g., summarizing a presentation while taking notes), might they be less prone to resource competition despite the shared modality?

It is also inferred that the subjective perception of task relationships can influence resource allocation, attention switching, motivation, and engagement, ultimately impacting performance outcomes. Specifically:

1. Influence on Resource Allocation. Subjective perception of complementary versus competitive tasks may alter individuals' resource allocation in advance. For example, individuals may allocate more attentional resources to tasks they perceive as complementary and intentionally restrain resource allocation to tasks perceived as competitive.

2. Influence on Attention Switching. Subjective perception of task relationships may also

influence attention switching. Perceiving tasks as complementary might encourage individuals to adopt a more integrated approach, potentially reducing switching costs and improving efficiency.

3. Influence on Motivation and Engagement. The perceived relationship between tasks may alter individuals' motivation and engagement. When individuals perceive tasks as related, they might find the substitute tasks more engaging, leading to more attention allocation to both tasks.

These propositions are consistent with the cognitive load theory (Sweller, 1994), which suggests that working memory capacity is not fixed and can be influenced by factors like motivation and cognitive flexibility. They are also supported by findings from studies like Szumowska et al. (2018), which showed that subjective task difficulty and motivation can impact dual-task performance.

Based on the above discussion, the following hypotheses are offered for Study 2:

Hypothesis 2.1: Task Relationship Effects:

1) A competitive task relationship will lead to lower performance, shorter sustained attention, and worse distractor filtering compared to a complementary relationship.

2) A complementary task relationship will lead to higher task engagement and better perceived task experience.

Hypothesis 2.2: Moderating Effects of Task Engagement:

Task engagement will moderate the relationship between task relationship and task performance, sustained attention, and distractor filtering. Specifically, the effect of task relationship on these outcomes will be stronger for individuals with higher levels of task engagement.

Hypothesis 2.3: Moderating Effects of Cognitive Flexibility:

Competitive relationships may demand resources from similar pools (e.g., working memory), leading to competition and potential interference (Kahneman, 1973). Individuals with higher cognitive flexibility (Diamond, 2013; Miyake & Friedman, 2012) can adapt strategies to mitigate this.

The current study hypothesizes that the negative effects of a competitive relationship on engagement, performance, and sustained attention will be stronger for individuals with lower cognitive flexibility.

Hypothesis 2.4: Cognitive Flexibility and Distractor Interference:

Study 1 showed that individuals with lower cognitive flexibility benefitted from the "shield effect" of a secondary task in distractor filtering. However, with competitive tasks, individuals might perceive tasks as interfering, potentially increasing distraction. The current study hypothesizes that the distractor interference effect will be stronger for individuals with lower cognitive flexibility in a competitive task relationship.

In addition to the hypotheses mentioned earlier, Study 2 poses an open question regarding media multitasking propensity. While research on habitual multitaskers presents mixed results, some argue that they excel in preferred multitasking environments (Ophir et al., 2009). and exhibit better performance when allowed to multitask (Poposki & Oswald, 2010). Others suggest that heavy media multitaskers face challenges in task switching and suppressing distractions (Ophir et al., 2009; Sanbonmatsu et al., 2013), show worse performance on task-switching and working memory tasks (Minear et al., 2013), and are more susceptible to interference from irrelevant stimuli (Cain & Mitroff, 2011). However, some studies found no significant differences between heavy and light media multitaskers in cognitive control abilities (Alzahabi & Becker, 2013; Minear et al., 2013). This leads to our final research question:

RQ1: To what extent does media multitasking propensity moderate the effects of a secondary task on engagement, performance, and attention management?

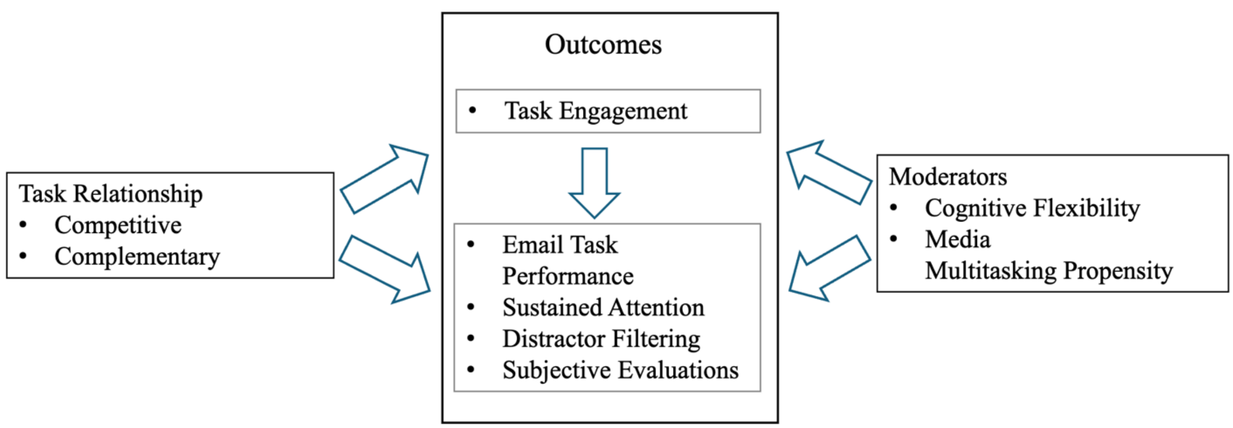

Figure 4.1 Study 2 Framework

4.4 Method

4.4.1 Participants

The research protocol was approved by the University of Illinois Institutional Research Board (IRB-20810). A total of 95 community members, including students, faculty, staff, and family members, participated in the study at a Midwestern university. Each participant received a ten-dollar Amazon gift card as an incentive for their participation. This change in the sample pool was made to generalize the findings to a broader population beyond university undergraduate students. The sample size was determined a priori using G*Power, with a power of .80 and an effect size (eta-squared) of .40. This analysis indicated that a sample size of 95 would be sufficient.

4.4.2 Between-Subjects Design

Building on Study 1, this study employed a between-subjects design to investigate how the perceived relationship between tasks (complementary vs. competitive) influences performance. The independent variable is task relationship, manipulated through instructions framing the video stimuli as either complementary or competitive to the email classification task. Both conditions utilized the same webpage design, email tasks, and video clips.

The manipulation was achieved by presenting participants with different instructions. In the complementary condition, instructions framed the video clips as supporting the email task (e.g., "The videos provide additional information relevant to the emails you will be classifying"). Conversely, the competitive condition presented the video clips as competing for attention (e.g., "The videos are unrelated to the email task and may distract you").

To ensure clear understanding, instructions were provided in both written and spoken format (researcher via intercom). Following instructions, participants completed the email classification task with the video clips auto-playing on the same screen. Afterward, all participants completed a post-experiment questionnaire assessing their experience and included a manipulation check to verify the effectiveness of the instructions (complementary vs. competitive). Participants were thanked and compensated for their participation, regardless of completing the entire study. Refer to Appendix B.1 for task relationship manipulation instructions and manipulation check measures.

4.4.3 Dependent Variables and Moderators

Following Study 1, this study utilized the same dependent variables to assess task performance (accuracy), sustained attention (eye gaze on task area), engagement (13-item scale), distractor filtering (eye location on distracting images), and perceived task experience (time perception and enjoyment). Additionally, moderators of cognitive flexibility (12-item scale) and propensity to media multitasking (2-item Likert scale) were measured to explore individual differences that might influence the effects of perceived task relationship.

4.4.4 Manipulation Check Complementary vs. Competitive Measure

The study employed two modified measures to assess participants' perceptions of the video stimuli: perceived usefulness and perceived competitiveness.

Perceived Usefulness: A 6-item adaptation of Davis' (1989) perceived usefulness of job/work scale (Cronbach's alpha = .98) was used. The original "job/work" reference was replaced with "videos" in the items (e.g., "The videos helped me work more quickly on the email task”). Participants rated their agreement with each item on a 7-point scale ranging from “strongly disagree” to “strongly agree.” The average score across the 6 items served as the perceived usefulness score.

Perceived Competitiveness: A 7-item adaptation of Li et al.’s (2002) intrusiveness of advertisement scale (Cronbach’s alpha = .91) was used. Similar to the usefulness measure, “advertisement” was replaced with “videos” in the items (e.g., “The videos were distracting while I completed the email task”). Participants rated their agreement with each item on a 7-point scale ranging from “strongly disagree” to “strongly agree.” The average score across the 7 items served as the perceived competitiveness score.

4.4.5 Manipulation Check

The complementary manipulation check was examined by an analysis of variance (ANOVA). The result revealed a significant main effect of task relationship on self-reported feel of complementary $F(1, 92)=3.90$, $p<.05$, such that participants in the complementary group ($M=2.92$, $SD=1.12$) reported significantly higher perceived usefulness of the videos compared to those in the competitive group ($M=2.38$, $SD=1.15$).

The competitive manipulation check was examined by an analysis of variance (ANOVA). The result revealed a marginally significant main effect of task relationship on self-reported feel of intrusiveness $F(1, 92)=3.63$, $p=.06$, such that participants in the competitive group ($M=3.90$, $SD=1.39$) reported marginally significantly higher perceived intrusiveness of the videos compared to those in the complementary group ($M=3.33$, $SD=1.18$).

4.5 Results

4.5.1 Task Engagement

Engagement, measured across physical, emotional, and cognitive dimensions (May et al., 2004), showed an unexpected result. An analysis of variance (ANOVA) revealed a significant main effect of task relationship on engagement ($F(1, 89) = 4.00$, $p < .05$, power = .51). However, participants in the competitive condition reported higher engagement (mean = 4.36, SD=1.05) compared to the complementary condition (mean = 3.96, SD=0.95). This finding suggests that Hypothesis 1, predicting lower task engagement for the competitive condition, is not supported. See Figure 4.2.

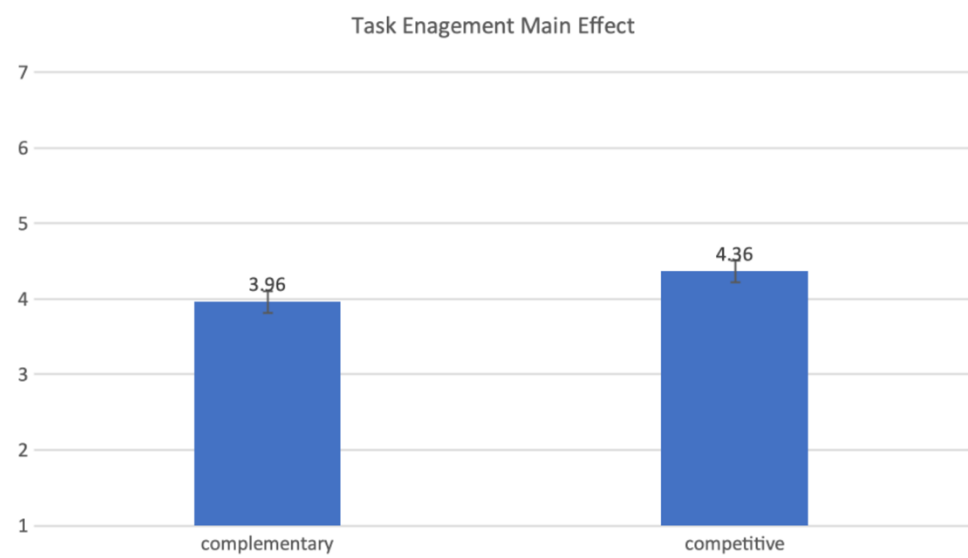

Figure 4.2 ANOVA Result for Task Engagement Between Conditions

4.5.2 Email Task Performance

The study examined whether perceived task relationship (complementary vs. competitive) impacted performance on the email classification task. An ANOVA (Table 4.1) revealed no significant main effect of task relationship on accuracy ($F(1, 89) = 0.42$, $p = 0.52$). This suggests that participants maintained relatively high accuracy in both the complementary condition (M = 96.7%, SD = 3.6%) and the competitive condition (M = 97.1%, SD = 2.2%). Therefore, Hypothesis 2.1, predicting lower performance in the competitive condition, was not supported.

Table 4.1 ANOVA Results for Email Performance Accuracy Between Conditions:

Source	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.000	1	.000	.418	.520
Within Groups	.078	89	.001		
Total	.079	90			

To further explore performance, the current study also examined how accuracy changed throughout the task. An inverted U-shaped pattern was found, with accuracy increasing as participants “got into” the task flow, followed by a decline as attention waned. The sequence of presentation for these three groups was randomized for each participant. This division allowed us to analyze performance across early, middle, and late stages of the task, regardless of the specific order in which participants encountered the email groups. A mixed-methods general linear model (GLM) revealed a significant main effect of time on accuracy (F(2, 89) = 6.10, p < .05, See Table 4.2). Consistent with expectations, participants exhibited an inverted U-shaped performance trajectory, demonstrating the lowest accuracy at the beginning, improvement in the middle, and a gradual decline towards the end, regardless of the perceived task relationship (Figure 4.3).

