AN EXPLORATION ACCOUNT OF MEDIA MULTITASKING: THE EXPLORATION-EXPLOITATION MODEL TO EXPLAIN MEDIA MULTITASKING BEHAVIOR

BY

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THESIS
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ABSTRACT

This study provides an Exploration-Exploitation Model of media multitasking, suggesting that people’s decision tendency toward exploration activates multitasking behavior, while a tendency toward exploitation keeps people media single-tasking. Moreover, I also propose that intrinsic motivation (curiosity) elicits exploration (vs. exploitation), determined by the intrinsic properties of the media tasks, such as novelty and uncertainty. A preliminary test at the individual difference level was performed and supported the Exploration-Exploitation Model of media multitasking. Specially, a Pick A Door Task (a version of the Four-Armed Bandit task) was used to measure trait tendency toward exploration (vs. exploitation). However, the association between trait curiosity (as intrinsic motivation tendencies) and trait media multitasking was not supported, which leaves a question regarding how the intrinsic and extrinsic value of information together influence people’s exploratory (vs. exploitive) media behaviors.
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CHAPTER 1

INTRODUCTION

Living in this information-saturated era, we can now access information, entertainment, and connect with others much more easily than ever before. For example, we can check our email, social media, and even watch a movie through our mobile phones. Given this background, people’s behavioral patterns on how they use media has been attracting scholars’ attention. Media multitasking (MMT) is one such behavior.

Previous studies have revealed both the prevalence and the impact of MMT. Based on a media use diary study, 29% of the time young people spent on media in 2010 was through using multiple media concurrently (Rideout, Foehr, & Roberts, 2010). Compared to single-tasking, MMT may negatively impact task-performance and learning. For example, MMT has been shown to lower students’ learning outcomes in academic settings (Fulton, Schweitzer, Scharff, & Boleng, 2011; Aguilar-Roca, Williams, & O’Dowd, 2012; Kraushaar & Novak, 2010; Wood et al., 2012). Cognitive studies also revealed that accuracy and overall performance on tasks could suffer due to multitasking (Adler & Benbaum-Fich, 2012; Ophir, Nass, & Wagner, 2009).

Moreover, MMT is also important to professionals in the media industry, especially in the advertising industry. This is because the effectiveness and persuasiveness of media content, such as commercials, highly relies on audiences’ attention to and engagement with the media content (Duff & Segijn, 2019). Besides, advertisements, such as advertising billboards (Edquist, Horberry, Hosking & Johnston, 2011) or in-game advertisements (Youn & Lee, 2012), are often regarded as distractors or secondary tasks. Thus, behavioral and attentional patterns involving MMT are inevitably informative and instructive to advertisers and media content producers. As reviewed in Duff and Segijn (2019), MMT may influence ad effectiveness through lowering ad irritation (Kazakova et al., 2016), perception of time passing (Chinchanachokchhai, Duff, & Sar, 2015), as well as ad intrusiveness (Yoon, Choi, & Song, 2011).

However, with the prevalence and impacts of MMT shown in previous literature, the activation mechanism of MMT or the reason why people media multitask has not yet been satisfactorily resolved (Uncapher & Wagner, 2018). This thesis aims to provide an exploration account for people’s MMT
behavior. Specifically, I am proposing that people’s motivation to multitask comes from the intrinsic rewards of the novel information encountered via MMT. Based on this, I propose the two-sided decision-making model -the Exploration-Exploitation Model- might explain people’s behavioral switching between MMT and media single-tasking. To support this exploration account, this thesis also gives a theoretical justification, from decision-making and reinforcement learning perspectives, to explain the intrinsically rewarding and motivating nature of exploration, which should be associated with MMT. I also performed an empirical test to verify the hypotheses derived from the exploration account of MMT, about individual differences (i.e., tendency toward exploration vs. exploitation, and trait curiosity) between high media multitaskers and low media multitaskers.