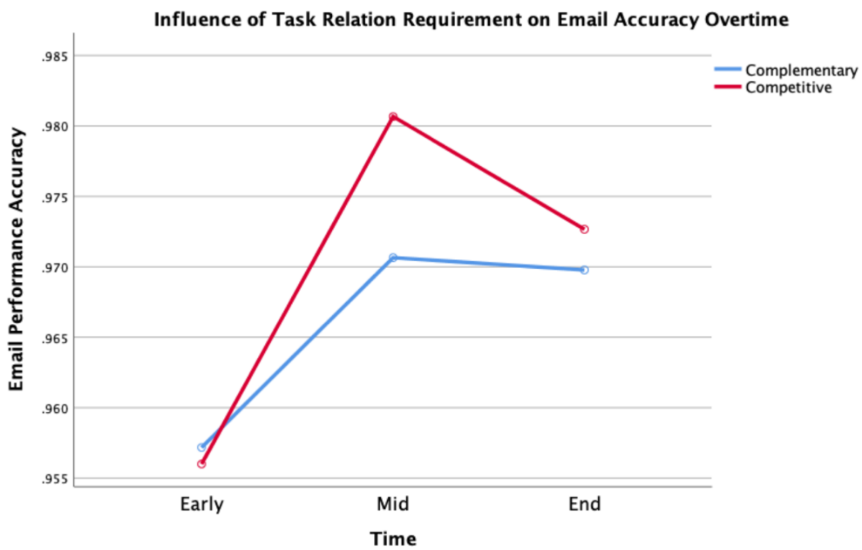

Figure 4.3 Influence of Task Relation on Email Task Performance Overtime (first 1/3 of email tasks, middle 1/3, and the last 1/3 of email tasks)

Table 4.2 Influence of Task Relation on Email Task Performance Overtime Multivariate Tests

Effect	F	Sig.
time	5.151	.008
time * Cond	.485	.617

4.5.3 Attention Management During the Task

This study examined how perceived task relationship influenced participants' attention allocation during the email classification task.

Sustained Attention: The current study measured sustained attention by calculating the proportion of eye gaze on the email task area relative to total gaze captured. An ANOVA revealed a surprising result. Participants in the competitive condition (M = 85.8%, SD = 10.3%) exhibited higher sustained attention compared to the complementary condition (M = 78.3%, SD = 13.7%) (F(1, 72) = 17.97, p < .01, power = .98). This result suggests that participants allocated more attention to the email task when they perceived the video stimuli as competing for resources, rejecting Hypothesis 2.1 which predicted lower attention in the competitive condition.

Distractor filtering: The current study measured distractor filtering by calculating the proportion of eye gaze directed toward the distracting image. The ANOVA revealed another unexpected result. Participants in the complementary condition (mean = 1%, SD = 1.2%) looked at the distracting image more often than those in the competitive condition (mean = 0.2%) ($F(1, 72) = 14.16$, $p < .01$, power = .96, SD = 0.3%). This finding suggests that participants were less likely to be distracted by the image when they perceived the videos as complementary to the email task, again rejecting Hypothesis 1, which predicted worse distractor filtering in the complementary condition.

4.5.4 Task Engagement

The analysis suggests a more nuanced relationship between perceived task relationship, task engagement, and performance than originally hypothesized, which predicted that a complementary task relationship would lead to higher task engagement that positively impact performance compared to a competitive relationship. A PROCESS mediation analysis was conducted to explore whether task engagement mediates the effect of perceived task relationship on email classification performance. The analysis revealed a small but slightly significant amount of variance in task performance (R squared = 0.06, $p = 0.10$). Both task relationship ($p<.05$) and task engagement ($p<.05$) have direct effects on performance accuracy, meaning higher levels of task engagement is associated with better performance, and that the competitive relationship between email task and video creates better email classification performance. See Table 4.3.

Table 4.3 Test of Influence of Complementary vs. Competitive Task Relation on Task Engagement

Condition	$engage_{low}$	$engage_{median}$	$engage_{high}$
complementary	0.959	0.968	0.978
competitive	0.977	0.972	0.966

Product terms key: Int_1 : Condition x engagement
Test(s) of highest order unconditional interaction(s):

	R2-chng	F	df1	df2	p
X*W	.0580	5.3957	1.0000	87.0000	.0225

Unexpected Findings:

Main Effect of Task Relationship: Contrary to Hypothesis 2.1, participants in the competitive condition showed better performance than those in the complementary condition.

Moderating Effect of Engagement: the effect of task relationship on performance was moderated by engagement. At low levels of engagement, participants in the competitive condition demonstrated significantly higher accuracy compared to the complementary condition. However, as engagement increased, performance in the complementary condition improved, while performance in the competitive condition remained stable (see Figure 4.4). This suggests a potential tipping point where the benefits of perceived task synergy emerge as engagement increases.

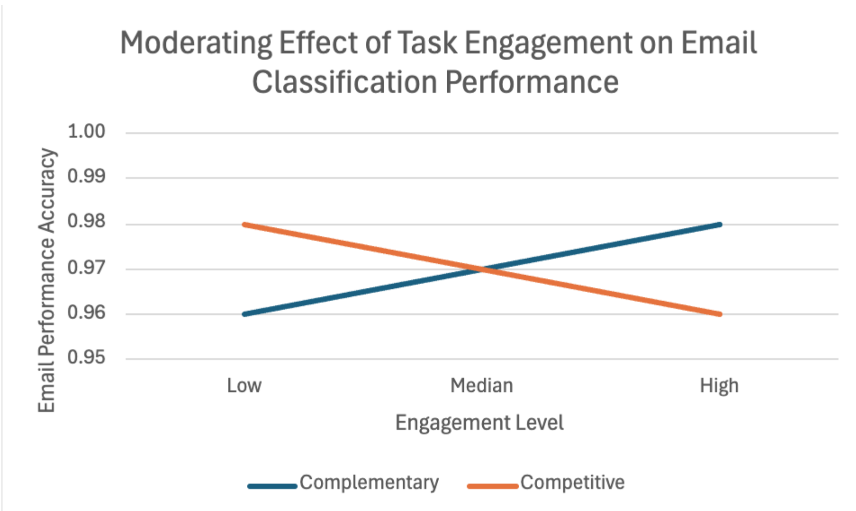

Figure 4.4 Moderating Effect of Task Engagement on the Relationship Between Task Relationship and Email Classification Performance

4.5.5 Subjective Evaluation of Task Experience.

Subjective evaluation of task experience was measured by the self-reported SAM, task enjoyment, motivation to complete the task, and time perception.

Motivation to complete the task: Different from study 1, where no significant effect was observed, in the current study, participants in the competitive task relationship condition (mean = 5.96, SD=1.28) were significantly more motivated to complete the email task than those in the complementary task relationship condition (mean = 5.00, SD=1.54), $F(1,92)=10.50$, $p<.01$. This may explain the unexpected finding of better performance in the competitive condition such that participants in the competitive condition were motivated to not get distracted and it, in turn, helped them concentrate on the primary task performance.

Self-reported SAM. A marginally significant effect of task relationship on the 3-item self-reported SAM was observed ($F(1, 92)=3.69$, $p=0.058$). Specifically, participants in the competitive relationship condition (mean = 5.04, SD=1.10) reported themselves to be more aroused during the task than those in the complementary condition (mean=4.62, SD=1.00). See Figure 4.5.

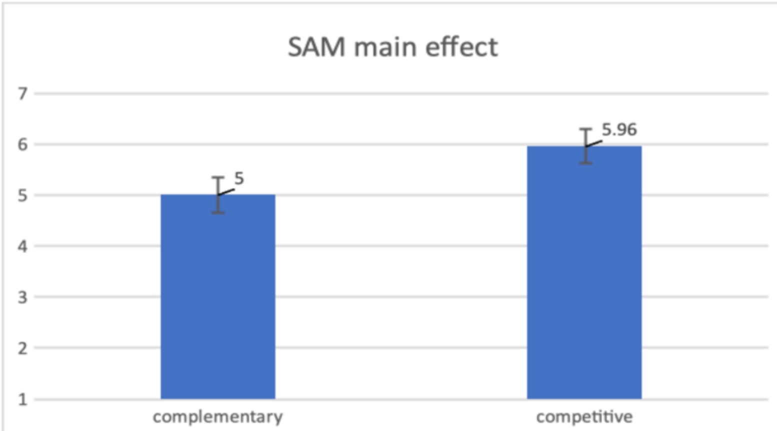

Figure 4.5 Influence of Task Relation on Self-Reported SAM

Media Multitask Propensity moderating effect. To address RQ1, the analysis explores the moderating effects of media multitasking propensity on the relationship between task conditions and our outcome variables. Both cognitive flexibility and multitask propensity were measured as moderators in the study. While no significant interactions between cognitive flexibility and other variables were found, the PROCESS model was run with propensity to multitask as the moderator and task relationship as the between-subject variable. Marginally significant interactions were found between propensity to multitask and perception of time, as well as task enjoyment.

Perception of time. The analysis explored how interactions between the propensity to multitask and task relationship influenced participants' perception of time. While the overall model fit is weak (R squared = 0.05, p=0.2), results showed a marginally significant interaction effect (p=0.08) between task relationship and propensity to multitask (Table 4.4). This indicates that the impact of task relationship on time perception depends on a participant's propensity to multitask. The result further suggests that in the competitive condition, participants with a higher propensity to multitask tend to perceive time passed slower. However, in the complementary task relationship condition, participants with a higher propensity to multitask tend to perceive time passing faster (Figure 4.6).

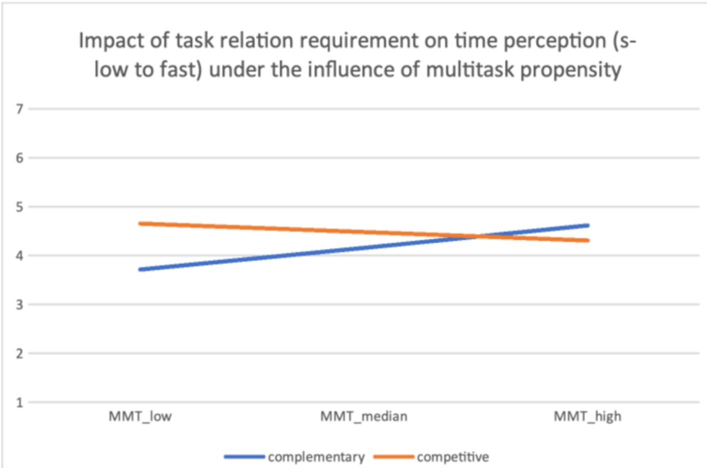

Figure 4.6 Multitask Propensity Moderates the Relationship Between Task Relation and Time Perception

Table 4.4 Multitask Propensity Moderating Effect on the Relationship Between Condition and Time Perception Test Statistics

Model Summary

R	R-sq	MSE	F	df1	df2	p
.2171	.0471	2.8550	1.4673	3.0000	89.0000	.2289

Product terms key: Int_1 : Condition x $Multitask_{Propensity}$
Test(s) of highest order unconditional interaction(s):

	R2-chng	F	df1	df2	p
X*W	.0338	3.1549	1.0000	89.0000	.0791

Task enjoyment. The analysis explored how interactions between propensity to multitask and task relationship influenced participants' self-reported enjoyment levels of the task. The overall model fit is not significant (R-squared=0.05, p=0.18). However, there's a marginally significant interaction effect (p=0.07) between task relationship and propensity to multitask (Table 4.5). Specifically, task enjoyment differences were highest when the propensity to multitask was low, such that participants who reported lesser intentions to multitask enjoyed the entire task much better in the competitive condition compared to those in the complementary task relationship condition. However, the enjoyment difference diminished as the multitask propensity increased (Figure 4.7).

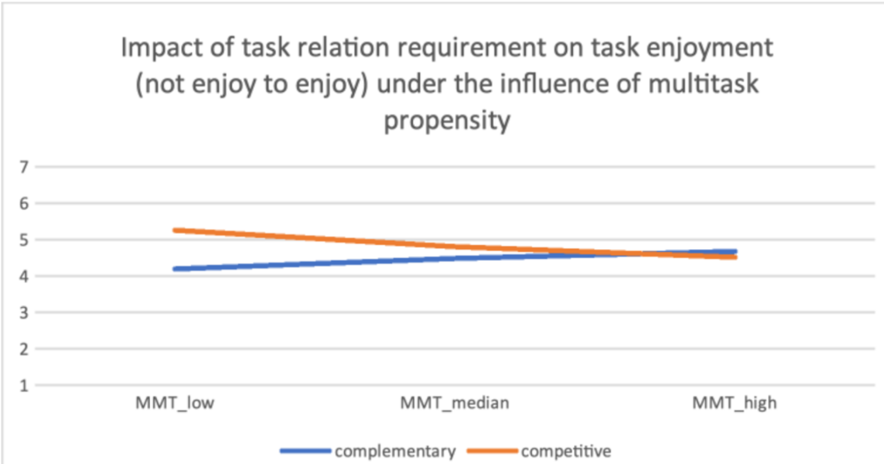

Figure 4.7 Multitask Propensity Moderates the Relationship Between Task Relation and Task Enjoyment

Table 4.5 Multitask Propensity Moderating Effect on the Relationship Between Condition and Task Enjoyment Test Statistics

Model Summary

R	R-sq	MSE	F	df1	df2	p
.2303	.0530	2.4543	1.6615	3.0000	89.0000	.1810

Product terms key: Int_1 : Condition x $Multitask_{Propensity}$
Test(s) of highest order unconditional interaction(s):

	R2-chng	F	df1	df2	p
X*W	.0355	3.3405	1.0000	89.0000	.0709

4.5.6 Results Summary

Study 2 explored how perceived task relationships (complementary vs. competitive) between an email classification task and additional video stimuli influenced task engagement, performance, attention management, and subjective evaluation. The main findings are summarized in Table 4.6.

Refer to Appendix B.2 for a descriptives table with means and standard deviations for all variables.

Contrary to Hypothesis 2.1, participants in the competitive condition showed higher engagement, sustained attention, and distractor filtering compared to the complementary condition. Task engagement interacted with task relationship to influence performance, partially supporting Hypothesis 2.2. At low engagement levels, the competitive condition showed higher accuracy, but as engagement increased, performance in the complementary condition improved.

No significant interactions were found between cognitive flexibility, media multitasking propensity, and task performance or attention management variables, failing to support Hypotheses 2.3 and 2.4. Subjective measures revealed that participants in the competitive condition were more motivated and aroused than those in the complementary condition. Propensity to multitask moderated the effects of task relationship on time perception and task enjoyment.

Table 4.6 Summary of Hypotheses and Results for Study 2

Hypothesis	Result
H2.1: Competitive tasks will lead to lower performance, attention, and filtering.	Not supported
H2.2: Task engagement will moderate the effect of task relationship on performance.	Partially supported
H2.3: Negative effects of competitive tasks will be stronger for low flexibility.	Not supported
H2.4: Distractor interference will be stronger for low flexibility in competitive tasks.	Not supported
RQ1: How does media multitasking propensity moderate the effects of secondary tasks?	Effects on time perception and task enjoyment

4.6 Discussion

Study 2 explored how perceived task relationships (complementary vs. competitive) between email classification task and additional video stimuli during task performance influenced an individual's task engagement, performance, attention management, and subjective evaluation of the experience. Contrary to the hypotheses, the current study found that participants in the competitive relationship condition reported higher task engagement and sustained attention compared to the complementary condition. And those in the complementary condition looked at the distracting image more often than those in the competitive condition. These findings suggest the competitive relationship between the mail task and video stimuli may have enhanced participants' attentional focus to prioritize the email task completion. In this case, the perceived competition between the email task and video stimuli may have triggered a state of heightened arousal and focus, leading to improved engagement and attention, which is also reflected in the result, such that participants in the competitive task relationship condition were more aroused and motivated to complete the email task than those in the complementary relationship condition.

Consequently, those in the competitive relationship condition treated the video stimuli as distraction, inhibiting resource allocated to areas outside of the email task, leading to improved performance.

These results contrast Study 1, where video stimuli alone did not significantly impact task engagement or performance. The key difference between the two studies lies in the manipulation of perceived task relationship. In Study 2, framing the video stimuli as competitive seems to have altered participants' mindset and resource allocation strategies, leading to the unexpected findings of improved engagement and attention in the competitive condition. This highlights the importance of subjective perceptions in shaping multitasking outcomes, even when the objective task demands remain the same.

Although study 2 found that task relationship difference influenced participants’ levels of engagement and strategies to allocate attentional resources, no significant main effect of task relationship on email task performance was found. However, the weak relevance between task engagement and email task performance changed when all three variables interacted together: the study results showed that task engagement partially interacted with perceived task relationship to influence email task performance: at low engagement levels, the competitive condition showed significantly higher accuracy, but as engagement increased, performance in the complementary condition improved while the competitive condition remained stable. This is consistent with previous research that demonstrated task engagement is closely related to resource allocation (e.g., Christian, Garza, Slaughter, 2011). What’s interesting is that at low levels of engagement, participants demonstrated better performance in the competitive condition compared to complementary condition, but the advantage of better performance diminished as levels of engagement increased. This suggests that the competitive task relationship may be particularly beneficial for individuals who are initially less engaged in the task, as it may help to boost their focus during the beginning period. However, as engagement increases, performance in the complementary condition improves while performance in the competitive relationship condition remains stable. This suggests the complementary relationship may be more beneficial for individuals already engaged in the task, as it may allow them to extend the high level of engagement for a longer time.

In terms of subjective evaluation, while task relationship alone does not influence task enjoyment, propensity to multitask is negatively related to task enjoyment in the competitive task relationship condition and is positively related to task enjoyment in the complementary task relationship condition. Individuals who are less inclined to multitask may find the competitive relationship more enjoyable because it provides a clear focus and reduces the temptation to divide attention between tasks. This is because the competitive relationship creates a sense of urgency and challenge, which motivates individuals to concentrate their attention on the primary task and avoid distractions. As a result, they may experience a greater sense of accomplishment and satisfaction from completing the task.

On the other hand, individuals who are more inclined to multitask may find the complementary relationship more enjoyable because it allows them to engage in both tasks simultaneously and leverage the multitasking setting. This is consistent with the findings from Study 1, which showed that a secondary video stimulus may serve a "corralling" function, preventing attentional resources from being allocated to other task-irrelevant distractors. While previous research shows that people who multitask may be less able to block out distractions and focus on a singular task (e.g., Sanbonmatsu et al., 2013), having an additional video stimuli available could be emotionally soothing and inherently enjoyable for those who prefer multitasking.

In the current study, participants exhibited an inverted U-shaped performance trajectory, demonstrating the lowest email classification accuracy at the beginning, improvement in the middle, and gradually declined towards the end, regardless of the task relationship condition. The current study also found that competitive relationship may have enhanced participants' attentional focus to prioritize email task completion. These findings raise the question of whether the timing of secondary stimuli involvement can influence task engagement, performance, and attention management.

Previous research has primarily focused on one-time task performance, neglecting the dynamic changes in attention allocation and resource availability that occur over time. Prolonged exposure to a task may lead to decreased motivation, reduced resources for task processing, or increased executive control demands. Additionally, as individuals gain experience with a task, they require fewer resources, leaving spare resources that may be allocated to other things, even task-irrelevant stimuli (Language & Chrzan, 2015; Himi et al., 2019).

Building on the findings of Study 1 and Study 2, which explored the potential facilitation effect of a secondary task from contextual (dual vs. single) and motivational (complementary vs. competitive task relationship) perspectives, Study 3 will investigate how the timing of secondary task exposure influences information processing over time. This third study aims to determine the optimal time to introduce the arousing secondary task to maximize its effectiveness in regaining cognitive resources and enhancing task engagement and performance.

A limitation of Study 2 is that the instructions given to participants in the competitive condition explicitly asked them to prioritize the primary task, which may have directly led to increased engagement and attention toward the email classification task. However, it's important to note that the perceived competitive task relationship did result in higher motivation and arousal, which is consistent with arousal theories like the Yerkes-Dodson law. Future studies could employ more balanced instructions across conditions to better isolate the effects of perceived task relationships on engagement and performance.

CHAPTER 5: STUDY 3 TIMING OF SECONDARY STIMULI INVOLVEMENT

5.1 Workflow Interruption and Timing

5.1.1 Dynamic Change of Attention Allocation

While previous media research has primarily focused on one-time task performance (Lang & Chrzan,2015; Jeong & Hwang, 2016), findings from Study 2 and theories on attentional resource allocation suggests that an individual's attentional focus on a task may fluctuate throughout the task processing period, and the resource allocation and availability may change throughout time. Prolonged exposure to states of high arousal or high effort devotion to the task might lead to a state of lowered motivation (e.g., fatigue, sleepiness), or weaken a particular resource to process the task (Hopstaken et al., 2015). When an individual's motivation to complete a task starts to decrease, resources may be reallocated to other stimuli that attract attention or new self-generated motivation, so that the individual may shift their engagement target (Smallwood et al., 2004; Thomson, Besner, & Smilek, 2016).

In addition, while increased arousal may enlarge the resources available for the task, resource pools may also shrink due to decreased arousal such that resources available for the task may decrease due to the increased cost of allocating these resources or additional executive control resources required to maintain a current motivational or engagement state (Kahneman, 1973). Finally, as an individual acquires experience with a task, fewer resources are required, leaving more spare resources through practices and experience. These resources are subject to use in other task-relevant process or even in task-irrelevant stimuli/thoughts (Pattyn et al., 2008).

5.1.2 Vigilance Decrement and Task demand

Vigilance decrement refers to the decrease in signal detection performance over time (Tiwari, Singh, & Singh, 2009). Previous research indicates that most of the decrement occurs within the first 15 minutes of the task (Teichner, 1974). However, when task demand is high, the decrement can happen as quickly as within the first 5 minutes (e.g., Helton, Dember, Warm, & Matthews, 2000; Temple, Warm, Dember, Jones, LaGrange, & Matthews, 2000).

Several factors can contribute to vigilance decrement. First, a decline in arousal due to lack of stimulation during repetitive tasks may lead to a decrease in performance over time. Second, high task demands can deplete information processing resources, causing a decrement even if the task is repetitive, as the limited capacity may not replenish quickly enough. Finally, mental workload, considered as the amount of resources used to complete a task (Cain, 2007), may also play a role in vigilance decrement. Introducing a secondary task during this critical period of resource depletion may further strain the limited cognitive capacity and impair performance on the primary task.

5.1.3 Empirical Evidence from Advertising and Media Multitasking Research

Research in the field of advertising has also investigated the impact of message timing and sequence on attention and recall, providing insights relevant to the dynamic nature of attentional resource allocation. Studies have demonstrated primacy and recency effects, where information presented at the beginning (primacy) and end (recency) of a sequence is better remembered than information in the middle (Li & Lo, 2015; Terry, 2005). These findings highlight the importance of considering the timing and placement of messages within a media context to optimize attention and memory.

In the media multitasking literature, several studies have explored the effects of task sequence and timing on cognitive outcomes. Theodorakioglou and Boutsouki (2022) compared simultaneous and sequential media multitasking conditions and found that simultaneous multitasking led to lower brand recall compared to sequential multitasking. This suggests that the timing and arrangement of tasks can influence how well individuals process and remember information from multiple sources.

The findings from advertising and media multitasking research, along with cognitive theories on attentional resource allocation, provide a strong foundation for investigating the optimal timing of introducing secondary tasks in a media multitasking context. Study 2's results further support the need to examine the impact of secondary task timing on task engagement, performance, and attention management, which is the focus of Study 3 in this dissertation.

5.1.4 Timing of Secondary Task Introduction

Given the dynamic nature of attention allocation, resource availability, and the potential for vigilance decrement, it is important to consider the timing of introducing a secondary task/stimulus during the primary task process in order to achieve optimal task engagement and performance. Introducing a secondary task/stimulus at the beginning of the primary task onset may not be as effective in retaining cognitive resources compared to introducing it later, when the individual starts to experience fatigue or decreased motivation/attention (Humphreys & Revelle, 1984).

However, if a secondary task/stimulus is introduced too late, when most resources have started or have already been misallocated to other stimuli, it may actually backfire and attract the individual’s attention away from the primary task, which could lead to the initiation of other self-defined task (e.g., being distracted and focusing on new stimuli) and consequently cause the individual to ignore the original task (Humphreys & Revelle, 1984).

The trade-off between introducing the secondary task too early (causing initial distraction) and too late (when resources are already depleted) highlights the need to identify the optimal timing window. This "sweet spot" should allow enough time for the individual to establish focused attention on the primary task, while introducing the secondary task before significant vigilance decrement or resource depletion occurs. Striking this balance is crucial for harnessing the potential benefits of secondary tasks in media multitasking contexts.

5.1.5 Cognitive Flexibility and Multitasking Propensity

Cognitive flexibility and multitasking propensity may each play a role in how individuals respond to the timing of secondary task introduction. Individuals with higher cognitive flexibility are better able to adapt to changing task demands and switch between tasks more efficiently (Monsell, 2003). In the context of secondary task timing, individuals with higher cognitive flexibility may be better able to integrate the secondary task into their workflow, regardless of when it is introduced. This adaptability may lead to more consistent levels of task engagement, performance, sustained attention, and distractor filtering, regardless of the timing of the secondary task introduction. In contrast, individuals with lower cognitive flexibility may be more sensitive to the timing of secondary task introduction. They may struggle to adapt to the changing task demands and effectively integrate the secondary task into their workflow, particularly when the secondary task is introduced simultaneously with the primary task onset. As a result, the timing of secondary task introduction may have a stronger impact on task engagement, performance, sustained attention, and distractor filtering for individuals with lower cognitive flexibility.

Previous research has shown conflicting findings on whether multitaskers are truly adept at task switching (Alzahabi & Becker, 2013; Ophir et al., 2009). Some studies suggest that frequent media multitaskers may be better at switching between tasks and integrating information from multiple sources (Alzahabi & Becker, 2013). If this is the case, individuals with higher multitasking propensity may be less affected by the timing of secondary task introduction, as they are better able to adapt to changing task demands and effectively manage their attention and resources.