My thesis begins with a definition of MMT and clarifications on several unsettled questions about the conceptualization of MMT. After reviewing previous explanations of MMT, my thesis presents two possible models (Information Foraging Model and Exploration Exploitation model) to explain MMT. Based on the Exploration-Exploitation Model of MMT, it hypothesizes the association between decisional tendency (exploration vs. exploitation) and MMT, as well as curiosity and MMT at individual difference level. Finally, I reported an empirical study that I conducted to test these two hypotheses.
CHAPTER 2
LITERATURE REVIEW

2.1 Definition of Media-Multitasking

Media Multitasking (MMT) is commonly regarded as “consumption of more than one item or stream of content at the same time” (Ophir, Nass, & Wagner, 2009; pg. 15583). As an interdisciplinary construct in relatively early research stage across various fields, such as communication, information science, and cognitive science (Spink, Cole, & Waller, 2008), the exact conceptual definition of MMT differs greatly among different perspectives.

The divergence and arguments about definitions of MMT include three main questions: how to separate different media “tasks”; whether to define MMT as concurrent or sequential (Liu & Wong, 2012; Lang & Chrzan, 2014); and whether to define MMT in terms of cognitive processing or behavioral action. Focusing on different aspects of MMT, studies have distinct conceptualization and operationalization of MMT on these three questions. The current section does not aim to offer an ambitious generative definition of MMT, but just to give a definition that fits well with our specific research question and research goal on MMT.

The broad research question of the current study is why people multitask with media. In other words, I am trying to figure out what drives the urge toward MMT. So, to answer the first definitional question about how to define media tasks, I adopted a human-centered (compared to task/medium centered; Segijn, Xiong, & Duff, 2018) perspective. More specifically, based on threaded cognition theory (Wang, Irwin, Cooper, & Srivastava, 2014; Salvucci & Taatgen, 2008; David, 2017), I define a media task as a cognitive thread which is media information that is encoded, organized, coordinated, and integrated by the cognitive mechanism. However, the core assumption of threaded cognition theory that information threads are established on goals (in a top-down way) is potentially problematic. Instead, a more reasonable way to identify a single thread and a single media task is in a bottom-up (automatic) way, determined by features of the information as well as the cognitive mechanism. For example, when the voice and images in a movie are out of sync, our cognitive system can hardly integrate the voice and images into a single thread, even
though the auditory and visual information serves the same goal – watching the movie. In that case, the out of sync voice and images in the movie might be processed as different cognitive threads, and thus interfere with each other, which separate the movie into multiple media tasks. Nevertheless, I would argue that the goal/motivation system still plays a critical role in selecting and fueling the processing of threads, which serve as options for people to choose, in a top-down way. So, in this study, media tasks are defined as motivated information thread, which is determined in both bottom-up and top-down way.

For the second definitional question, I would treat concurrent multitasking and sequential multitasking as a totality that is the opposite of single-tasking, which means that I see concurrent multitasking and sequential multitasking both as MMT. There are drawbacks of this view of MMT because it neglects many other media processing states like the rest state, boredom state, mind wandering state, etc. But at this initial stage of this study, this simplified model (treating concurrent and sequential MMT as a totality) fits well with our goal to understand the rewarding/motivating nature of MMT, as a deviation from single-tasking without needing to scrutinize the level of which processing occurs.

For the last definitional question, I would define MMT in a behavioral way instead of in a cognitive processing way. This is because our goal is to explain what initiates or activates MMT versus single-tasking. So, I specifically focus on the initiation and activation point between multitasking and single-tasking, instead of the ongoing processes after the putative initiation or activation. Thus, in the current study, I define MMT as a motivated action which initiates concurrent or sequential processing of multiple threads of information on media. For example, I would define the action of opening a music app while reading a book as MMT.

2.2 “Umbrella” Concepts of Media-Multitasking

There are two main “umbrella” concepts of MMT. One is multitasking, and another one is human information behavior (HIB; comes from the literature of information science; for a review: Wilson, 2000). MMT is commonly regarded as a specific type of multitasking (Lang & Chrzan, 2014). In this way, it could be easily assumed that the motivation toward multiple media tasks would be similar to the motivation
toward multiple general tasks. But the question, why processing multiple general tasks could be motivating, is still unsolved.