However, other studies have found that frequent media multitaskers may be more susceptible to distraction and less effective at filtering out irrelevant information (Ophir et al., 2009). These mixed findings are further complicated by research showing that the relationship between media multitasking and cognitive control abilities may depend on factors such as task difficulty and individual strategies. Szumowska et al. (2018) found that frequent media multitaskers performed worse than light multitaskers on a dual-task paradigm only when the tasks were difficult and required high levels of self-regulation. When given specific strategies to manage the task demands, the performance difference between heavy and light media multitaskers disappeared. A recent meta-analysis by Wiradhany et al. (2021) also highlights the complex relationship between media multitasking and various cognitive domains. The analysis revealed weak associations between media multitasking and some cognitive abilities (e.g., working memory, task switching), but not others (e.g., interference control, response inhibition). The authors emphasize the need for more research to unravel the nuances in these relationships and identify potential moderating factors.

In the context of Study 3, cognitive flexibility and multitasking propensity are examined as potential moderators of the relationship between secondary task timing and various cognitive and behavioral outcomes. These variables were also investigated in Study 2. Specifically, Study 2 found no significant interactions between cognitive flexibility and other variables. However, multitasking propensity showed marginally significant moderating effects on time perception and task enjoyment. Participants with lower multitasking propensity reported higher task enjoyment in the competitive condition, while those with higher multitasking propensity showed less difference in enjoyment between conditions. Additionally, multitasking propensity influenced time perception differently in competitive and complementary conditions. By further investigating these individual differences, Study 3 aims to provide a more nuanced understanding of how personal characteristics may influence the optimal timing of secondary task introduction in media multitasking scenarios. The findings from both studies can contribute to the development of personalized strategies for managing attention and cognitive resources in media-rich environments.

5.2 Research Questions and Hypotheses

Building on the findings of Study 1 and Study 2, which explored the potential facilitation effect of a secondary task from contextual (dual vs. single) and motivational (complementary vs. competitive task relationship) perspectives, Study 3 investigates how the timing of secondary task exposure influences information processing over time. Specifically, this study aimed to determine the optimal time to introduce the arousing secondary task to maximize its effectiveness in regaining cognitive resources and enhancing task engagement and performance.

As discussed earlier, high task demands can lead to a vigilance decrement within the first 5 minutes of the task (Helton et al., 2007; Warm et al., 2008). By introducing the secondary task at the 5-minute mark, when the individual may start experiencing fatigue or decreased motivation, it is expected to help re-engage the individual and improve overall performance and attention management. The choice of 5 minutes as the timing for introducing the secondary task is based on previous research that has used similar timings to investigate the effects of task interruptions and secondary task introduction (e.g., Helton, Dember, Warm, & Matthews, 2000; Temple, Warm, Dember, Jones, LaGrange, & Matthews, 2000).

Research Question: How does the timing of secondary task introduction (simultaneous with primary task onset vs. 5 minutes after primary task onset) influence task engagement, performance, and attention management over time?

5.2.1 Main effect of Secondary Task Introduction Timing

Introducing the secondary task simultaneously with the primary task onset may lead to an increased cognitive load and divided attention from the beginning of the task. This could potentially hinder the individual's ability to fully engage with the primary task and establish a focused attentional state. In contrast, introducing the secondary task after 5 minutes allows the individual to establish a focused attentional state on the primary task before the introduction of the secondary task, which may help to maintain task engagement, performance, and sustained attention. Therefore:

Hypothesis 3.1a: Introducing the secondary task 5 minutes after the primary task onset will lead to higher task engagement compared to introducing the secondary task simultaneously with the primary task onset.

Hypothesis 3.1b: Introducing the secondary task 5 minutes after the primary task onset will lead to better performance compared to introducing the secondary task simultaneously with the primary task onset.

The impact of secondary task timing on sustained attention and distractor filtering may be complex and influenced by various factors. According to Lavie's load theory, increasing perceptual load through a secondary task could help individuals block out task-irrelevant distractors by exhausting perceptual capacity (Lavie, 2005; Murphy et al., 2017). However, introducing a secondary task may also cause divided attention, potentially impairing attention management and the ability to filter out distractors effectively. Given these competing perspectives, exploring the relationship between secondary task timing and attention management through research questions allows for a more comprehensive investigation of the underlying mechanisms and potential moderating factors.

Research Question 3.1: How does the timing of secondary task introduction (5 minutes after primary task onset vs. simultaneously with primary task onset) influence sustained attention toward the primary task and distractor filtering during the primary task?

5.2.2 Moderation Effects of Cognitive Flexibility and Media Multitasking Propensity

The following hypotheses are based on the idea that individuals with higher cognitive flexibility are better able to adapt to changing task demands and integrate secondary tasks into their workflow. As such, it is expected that the timing of secondary task introduction will have less of an impact on task engagement, performance, and attention management for individuals with higher cognitive flexibility compared to those with lower cognitive flexibility:

H3.2. Individual differences in cognitive flexibility will moderate the effect of secondary task timing on performance and attention management, such that:

1) H3.2a. The effect of secondary task timing on task engagement will be weaker for individuals with higher cognitive flexibility compared to those with lower cognitive flexibility.
2) H3.2b. The effect of secondary task timing on task performance will be weaker for individuals with higher cognitive flexibility compared to those with lower cognitive flexibility.
3) H3.2c. The effect of secondary task timing on sustained attention will be weaker for individuals with higher cognitive flexibility compared to those with lower cognitive flexibility.
4) H3.2d. The effect of secondary task timing on distractor filtering will be weaker for individuals with higher cognitive flexibility compared to those with lower cognitive flexibility.

Given the inconsistencies in previous studies on media multitasking propensity, with some suggesting benefits for multitaskers (Alzahabi & Becker, 2013) and others showing costs (Szumowska et al., 2018), the current study aims to investigate the role of multitasking propensity in the context of secondary task timing and its effects on task engagement, performance, and attention management. The findings could shed light on how individual differences in multitasking propensity may influence the optimal timing of secondary task introduction and its impact on various aspects of task execution and attention management.

Research Question 3.2 - Media multitasking propensity: How does an individual's multitasking propensity influence the effect of secondary task timing on task engagement, performance, and attention management?

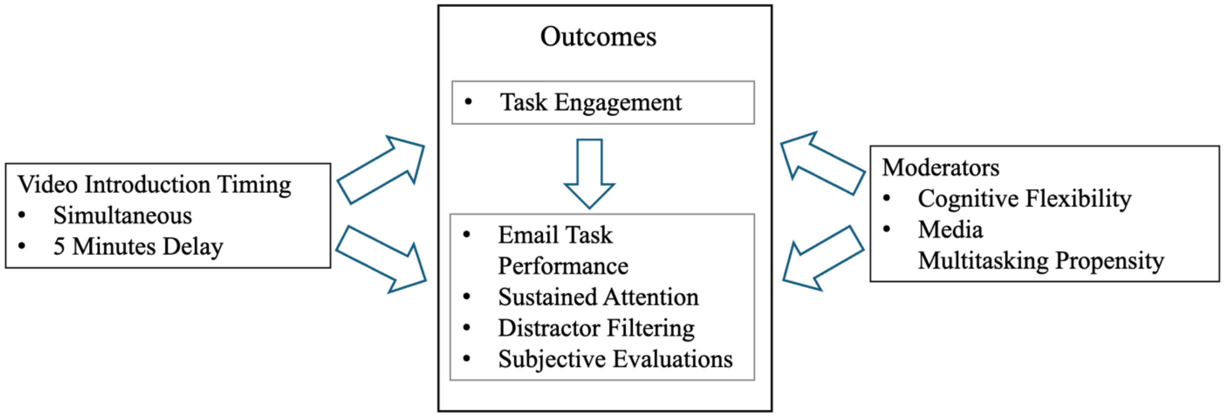

Figure 5.1 Study 3 Framework

5.3 Method

5.3.1 Participants

The research protocol was approved by the University of Illinois Institutional Research Board (IRB-20810). A total of 83 participants were recruited from the campus community through community e-newsletters and flyers. The sample size was determined a priori using G*Power, with a power of .80 and an effect size (eta-squared) of .40. This analysis indicated that a sample size of 83 would be sufficient. Each participant received an Amazon gift card as monetary incentive for their participation.

5.3.2 Design and Stimuli

Study 3 employs a 2 (secondary task timing: simultaneous with primary task onset vs. 5 minutes after primary task onset) x 2 (cognitive flexibility: high vs. low) x 2 (media multitasking propensity: high vs. low) mixed design. Secondary task timing is a between-subjects factor, while cognitive flexibility and media multitasking propensity are measured as individual difference variables.

The primary task is the same email classification task used in Study 1 and Study 2. However, Studies 1 and 2 observed high accuracy rates (98% and 97%) across conditions in the email classification task, potentially indicating a floor effect. To address this in Study 3, the current study made targeted adjustments to increase task difficulty and allow for greater performance variability. Specifically, the current study modified a few existing emails to increase their length and complexity while maintaining ecological validity. 11 new emails that were previously pretested to have lower than 80% accuracy in classification tasks were added to the email task pool. These additions were carefully selected to introduce more challenging items without fundamentally altering the nature of the task. The total number of emails increased from 89 to 100, and the five original categories were retained. Participants are required to categorize emails into one of five predefined categories. The secondary task involves watching video clips that play automatically on the same screen. The video clips are the same as those used in Study 1 and 2.

5.3.3 Procedure

Participants are welcomed to the lab and provided with informed consent. After being seated at a specific distance from the computer screen, they receive instructions that the video stimuli will appear either at the beginning of the email task or after 5 minutes, and that they should allocate their attention naturally as they would in their daily digital media environment. They then undergo calibration for eye-tracking. Participants are randomly assigned to one of two conditions: secondary video clips introduction simultaneous with primary email task onset or secondary video clips introduction 5 minutes after primary email task onset.

In the simultaneous condition, the video clips start playing automatically when the email classification task begins. In the 5-minute delay condition, the video clips start playing automatically 5 minutes after the email classification task begins. Participants complete the email classification task while the video clips play on the same screen. In both conditions, task-irrelevant distracting images appear in randomized order in a designated area of the screen from the beginning of the task, independent of the video clip introduction timing.

After completing the email classification task, participants fill out a post-experiment questionnaire (Refer to Appendix D) assessing task engagement, perceived task experience, cognitive flexibility, and media multitasking propensity.

5.3.4 Measures

The study uses the same measures as Study 1 and Study 2 for the following variables: Task engagement: Measured using the 13-item task engagement scale developed by May, Gilson, and Harter (2004). Task performance: Calculated as the proportion of accurately categorized emails to the total number of emails. Sustained attention: Measured as the proportion of eye gaze on the email task area relative to the total area. Distractor filtering: Calculated as the proportion of eye location on the distracting image area versus the entire eye gaze shortly after the onset of a new distracting image. Perceived task experience: Adapted from Chinchanachokchai, Duff, and Sar (2015), including time perception and task enjoyment. Cognitive flexibility: Measured using the 12-item, 7-point general cognitive flexibility scale developed by Martin and Rubin (1995). Media multitasking propensity: Assessed through a 2-item, 7-point Likert scale (Duff, Yoon, Wang, & Anghelcev, 2014).

5.4 Results

Study 3 examined the impact of secondary video stimuli exposure timing on email task performance, attention management during task participation, and subjective evaluation of task experience. Refer to Appendix C.1 for a descriptives table with means and standard deviations for all variables.

5.4.1 Main effects of Secondary video stimuli exposure timing

Email Classification Performance Accuracy. An ANOVA was conducted to examine the effect of secondary video timing on email classification performance accuracy. Results revealed a significant main effect of secondary task timing on email classification performance accuracy ($F(1, 82) = 6.49$, $p<.01$, 2 = 0.07, power = 0.43). Participants in the 5-minute delay condition demonstrated higher accuracy (M = 0.99, SD=0.02) compared to those in the simultaneous condition (M = 0.98, SD=0.01). This finding supports H3.1b, such that introducing the videos 5 minutes after the email task onset led to better performance compared to simultaneous introduction. See Table 5.1.

Table 5.1 ANOVA Results for Email Performance Accuracy Between Simultaneous vs. Delay Condition

Source	Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Observed Power
Between Groups	0.001315	1	0.001315	4.547	0.036	0.052	0.323

Task engagement. An ANOVA was conducted to examine the effect of secondary task timing on task engagement. The results showed no significant main effect of timing on engagement ($F(1, 82) = 0.04$, $p = 0.83$, 2 = 0.001, power = 0.05). Participants in the 5-minute delay condition (M = 3.88, SD = 0.95) and the simultaneous condition (M = 3.83, SD = 0.95) reported similar levels of engagement (Table 5.2). Therefore, H3.1a was not supported, which predicted that introducing the video 5 minutes after the email task onset would lead to higher task engagement compared to simultaneous introduction.

Table 5.2 ANOVA Results for Task Engagement Between Simultaneous vs. Delay Condition

Source	Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Observed Power
Between Groups	0.038	1	0.038	0.044	0.834	0.001	0.053

Sustained attention. An ANOVA revealed no significant main effect of video exposure timing on email area eye gaze (F(1, 82) = 0.45, p = 0.51, 2 = 0.005, power = 0.08). This finding addresses Research Question 3.1, indicating that the timing of video introduction did not significantly influence sustained attention toward the primary email task. See Table 5.3.

Table 5.3 ANOVA Results for Gaze on Email Area Ratio Between Simultaneous vs. Delay Condition

Source	Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Observed Power
Between Groups	0.001	1	0.001	0.448	0.505	0.005	0.076

Distractor Filtering. An ANOVA revealed a significant main effect of video exposure timing on distracting image eye gaze (F(1, 82) = 4.50, p<.05, 2 = 0.05, power = 0.32). Participants in the 5-minute delay condition had a higher proportion of eye gaze on the distracting images (M = 0.02, SD = 0.02) compared to those in the simultaneous condition (M = 0.01, SD = 0.01). This finding addresses Research Question 3.2, suggesting that when videos were introduced at a later time, participants were less vulnerable against distracting images, and were less able to filter task-irrelevant stimuli. See Table 5.4.

Table 5.4 ANOVA Results for Gaze on Distracting Images Ratio Between Simultaneous vs. Delay Condition

Source	Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Observed Power
Between Groups	0.001	1	0.001	4.496	0.037	0.051	0.320

Subjective Evaluation of Task Experience. No significant main effects of secondary task timing were found, suggesting that the timing of secondary task introduction did not significantly influence participants' subjective evaluation of their task experience. Participants in the 5-minute delay condition and the simultaneous condition reported similar levels of time perception (M = 4.12, SD = 1.73 vs. M = 3.91, SD = 1.73), self-reported motivation (M = 5.15, SD = 1.54 vs. M = 5.47, SD = 1.28), self-reported enjoyment (M = 3.95, SD = 1.72 vs. M = 4.12, SD = 1.61), self-reported boredom (M = 4.34, SD = 1.67 vs. M = 4.37, SD = 1.92), and self-reported interest (M = 3.63, SD = 1.67 vs. M = 3.67, SD = 1.70).

5.4.2 Moderation effects

Cognitive Flexibility. A moderation analysis using multiple regression was conducted to examine the moderating effect of cognitive flexibility on the relationship between video exposure timing and various outcome variables. Results showed that cognitive flexibility significantly moderated the effects of exposure timing on distractor filtering (R-squared = 0.052, F(1, 80) = 4.38, p<.05). Participants in the 5-minute delay condition had a higher proportion of eye gaze on the distracting images (M = 0.02) compared to those in the simultaneous condition (M = 0.01) when cognitive flexibility was taken into account, such that as cognitive flexibility increases, the proportion of eye gaze on distracting images generally decreases for both conditions. However, the decrease is more prominent in the simultaneous condition compared to the 5-minute delay condition (Table 5.5). This suggests that individuals with higher cognitive flexibility are better able to filter out distractions, especially when the secondary task is introduced simultaneously with the primary task.

Table 5.5 Moderator Analysis Results for Gaze on Images Ratio with Moderator Cognitive Flexibility

Source	Sum of Squares	df	F	p
$Condition_{numeric}$	0.000897	1.0	4.381196	0.039506
$cognitive_{flexibility}$	0.000000	1.0	0.002137	0.963244
$Condition_{numeric}$:$cognitive_{flex}$	0.000001	1.0	0.003169	0.955247
R2	0.052			

No significant moderation effects were found for email accuracy, task engagement, SAM, email area eye gaze, video area eye gaze, time perception, self-reported motivation, self-reported enjoyment, self-reported boredom, or self-reported interest.

Media Multitasking Propensity. A moderation analysis using multiple regression was conducted to examine the moderating effect of media multitasking propensity on the relationship between video exposure timing and various outcome variables. The results showed that media multitasking propensity significantly moderated multiple effects. The results showed that media multitasking propensity significantly moderated the effects of exposure timing on email classification accuracy (R-squared = 0.06, F(1, 80) = 4.83, p<.05). Specifically, as media multitasking propensity increases, email classification accuracy generally decreases for both conditions. However, the decrease is less pronounced in the 5-minute delay condition compared to the simultaneous condition (Table 5.6). This suggests that individuals with higher media multitasking propensity perform better when the secondary task is introduced after a delay, while those with lower media multitasking propensity perform better when the secondary task is introduced simultaneously.

Table 5.6 Results for Email Performance Accuracy with Moderator Multitask Propensity

Source	Sum of Squares	df	F	p
$Condition_{numeric}$	0.001412	1.0	4.831319	0.030838
$Multitask_{propensity}$	0.000128	1.0	0.438998	0.509511
$Condition_{numeric}$:$Multitask_{propensity}$	0.000057	1.0	0.195268	0.659760
R-squared	0.060			

The result showed that multitasking propensity significantly moderated the effect of video exposure timing on self-reported feel of being distracted (F(1, 80) = 4.80, p<.05, R-squared = 0.07). Specifically, as media multitasking propensity increases, the feeling of being distracted generally increases for both conditions. However, the increase is more pronounced in the simultaneous condition (M = 3.16, SD = 0.96) compared to the 5-minute delay condition (M = 3.12, SD = 1.06). This implies that individuals with higher media multitasking propensity feel more distracted when the secondary task is introduced simultaneously, while those with lower multitask propensity feel more distracted when the secondary task is introduced after a delay. See Table 5.7.

Table 5.7 Results for Feel of Distraction with Moderator Multitask Propensity

Source	Sum of Squares	df	F	p
$Condition_{numeric}$	0.318801	1.0	0.326515	0.569320
$Multitask_{propensity}$	4.689985	1.0	4.803467	0.031310
$Condition_{numeric}$:$Multitask_{propensity}$	1.049274	1.0	1.074663	0.303018
R-squared	0.069			

The result showed that multitasking propensity significantly moderated the effect of video exposure timing on SAM scales (F(1, 80) = 7.24, p<.01, R-squared = 0.11). Specifically, as media multitasking propensity increases, arousal levels generally increase for both conditions. However, the increase is more prominent in the 5-minute delay condition (M = 4.54, SD = 1.10) compared to the simultaneous condition (M = 4.28, SD = 0.98). This suggests that individuals with higher media multitasking propensity experience higher arousal when the secondary task is introduced after a delay, while those with lower media multitasking propensity experience higher arousal when the secondary task is introduced simultaneously. See Table 5.8.

Table 5.8 Results for Self-Reported SAM with Moderator Multitask Propensity

Source	Sum of Squares	df	F	p
$Condition_{numeric}$	0.495955	1.0	0.493067	0.484600
$Multitask_{propensity}$	7.286774	1.0	7.244336	0.008658
$Condition_{numeric}$:$Multitask_{propensity}$	1.331330	1.0	1.323577	0.253378
R-squared	0.111			

5.4.3 Results Summary

Study 3 investigated the impact of secondary video stimuli exposure timing on email task performance, attention management, and subjective evaluation of task experience. The main findings are summarized in Table 5.9. Hypothesis 3.1a, which predicted that introducing the video 5 minutes after the email task onset would lead to higher task engagement compared to simultaneous introduction, was not supported. However, introducing the secondary task 5 minutes after the primary task onset led to better email classification accuracy compared to simultaneous introduction, supporting Hypothesis 3.1b.

Regarding Research Question 3.1, video exposure timing did not significantly influence sustained attention toward the primary email task. However, participants in the 5-minute delay condition had a higher proportion of eye gaze on the distracting images compared to those in the simultaneous condition.

Hypotheses 3.2a, 3.2b, and 3.2c, which predicted that the effect of secondary task timing on task engagement, performance, and sustained attention would be weaker for individuals with higher cognitive flexibility, were not supported. Contrary to Hypothesis 3.2d, cognitive flexibility moderated the effects of exposure timing on distractor filtering in the opposite direction. Individuals with higher cognitive flexibility were better able to filter out distractions, especially when the secondary task was introduced simultaneously.

Regarding Research Question 3.2, media multitasking propensity moderated the effects of exposure timing on email classification accuracy, feelings of being distracted, and arousal levels. Individuals with higher multitasking propensity performed better, felt more aroused, and were better able to filter distractions when video exposure was delayed.

Table 5.9 Summary of Hypotheses and Results for Study 3

Hypothesis	Result
H3.1a: Delayed video will lead to higher task engagement than simultaneous video.	Not supported

Table 5.9 (cont.) Summary of Hypotheses and Results for Study 3

H3.1b: Delayed video will lead to better performance than simultaneous video.	Supported
RQ3.1: Effect of video timing on sustained attention and distractor filtering.	No effect on attention, more distraction in delay
H3.2a-c: Effect of video timing on engagement, performance, and attention will be weaker for high cognitive flexibility.	Not supported
H3.2d: Effect of video timing on distractor filtering will be weaker for high cognitive flexibility.	Not supported (opposite)
RQ3.2: Multitasking propensity moderated effects of video timing on accuracy, distraction, and arousal.	Supported

5.5 Discussion

Study 3 aimed to investigate the optimal timing for introducing a secondary task to maximize its effectiveness in regaining cognitive resources and enhancing task engagement and performance. The results partially supported the hypotheses and provided valuable insights into the dynamic nature of attention allocation and the role of individual differences in cognitive flexibility and media multitasking propensity.

The finding that introducing the secondary task 5 minutes after the primary task onset led to better email classification accuracy compared to simultaneous introduction aligns with the literature on vigilance decrement and task demand (Helton et al., 2007; Warm et al., 2008). This suggests that allowing individuals to establish a focused attentional state on the primary task before introducing the secondary task can help maintain performance. However, the lack of significant main effects for task engagement, sustained attention, and subjective evaluation of task experience indicates that exposure timing may not have a uniform impact on all aspects of task processing and subjective experience.

The result that delayed video introduction led to more distraction from task-irrelevant images was unexpected and contradicts the hypothesis that later secondary task introduction would help maintain focused attention. This finding suggests a potential trade-off between the benefits of allowing individuals to initially focus on the primary task and the costs of introducing a secondary task when attentional resources may already be depleted. It is possible that the delayed video onset captured attention at a point when individuals were more susceptible to distraction due to fatigue or reduced motivation (Hopstaken et al., 2015; Thomson et al., 2016). Future research should further investigate the conditions under which delayed secondary task introduction may hinder or facilitate attention management. The moderation effect of cognitive flexibility on distractor filtering highlights the importance of considering individual differences in cognitive abilities when designing tasks and introducing secondary stimuli. The finding that individuals with higher cognitive flexibility are better at filtering out distractions when the secondary task is introduced simultaneously can be explained by their ability to rapidly adapt to changing task demands and effectively allocate attentional resources (Monsell, 2003). In a simultaneous condition, the sudden introduction of the secondary task requires a quick reallocation of attentional resources, which individuals with higher cognitive flexibility may be better equipped to handle. This ability to swiftly adapt and refocus attention may help them filter out distractions more effectively in this condition. In contrast, when the secondary task is introduced after a delay, the change in task demands may be less abrupt, and the advantage of higher cognitive flexibility in filtering out distractions may be less pronounced.

The moderation effects of media multitasking propensity on task performance and attention management provide insights into the potential benefits of secondary tasks in "corralling" cognitive resources. Individuals with higher multitasking propensity may have poorer resource executive control (Seddon, Adams, and Simmons, 2021), and therefore benefit more from a delayed introduction of the secondary task. The results of multitasking propensity moderation effect suggest that individuals with higher media multitasking propensity may benefit more from a delayed introduction of the secondary task, as they experience better performance, less distraction, and higher arousal in this condition. The 5-minute delay allows them to establish a focused attentional state on the primary task before the introduction of the secondary stimulus, which helps to "corral" their cognitive resources and reduce the likelihood of sparing resources to task-irrelevant items. In contrast, a simultaneous introduction of the secondary task may divide their initial efforts on the primary task, leading to performance impairments. These findings contribute to the ongoing debate on the effects of media multitasking on cognitive performance (Alzahabi & Becker, 2013; Ophir et al., 2009) and highlight the need for personalized approaches in task design and secondary stimuli introduction.

The lack of support for hypotheses 3.2a, 3.2b, and 3.2c, which predicted weaker effects of secondary task timing on engagement, performance, and attention for individuals with higher cognitive flexibility, suggests that the relationship between cognitive flexibility and the impact of secondary task timing may be more complex than initially hypothesized. It is possible that other factors, such as task difficulty or individual strategies (Szumowska et al., 2018), may interact with cognitive flexibility to shape the outcomes of secondary task timing. Future research should explore these potential moderators and their implications for optimizing media multitasking performance.

The finding that media multitasking propensity moderated the effects of secondary task timing on email classification accuracy, distraction, and arousal in different directions highlights the complex nature of media multitasking and its relationship to cognitive performance. The results suggest that individuals with higher media multitasking propensity may benefit from delayed secondary task introduction in terms of accuracy and reduced distraction, but also experience heightened arousal in this condition. This pattern of results aligns with the notion that media multitaskers may have difficulty filtering out irrelevant information (Ophir et al., 2009) and benefit from strategies that help them maintain focus on the primary task. However, the increased arousal experienced by high media multitaskers in the delayed condition suggests that they may also be more sensitive to changes in task demands and the introduction of new stimuli (Szumowska et al., 2018). These findings underscore the importance of considering individual differences in media multitasking propensity when designing interventions to optimize cognitive performance in media-rich environments.

The study's findings have both theoretical and practical implications. Theoretically, the results support the dynamic nature of attention allocation and resource availability over time (Kahneman, 1973; Thomson et al., 2016) and emphasize the importance of considering individual differences in cognitive abilities and multitasking propensity when investigating the effects of secondary tasks on performance and attention management. The results suggest that secondary tasks or stimuli can be strategically introduced to benefit task performance, engagement, and attention management, depending on individual cognitive abilities and multitasking propensity. For individuals with higher cognitive flexibility, a simultaneous introduction of the secondary task may be more beneficial in filtering out distractions, while for those with higher multitasking propensity, a delayed introduction may help "corral" cognitive resources and improve task performance.

However, the study has some limitations that should be addressed in future research. First, the sample size was relatively small, which may have limited the power to detect significant effects for some variables. Future studies should aim to replicate these findings with larger and more diverse samples. Second, the study focused on a specific type of primary and secondary task (email classification and video stimuli). Future research should investigate the generalizability of these findings across different task domains and types of secondary stimuli.

Another limitation of Study 3 is that we did not analyze changes in task performance during the first 5 minutes compared to later performance in the delayed introduction condition. Future research should examine if the initial 5 minutes without video, which could potentially be less distracting for some individuals, is what truly drives the difference in email classification accuracy rather than the delayed introduction itself. Comparing performance before and after video introduction in the delayed condition could provide valuable insights into the mechanisms behind the observed effects. It's possible that the absence of video for the first 5 minutes, rather than the timing of introduction, is the critical factor in improving task performance.

In conclusion, Study 3 contributes to our understanding of the dynamic nature of attention allocation and the role of individual differences in cognitive flexibility and media multitasking propensity in shaping the optimal timing of secondary task introduction. The findings highlight the importance of considering individual characteristics when designing tasks and introducing secondary stimuli to maximize performance and attention management. Future research should continue to investigate these factors across different task domains and explore additional individual difference variables to develop personalized approaches to task design and secondary stimuli introduction.

CHAPTER 6: GENERAL DISCUSSION

The aim of this dissertation was to investigate the potential facilitation effects of introducing a secondary task/stimulus during media use on task engagement, performance, and attention management. The research was motivated by the need to move beyond the dominant "limited capacity" perspective in media multitasking research, which emphasizes the detrimental effects of secondary tasks on cognitive performance. By exploring contextual and motivational factors, as well as individual differences in cognitive flexibility and media multitasking propensity, this dissertation sought to provide a more nuanced understanding of the conditions under which secondary tasks/stimuli may enhance rather than hinder task engagement and performance.

6.1 Synthesis of Findings

The three studies in this dissertation provide converging evidence for the potential facilitation effects of secondary tasks on task engagement, performance, and attention management, depending on various con textual, motivational, and individual factors.

The presence of a secondary task, whether a video (Study 1), a perceived competitive task (Study 2), or a delayed introduction (Study 3), demonstrated the potential to facilitate task engagement, performance, or attention management under certain conditions. This suggests that the effects of secondary tasks on media multitasking outcomes are not uniformly detrimental, but rather depend on how the secondary task is designed, perceived, and timed in relation to the primary task.

Study 1 demonstrated that while the presence of video stimuli did not directly enhance task engagement or performance, it served a "corralling" function by reducing attention to task-irrelevant distractions. This finding aligns with recent research on the role of perceptual load in attention management (e.g., Murphy et al., 2017; Himi, Bühner, Schwaighofer, Klapetek, & Hilbert, 2019), suggesting that the perceptual load imposed by the video stimuli helped to focus attentional resources on the primary task.

Study 2 further explored the role of perceived task relationships (complementary vs. competitive) in shaping the effects of secondary tasks. Contrary to expectations, participants in the competitive condition exhibited higher task engagement, sustained attention, and distractor filtering compared to those in the complementary condition. This suggests that the perceived competition between tasks may have triggered a state of heightened arousal and focus, leading to improved engagement and attention management. These findings contribute to the growing body of research on the role of task relevance evaluation in media multitasking (e.g., Beuckels, Ye, Hudders, and Cauberghe, 2021; Szumowska, Popławska-Boruc, & Kossowska, 2018).

Study 3 investigated the optimal timing of secondary task introduction (simultaneous vs. delayed) and its impact on task performance and attention management. The results showed that introducing the secondary task 5 minutes after the primary task onset led to better email classification accuracy compared to simultaneous introduction. This finding supports the idea that allowing individuals to establish a focused attentional state on the primary task before introducing the secondary task can help maintain performance. These results align with recent research on the dynamic nature of attention allocation and resource availability over time (e.g., Rusz, Bijleveld, & Kompier, 2019; Thomson, Smilek, & Besner, 2014).

Across all three studies, individual differences in cognitive flexibility and media multitasking propensity emerged as significant moderators of the effects of secondary tasks. This is consistent with previous research highlighting the role of individual differences in shaping media multitasking outcomes (e.g., Alzahabi & Becker, 2013; Kazakova, Cauberghe, Pandelaere, & De Pelsmacker, 2015; Seddon, Derbyshire, Drury, & Iyer, 2022; Wiradhany, van Vugt, & Nieuwenstein, 2020). The current findings extend this body of work by demonstrating how cognitive flexibility and media multitasking propensity interact with specific task characteristics (e.g., perceptual load, perceived task relationship, timing of introduction) to influence task engagement, performance, and attention management.

6.2 Theoretical Implications

The findings of this dissertation make several important contributions to the theoretical understanding of media multitasking and cognitive performance.

First, by demonstrating the potential facilitation effects of secondary tasks under certain conditions, the results challenge the dominant "limited capacity" perspective that has emphasized the detrimental effects of media multitasking on cognitive performance (e.g., Jeong & Hwang, 2016; Segijn & Eisend, 2019). This highlights the need for a more nuanced approach that considers contextual, motivational, and individual factors when studying the effects of media multitasking (van der Schuur, Baumgartner, Sumter, & Valkenburg, 2015; Wang, Irwin, Cooper, & Srivastava, 2015). For example, Study 2 demonstrates the importance of perceived task relationships (complementary vs. competitive) in shaping the effects of secondary tasks on engagement and attention management. This suggests that researchers should not only consider the objective characteristics of media multitasking tasks but also how individuals subjectively perceive the relationships between these tasks. Similarly, Study 3 highlights the role of temporal factors, such as the timing of secondary task introduction, in influencing cognitive performance. Second, the findings support and extend recent research on the role of perceptual load in attention management (e.g., Murphy et al., 2017; Himi et al., 2019). The "corralling" function of secondary tasks in reducing distraction, as demonstrated in Study 1, aligns with load theory's proposition that high perceptual load can exhaust attentional capacity and reduce processing of task-irrelevant stimuli (Lavie, 2005). This dissertation expands on load theory by showing how strategically introducing secondary tasks can leverage this effect to facilitate task engagement and performance. For instance, Study 1 suggests that introducing a perceptual secondary task (e.g., a video) can help to focus attentional resources on the primary task by reducing the processing of task-irrelevant distractions. By demonstrating the potential benefits of strategically introducing secondary tasks, this dissertation extends load theory and offers new insights into how the principles of perceptual load can be applied to optimize cognitive performance in media multitasking contexts.

Third, the results underscore the importance of individual differences in cognitive flexibility and media multitasking propensity in shaping the effects of secondary tasks. This aligns with and contributes to the growing body of research emphasizing the role of individual differences in media multitasking outcomes (e.g., Alzahabi & Becker, 2013; Kazakova et al., 2015; Seddon et al., 2022; Wiradhany et al., 2020). Previous studies have investigated various individual difference variables, such as working memory capacity (Sanbonmatsu, Strayer, Medeiros-Ward, & Watson, 2013), attentional control (Ophir, Nass, & Wagner, 2009), and personality traits (Duff, Yoon, Wang, & Anghelcev, 2014). The current findings extend this line of research by demonstrating how cognitive flexibility and media multitasking propensity interact with specific task characteristics to influence task engagement, performance, and attention management. This highlights the need for personalized approaches in task design and media multitasking research that take into account individual differences in cognitive abilities and preferences.

The findings suggest that individuals with higher cognitive flexibility and lower multitasking propensity may be better equipped to adapt to and benefit from secondary tasks, highlighting the need for personalized approaches in task design and media multitasking research. For example, Study 1 found that participants with lower multitasking propensity benefited more from the presence of a secondary video task in terms of engagement, while those with higher propensity found the video detrimental. This suggests that task designers should consider individual differences in media multitasking propensity when developing interventions or strategies to enhance cognitive performance. Similarly, Study 3 demonstrated that individuals with higher cognitive flexibility were better able to filter out distractions when a secondary task was introduced simultaneously, indicating that the timing of secondary task introduction may need to be tailored to individual cognitive abilities.

The current studies are among the first to investigate the moderating roles of cognitive flexibility and media multitasking propensity in the context of secondary task effects on media multitasking outcomes. Previous studies have examined other individual difference variables, such as working memory capacity (Sanbonmatsu et al., 2013), attentional control (Ophir et al., 2009), and personality traits (Duff et al., 2014). By focusing on cognitive flexibility and media multitasking propensity, this dissertation broadens the scope of individual differences considered in media multitasking research and highlights the need for personalized approaches in task design that take into account these cognitive abilities and preferences.

Furthermore, by demonstrating the influence of perceived task relationships (Study 2) and the timing of secondary task introduction (Study 3) on cognitive performance, this dissertation extends the literature on task relevance and the dynamic nature of attention allocation in media multitasking contexts. The findings contribute to a more nuanced understanding of how subjective perceptions and temporal factors shape the outcomes of media multitasking, building on recent work in these areas (e.g., Beuckels et al., 2021; Szumowska et al., 2018; Rusz et al., 2020; Thomson et al., 2014). Study 2 reveals that the perceived relationship between tasks (complementary vs. competitive) can significantly influence task engagement, attention management, and cognitive performance. This finding challenges the traditional view that task relevance is solely determined by objective characteristics (e.g., Segijn, Voorveld, Vandeberg, & Smit, 2017) and highlights the importance of considering individuals' subjective perceptions in media multitasking research. Study 3 further demonstrates the dynamic nature of attention allocation and resource availability over time, showing that the timing of secondary task introduction can have a significant impact on cognitive performance. These findings contribute to a growing body of literature that emphasizes the need to consider the temporal dynamics of media multitasking (e.g., Rusz et al., 2020) and the role of subjective factors in shaping media multitasking outcomes (e.g., Beuckels et al., 2021). Overall, this dissertation advances media multitasking theory by providing evidence for the potential facilitation effects of secondary tasks, highlighting the importance of contextual, motivational, and individual factors, and providing suggestions for research on the dynamic and personalized nature of media multitasking experiences. The findings challenge the prevailing "limited capacity" view and contribute to a more comprehensive understanding of the complex interplay between media multitasking and cognitive performance.

6.3 Practical Implications

The findings of this dissertation have significant practical implications for the design of media environments and the development of task management strategies in various settings, such as educational, professional, media, and personal contexts.

First, the results suggest that secondary tasks or stimuli can be strategically introduced to benefit task performance, engagement, and attention management, depending on individual cognitive abilities and multitasking propensity. For example, individuals with higher cognitive flexibility may benefit from a simultaneous introduction of secondary tasks to help filter out distractions, while those with higher multitasking propensity may perform better when secondary tasks are introduced after a delay. These findings can inform the development of adaptive learning systems or work environments that tailor the presentation of secondary tasks or stimuli based on individual cognitive profiles. In educational settings, this could involve designing multimedia learning materials that present secondary information or tasks in a manner that optimizes engagement and performance for students with different cognitive abilities and multitasking tendencies. In professional contexts, managers could use these insights to create personalized work environments that minimize distractions and maximize productivity for employees with diverse cognitive styles and multitasking propensities.

Second, the findings highlight the importance of considering the perceived relationship between tasks (complementary vs. competitive) in designing multitasking environments. While competitive relationships may lead to heightened arousal and focus in some cases, complementary relationships may be more beneficial for individuals who are already highly engaged in the primary task. These insights can guide the development of media environments and task management strategies that optimize cognitive performance and attention management based on individual perceptions of task relationships. For example, in advertising contexts, the findings suggest that media multitasking may not always be detrimental to attention to advertisements. If the secondary task is perceived as complementary to the primary task (e.g., a relevant ad alongside a news article), it may enhance engagement and attention to the advertisement. Conversely, if the secondary task is perceived as competitive (e.g., an intrusive pop-up ad), it may lead to heightened arousal but ultimately distract from the primary task and the advertisement itself. Advertisers can use these insights to design more effective and engaging multimedia campaigns that leverage the potential benefits of media multitasking while minimizing its potential drawbacks.

Third, the results underscore the need for personalized approaches in task design and secondary stimuli introduction based on individual differences in cognitive abilities and multitasking propensity. This suggests that a one-size-fits-all approach to media multitasking may not be effective, and that tailoring task environments to individual characteristics can optimize performance and attention management. Advertisers, content creators, and platform designers can use these insights to develop targeted strategies that cater to users with different cognitive profiles and multitasking preferences. Based on these assessments, they can then design task environments and introduce secondary stimuli in a manner that aligns with each individual's cognitive profile. For example, media content creators could tailor their content delivery strategies based on audience cognitive profiles. For instance, podcasts or video content designed for listeners with higher cognitive flexibility could incorporate relevant secondary information or tasks simultaneously with the main content, enhancing engagement and information processing. On the other hand, content targeted at audiences with higher multitasking propensity could be structured with clear segments and natural breaks, facilitating effective task-switching and reducing the cognitive load associated with continuous multitasking. Moreover, media platform designers could develop personalized user interfaces and content recommendation systems that adapt to individual differences in cognitive abilities and multitasking preferences. By leveraging user data and cognitive assessments, platforms could optimize the presentation and timing of secondary tasks, such as notifications, recommendations, or sponsored content, to align with users' cognitive profiles. This personalized approach could help maximize user engagement, minimize distraction, and enhance the overall user experience. By tailoring task design and secondary stimuli introduction to individual cognitive abilities and multitasking propensities, practitioners can create more effective and efficient media multitasking environments that maximize the potential benefits of media multitasking while minimizing its potential drawbacks.

In conclusion, the findings of this dissertation have practical implications for the design of media environments and task management strategies across various domains. By leveraging the strategic introduction of secondary tasks or stimuli, considering the perceived relationships between tasks, and adopting personalized approaches based on individual differences in cognitive abilities and multitasking propensities, practitioners can create more engaging, effective, and efficient media multitasking environments. These personalized environments can optimize cognitive performance, enhance attention management, and ultimately lead to better outcomes in educational, professional, and personal contexts. As media multitasking becomes increasingly prevalent in our daily lives, the insights provided by this dissertation can guide the development of evidence-based strategies for navigating the complexities of media multitasking and utilizing its potential benefits while mitigating its potential challenges.

6.4 Limitations and Future Directions

Despite the contributions of this dissertation, there are several limitations that should be addressed in future research. First, the sample sizes in the three studies were relatively small, which may have limited the power to detect significant effects for some variables. Future studies should aim to replicate these findings with larger and more diverse samples to ensure the generalizability of the results. For instance, the studies could be extended to include participants from different age groups, as previous research has shown that media multitasking behaviors and cognitive performance may vary across the lifespan (Voorveld & van der Goot, 2013). Matthews et al. (2022) investigated media multitasking across different age groups and found that younger adults (aged 18-30) engaged in more media multitasking compared to older adults (aged 60-75). However, the study also found that the relationship between media multitasking and cognitive control abilities (e.g., working memory, attention switching) did not differ significantly between the age groups. Extending the current findings to include participants from different age groups can provide insights into the generalizability of the facilitation effects of secondary tasks and the role of individual differences in shaping media multitasking outcomes across the lifespan.

Second, the dissertation focused on specific types of primary and secondary tasks (email classification and video stimuli). Future research should explore a wider range of primary tasks (e.g., reading comprehension, problem-solving) and secondary tasks (e.g., music, social media) to establish the boundary conditions of the facilitation effects of secondary tasks. For example, a study could investigate the effects of different types of music (e.g., instrumental, lyrical) on media content comprehension and engagement, considering individual differences in cognitive abilities. Such an approach would provide a more comprehensive understanding of the conditions under which secondary tasks may enhance or hinder cognitive performance in various media multitasking contexts.

Third, the studies relied on laboratory-based experiments, which may not fully capture the complexity of real-world media multitasking situations. Future research should employ more naturalistic study designs, such as experience sampling methods or field experiments, that investigate media multitasking behaviors in everyday contexts. For example, a study could use smartphone apps to track participants' actual media multitasking habits (e.g., using social media while watching TV or studying) and assess their cognitive performance, engagement, and attention management in real-time. This could be achieved by using mobile eye-tracking devices to measure attention allocation and task engagement, while also administering brief cognitive tests and surveys at regular intervals throughout the day. Such an approach would provide valuable insights into the generalizability of the current findings to real-world media multitasking experiences and help identify the factors that influence the effectiveness of secondary tasks in naturalistic settings.

Finally, the dissertation focused on cognitive flexibility and media multitasking propensity as key individual difference variables. Future research should explore additional individual difference variables, such as working memory capacity, attentional control, and motivation, to develop a more comprehensive understanding of the factors that shape the effects of secondary tasks on task engagement and performance (e.g., Wiradhany et al., 2020).

In conclusion, this dissertation challenges the dominant “limited capacity” perspective in media multitasking research by demonstrating the potential facilitation effects of secondary tasks on task engagement, performance, and attention management. The findings highlight the importance of considering contextual, motivational, and individual factors in studying the effects of media multitasking and underscore the need for personalized approaches in task design and secondary stimuli introduction. By providing a more nuanced understanding of the conditions under which secondary tasks may enhance rather than hinder cognitive performance, this dissertation opens new avenues for research and practice in the field of media psychology and human-computer interaction.

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APPENDIX A: STUDY 1 MATERIALS

Appendix A.1(1) Email Classification Task Illustration (With-Video Condition)

Please classify the following email into one of the category options:

From: beng@cae.wisc.edu (Beng Ting)
Subject: Madison/Chicago --> Italy Air Ticket Wanted

Hi,

I am looking for a round trip Madison/Chicago --> Milan (Italy) air ticket. Anybody who has a transferable ticket but will not use it please contact me at beng@cae.wisc.edu. Open-jaw ticket highly desired.

Thank you.

B. T. Ting
beng@cae.wisc.edu

- Medication
- Electronics
- Space Science
- Baseball
- Hockey
- For Sale

Appendix A.1(2) Email Classification Task Illustration (Without-Video Condition)

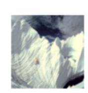
Please classify the following email into one of the category options:

From: amigan@cup.portal.com (Mike - Medwid)
Subject: Emphysema question

A friend of mine is going in later this week for tests to see if has emphysema. His lung capacity has decreased over time. His father died of the disease. He works in woodworking. I believe he has a very occasional cigarette, perhaps one cigarette a day or even less. He has some healthy life style habits, good diet, exercise, meditation, retreats, therapy etc. Anyhow..he is very concerned with this check up. I know really nothing about the disease. I believe it interferes with the lining of the lung being able to exchange oxygen.

Is a diagnosis of emphysema a death sentence? If he were to give up smoking entirely would that better his chances for recovery? What are some modern therapies used in people with this disease? I would appreciate any information. Thanks. amigan@cup.portal.com

- Medication
- Electronics
- Space Science
- Baseball
- Hockey
- For Sale



→

Appendix A.2 for selected video clip links

Video Clip Links
https://www.youtube.com/watch?v=YNwfZlIEh2Q
https://www.youtube.com/watch?v=y1uJlBGZTMs
https://www.youtube.com/watch?v=61hVxP-AObU
https://www.youtube.com/watch?v=QUsggBb1cTQ

Appendix A.3 Folder Link for selected IAPS Image Used in All Three Studies

https://www.dropbox.com/scl/fo/e7o0deyyulftukzizerps/AMWgmSLkv30JpMyT8WVvP7Q?rlkey=122ol65kh6kqxaru3gbcjygv8&st=okiplsyr&dl=0

Appendix A.4 Full List of Measures Submitted to the IRB

Self-reported Measurement

- **Self-Assessment Manikin Scale (Bradley & Lang, 1994)**

Arousal

This scale is the excited vs. calm scale. If you felt completely stimulated, excited, aroused while doing the task, place an "X" over the figure at the right of the row; if you felt completely relaxed, calm, sleepy, place an "X" over the figure at the left of the row.

- **Perceived task experience (adapted from Chinchanachokchai, Duff, & Sar, 2015)**
- ***Task enjoyment***

Please indicate how much you enjoyed the last trial.
0 (Not at all) - 6 (Very much)

2. Perception of time

Please indicate the subjective estimate of how time seemed to progress for you during the last trial.
0 (Very slowly) - 6 (Very fast)

- **Self-reported task engagement (adapted from May, Gilson, & Harter, 2004)**

0 (Strongly Disagree) - 6 (Strongly agree)

- ***Cognitive***

Performing the last trial is so absorbing that I forget about everything else.
I often think about other things when performing the last trial. (r)
I am rarely distracted when performing the last trial.
Time passes quickly when I perform the last trial.

- ***Emotional***

I really put my heart the last trial.
I get excited when I perform well on the last trial.
I often feel emotionally detached from the last trial. (r)
My own feelings are affected by how well I perform the last trial.

- ***Physical***

I exert a lot of energy performing the last trial.
I stay until the job is done.

I avoid working overtime whenever possible. (r)
I take work home to do.
I avoid working too hard. (r)
*** Note. Items marked (r) are reverse scored.**

- **Propensity to media multitask (adapted from Duff, Yoon, Wang, & Anghelcev, 2014)**
- How often do you multitask in general?

0 (Never) - 6 (All the time)

- How often do you use multiple media at the same time?

0 (Never) - 6 (All the time)

- **General cognitive flexibility scales (Martin, & Rubin, 1995)**

Instruction: The following statements deal with your beliefs and feelings about your own behavior. Read each statement and choose the option that best represents your agreement with each statement.
0 (Strongly Disagree) – 6 (Strongly Agree)

1. I can communicate an idea in many different ways.
2. I avoid new and unusual situations. (r)
3. I feel like I never get to make decisions. (r)
4. I can find workable solutions to seemingly unsolvable problems.
5. I seldom have choices when deciding how to behave. (r)
6. I am willing to work at creative solutions to problems.
7. In any given situation, I am able to act appropriately.
8. My behavior is a result of conscious decisions that I make.
9. I have many possible ways of behaving in any given situation.
10. I have difficulty using my knowledge on a given topic in real life situations. (r)
11. I am willing to listen and consider alternatives for handling a problem.
12. I have the self-confidence necessary to try different ways of behaving.

*** Note. Items marked (r) are reverse scored.**

- **Email classification task performance**

Email classification requires participants to review the subject descriptor of a message, reason about which other messages can be categorized together, and drag the message to the predefined folder. An example of how email classification task look like can be found in file *D. Stimuli example.*

Eye-tracking measures (sustained attention, distractor filtering)

- Sustained attention to tasks. Measured by the proportion of eye gaze time spent (oculomotor capture) among the four areas listed below in each condition: (a) the task-relevant area where the primary task and/or the secondary task are displayed, (b) the distracting image, (c) the location of the previous distracting image (which disappears from the display at the time the new image onsets), or (d) a blank empty region on the display (Buetti & Lleras, 2016). The proportion is divided between area (a) and the entire four areas.

- Distractor filtering. Measured by the proportion of eye location (oculomotor capture) on the distracting image area versus the entire eye gaze shortly after the onset of the new distracting image (Buetti & Lleras, 2016; Hollingworth, Matsukura, & Luck, 2013). For the oculomotor capture proportion, it is computed by counting the number of looks at the distracting image divided by the total number of looks of the four possible locations in the display.

Appendix A.5 Descriptives Table – Study 1

Variable	Condition	Mean	SD
Email Classification Accuracy	Without video	0.98	0.02
	With video	0.98	0.02
Task Engagement	Without video	4.03	1.13
	With video	4	1.13
Feel of Being Distracted	Without video	3.41	1.17
	With video	3.72	1.28
SAM	Without video	4.27	0.96
	With video	4.05	1.22
Ratio of Gaze on Email Area	Without video	0.98	0.04
	With video	0.96	0.05
Ratio of Gaze on Video Area	Without video	-	-
	With video	0.03	0.03
Ratio of Gaze on Image Area	Without video	0.02	0.01
	With video	0.01	0.01
Time Perception	Without video	4.19	1.71
	With video	4.43	2.14
Self-Reported Motivation	Without video	5.22	1.23
	With video	5.38	1.72
Self-Reported Enjoyment	Without video	4.19	1.53
	With video	3.84	1.77
Self-Reported Boredom	Without video	4.03	1.76
	With video	3.89	1.81
Self-Reported Interest	Without video	4	1.56
	With video	3.95	1.47

APPENDIX B: STUDY 2 MATERIALS

Appendix B.1(1) Study 2 Task Relation Manipulation Step 1 - Manipulation Instruction Manipulation Between Complementary and Competitive Conditions

Complementary Condition Text & Oral Instruction	**Competitive Condition Text & Oral Instruction**
While you are classifying emails, there will also be auto-play videos on the side. **You have the option to watch these videos at your own pace.** Consider these videos as a complementary resource for you to switch at will between completing the email classification task and watching a video. There is NO SOUND for the videos.	While you are classifying emails, there will also be auto-play videos on the side. **You need to ignore the videos and focus on the email classification.** You should not let the videos influence your email classification progress. Because the videos cannot be manually stopped, closed or minimized, try to control yourself from watching them. There is NO SOUND for the videos.

Appendix B.1(2) Study 2 Task Relation Manipulation Step 2 - Manipulation Check Measures

Measures	Complementary (Davis, 1989)	Competitive (Li, Edwards, & Lee, 2022)
Items of the Measure	• Having videos on the side improves my email task performance • Having videos on the side enables me to accomplish the email task more quickly. • Having videos on the side enhances my effectiveness on the email task. • Having videos on the side increases my productivity. • Having videos on the side makes it easier to do my job. • Overall, I find having videos on the side useful in the email task.	• When the videos were playing, I thought they were intrusive. • When the videos were playing, I thought they were disturbing. • When the videos were playing, I thought they were distracting. • When the videos were playing, I thought they were forced. • When the videos were playing, I thought they were interfering. • When the videos were playing, I thought they were invasive. • When the videos were playing, I thought they were obtrusive.
Scale	7-point Likert scale, ranging from "strongly disagree" (1) to "strongly agree" (7)	

Appendix B.2 Descriptives Table – Study 2

Variable	Condition	Mean	SD
Email Classification Accuracy	Complementary	0.97	0.04
	Competitive	0.97	0.02
Task Engagement	Complementary	3.96	0.95
	Competitive	4.36	1.05
Ratio of Gaze on Email Area	Complementary	0.78	0.14
	Competitive	0.86	0.1
Ratio of Gaze on Video Area	Complementary	0.13	0.08
	Competitive	0.07	0.05
Ratio of Gaze on Image Area	Complementary	0.01	0.01
	Competitive	0	0
Task Enjoyment	Complementary	4.48	1.53
	Competitive	4.87	1.63
Time Perception	Complementary	4.19	1.57
	Competitive	4.49	1.84
Self-Reported Motivation	Complementary	5	1.54
	Competitive	5.96	1.28
Email Boredom	Complementary	4.25	1.68
	Competitive	3.64	2.04
Email Interest	Complementary	3.94	1.51
	Competitive	4.24	1.84
Video Boredom	Complementary	3.42	1.47
	Competitive	3.38	1.83
Video Interest	Complementary	4.9	1.24
	Competitive	4.33	1.6
SAM	Complementary	4.62	1
	Competitive	5.04	1.1
Ratio of Distractor (Self-reported)	Complementary	0.08	0.14
	Competitive	0.07	0.13

APPENDIX C: STUDY 3 MATERIALS

Appendix C.1 Descriptives Table – Study 3

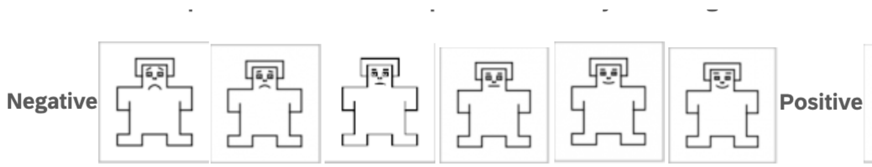
Variable	Condition	Mean	SD
Email Classification Accuracy	5min_after	0.99	0.02
	Simultaneous	0.98	0.01
Task Engagement	5min_after	3.88	0.95
	Simultaneous	3.83	0.95
Feel of Being Distracted	5min_after	3.16	0.96
	Simultaneous	3.12	1.06
SAM	5min_after	4.54	1.1
	Simultaneous	4.28	0.98
Ratio of Gaze on Email Area	5min_after	0.96	0.06
	Simultaneous	0.96	0.04
Ratio of Gaze on Video Area	5min_after	0.03	0.05
	Simultaneous	0.03	0.03
Ratio of Gaze on Image Area	5min_after	0.02	0.02
	Simultaneous	0.01	0.01
Time Perception	5min_after	4.12	1.73
	Simultaneous	3.91	1.73
Self-Reported Motivation	5min_after	5.15	1.54
	Simultaneous	5.47	1.28
Self-Reported Enjoyment	5min_after	3.95	1.72
	Simultaneous	4.12	1.61
Self-Reported Boredom	5min_after	4.34	1.67
	Simultaneous	4.37	1.92
Self-Reported Interest	5min_after	3.63	1.67
	Simultaneous	3.67	1.7

APPENDIX D: POST-SURVEY QUESTIONNAIRE (STUDY 2 AS EXAMPLE)

1. Self-Assessment Manikin (SAM) Scale

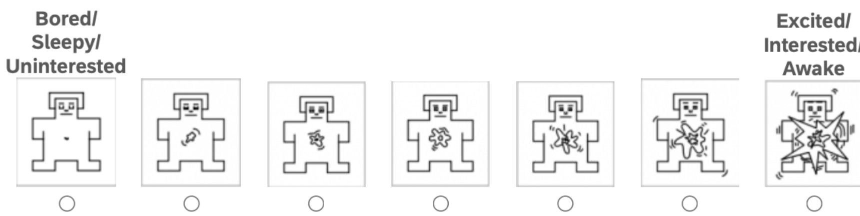
Instructions: Please select the picture that best corresponds with how you feel right now:

SAM1:



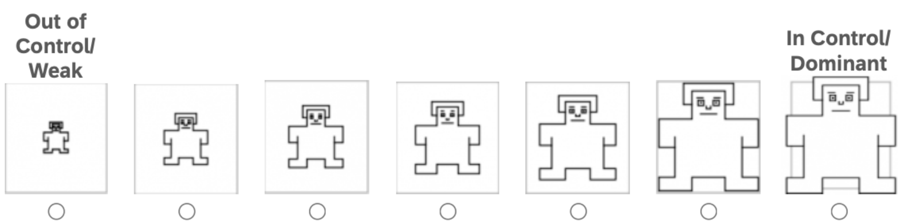
Response options: Negative to Positive

SAM2:



Response options: Bored/Sleepy/Uninterested to Excited/Interested/Awake

SAM3:



Response options: Out of Control/Weak to In Control/Dominant

2. Perceived Task Experience/Motivation

a. Task Enjoyment:
"Please indicate how much you enjoyed the email task:"
Response scale: Not at all (1) to Very much (7)

b. Time Perception:
"Please indicate the subjective estimate of how time seemed to progress for you during the email task:"
Response scale: Very slowly (1) to Very fast (7)

c. Motivation:
"How motivated were you to do well on the email task?"
Response scale: Not motivated at all (1) to Very motivated (7)

3. Task Engagement

Instructions: The following statements deal with your engagement experience. Read each statement and choose the option that best represents your agreement with each statement:

Response options: Strongly Disagree (1), Disagree (2), Somewhat Disagree (3), Neutral (4), Somewhat Agree (5), Agree (6), Strongly Agree (7)

a. Performing the email task was so absorbing that I forgot about everything else
b. I often thought about other things when performing the email task
c. I was rarely distracted when performing the email task
d. Time passed quickly when I perform the email task
e. I really put my heart in the email task
f. I got excited when I perform well on the email task
g. I often felt emotionally detached from the email task
h. My own feelings were affected by how well I performed the email task
i. I exerted a lot of energy performing the email task

4. Video Complementary

Instructions: The following statements are related to your perceived usefulness of the videos during the email task. Read each statement and choose the option that best represents your agreement with each statement:

Response options: Strongly Disagree (1), Disagree (2), Somewhat Disagree (3), Neutral (4), Somewhat Agree (5), Agree (6), Strongly Agree (7)

a. Having videos on the side improves my email task performance
b. Having videos on the side enables me to accomplish the email task more quickly
c. Having videos on the side enhances my effectiveness on the email task
d. Having videos on the side increases my productivity
e. Having videos on the side makes it easier to do my job
f. Overall, I find having videos on the side useful in the email task

5. Video Competitive

Instructions: When the videos were playing, I thought they were...

Response options: Strongly Disagree (1), Disagree (2), Somewhat Disagree (3), Neutral (4), Somewhat Agree (5), Agree (6), Strongly Agree (7)

a. When the videos were playing, I thought they were intrusive
b. When the videos were playing, I thought they were disturbing

c. When the videos were playing, I thought they were distracting
d. When the videos were playing, I thought they were forced
e. When the videos were playing, I thought they were interfering
f. When the videos were playing, I thought they were invasive
g. When the videos were playing, I thought they were obtrusive

6. Boredom/Interest

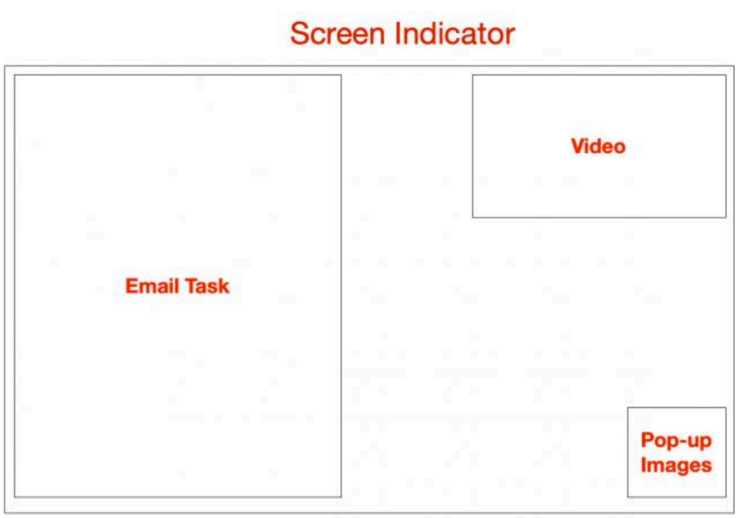
a. Email Task Boredom:
"How boring did you find the email task?"
Response scale: Not boring at all (1) to Very boring (7)

b. Email Task Interest:
"How interesting did you find the email task?"
Response scale: Not interesting at all (1) to Very interesting (7)

c. Video Boredom:
"How boring did you find the videos on the side?"
Response scale: Not boring at all (1) to Very boring (7)

d. Video Interest:
"How interesting did you find the videos on the side?"
Response scale: Not interesting at all (1) to Very interesting (7)

7. Attention Distribution



Instructions: Assuming your full attention is 100%. Out of 100%, how much attention went to the following four aspects respectively: email task, videos, pop-up images, and everything else? (The percentages of your attention to these four aspects need to add up to 100)

Response format: Percentages
- Email Task: ____%
- Videos: ____%
- Pop-up Images: ____%
- Everything Else: ____%
Total: 100%

8. Distraction Perception

Instructions: When the images popped up, I thought they were...

Response options: Strongly disagree (1), Disagree (2), Somewhat disagree (3), Neither agree nor disagree (4), Somewhat agree (5), Agree (6), Strongly agree (7)

a. Distracting
b. Interfering
c. Disturbing
d. Intrusive
e. Forced
f. Obtrusive
g. Invasive

9. Multitasking Propensity

a. "How often do you multitask in general (e.g. talk to a friend while watching TV)?"
Response scale: Never (1) to Always (7)

b. "How often do you use multiple media at the same time (e.g. use a computer while watching TV)?"
Response scale: Never (1) to Always (7)

c. "How much do you enjoy multitasking?"
Response scale: Not at all (1) to Very much (7)

10. Cognitive Flexibility - General

Instructions: The following statements deal with your beliefs and feelings about your own behavior. Read each statement and choose the option that best represents your agreement with each statement:

Response options: Strongly Disagree (1), Disagree (2), Somewhat Disagree (3), Neutral (4), Somewhat Agree (5), Agree (6), Strongly Agree (7)

a. I can communicate an idea in many different ways
b. I avoid new and unusual situations
c. I feel like I never get to make decisions

d. I can find workable solutions to seemingly unsolvable problems
e. I seldom have choices when deciding how to behave
f. I am willing to work at creative solutions to problems
g. In any given situation, I am able to act appropriately
h. My behavior is a result of conscious decisions that I make
i. I have many possible ways of behaving in any given situation
j. I have difficulty using my knowledge on a given topic in real life situations
k. I am willing to listen and consider alternatives for handling a problem
l. I have the self-confidence necessary to try different ways of behaving

11. Demographics

Instructions: Good job! You are towards the end of the survey. Please answer some demographic questions below.

a. Gender:
"What is your gender?"
Response options: Male, Female, Transgender/Others, Prefer not to answer

b. Age:
"How old are you? (Please input a NUMBER, for example: 20, please DON'T input words such as twenty)"
Response format: Open-ended numeric

c. Race:
"Which category best describes your race?"
Response options: American Indian/Alaska Native, Asian, Black or African American, Native Hawaiian/Other Pacific Islander, Hispanic or Latino, White, Other, Unavailable/Unknown, Prefer not to report

d. Language:
"Is English your first language?"
Response options: Yes, No

12. Open-Ended Questions

a. "How did you feel about the videos that were playing on the side during the email classification task?"
Response format: Open-ended text

b. "If you have any questions or additional thoughts about the experiment, please enter them here."
Response format: Open-ended text