Thus, to examine the motivation toward MMT, I think it might be helpful to discuss another “umbrella” concept, human information behavior (HIB). HIB is broadly defined as “totality of human behavior in relation to sources and channels of information, including both active and passive information seeking, and information use” (Wilson, 2000, pg. 49). Thus, based on this definition, HIB should include all kinds of media behavior, such as watching a movie, reading a book, or browsing on social media, because media is regarded as a type of information source or carrier. Based on this idea, I am emphasizing that MMT is a type of information behavior (Spink & Park, 2006; Spink, Park, Jansen, & Pedersen, 2006). Taking a step further, from a human-centered perspective, I would argue that human’s media behavior could hardly be a passive information behavior, but rather in an active and selective manner. This is based on Limited Capacity for Motivated Processing model (LC4MP; Lang, 2009), which posits that people’s media message processing, such as television viewing, is an interplay of motivation system and cognitive resources system. And it is also consistent with the commonly appreciated ideas that our attention is selectively guided by both bottom-up and top-down processes (Johnson & Dark, 1986), and thus could be regarded as motivated attention (Lang, Bradley, & Cuthbert, 1997). Even though it is admitted that passive media content processing might exist, this thesis specifically focuses on the active and motivating aspect of media behaviors.

So, based on this idea that our attention on media is active and selective, I further assume that media use is a type of sensory information seeking behavior, which is broadly defined as the motivated acquisition of information from selected information carriers (Johnson, 1997). Thus, MMT is viewed as a specific type of sensory information seeking behavior. For example, switching the television channel could be as sensory information-seeking behavior for the new sensory information at the new channel. Likewise, opening music player while reading a book could be information seeking behavior for the new auditory information. With this assumption, I propose that the rewarding nature of MMT simply comes from the sensory information itself, or some properties of the sensory information that is provided from the multitasking behavior.
2.3 Previous Explanation of MMT: Motivation Approach

In motivational studies of MMT, Uses and Gratifications (U&G) framework has been used to explain why people tend to media multitask (Zhang, & Zhang, 2012; Xu, Wang, & David, 2015; Wang, & Tchernev, 2012; Hwang, Kim, & Jeong, 2014). It suggests that people’s MMT behavior is driven by certain needs as well as gratification by satisfying the needs, such as work, entertainment, and social interaction. However, this framework focuses on separating MMT into different types of MMT (like work, entertainment, or social interaction) instead of treating MMT as a general tendency, so it can hardly explain the motivation toward the general MMT. Another problem of this U&G explanation of MMT is that it assumes rewards of MMT solely comes from the adherent tasks instead of coming from MMT itself. For example, it explains the affective gratification of work MMT comes from the task of work, and gratification of entertainment MMT comes from the task of entertainment. So, it only focuses on the extrinsic rewards of MMT, neglecting that MMT by itself could be rewarding.

Instead of investigating separate needs and gratifications from media use, as illustrated from the Uses and Gratification theoretical framework, a model to explain the general media multitasking behavior as well as its rewarding nature will be proposed in this thesis. Empirical evidence for the rewarding and motivating nature of MMT is elusive but robust. Yeykelis, Cummings, and Reeves (2009) revealed that people’s arousal, regarded as motivational intensity, covaries with media task-switching behaviors. Wang and Tchernev (2012) used emotional gratification, led by fulfillment of specific needs, to explain MMT. Similarly, Strayer and Watson (2012) found dopamine release when people turned to a new task. Moreover, many other studies focusing on individual differences have shown that sensation-seeking (Duff, Wang, & Anghelcev, 2014) and impulsivity (Sanbonmatsu, Strayer, Ward, Watson, 2013) are significant correlates of trait MMT. These findings together indicate an inherently rewarding and motivational nature of MMT. However, to our knowledge, there hasn’t been an integrative theory explaining this rewarding nature of MMT.
2.4 Previous Explanation of MMT: Cognitive Control Approach

An alternative explanation is about cognitive control, which refers to a family of top-down mental processes including inhibition, interference control, working memory, and cognitive flexibility (see a review, Diamond, 2013). Cognitive control capacity, as a trait, can explain individual differences between high media multitaskers and low media multitaskers (For a review, please see Uncapher and Wagner, 2018). Specifically, lower cognitive control, including working memory capacity (Wiradhany & Nieuwenstein, 2017), information filtering (Ophir, Nass & Wagner, 2009), task-switching (Baumgartner et al., 2014), and inhibitory control (Xu, Wang, & David, 2016; Baumgartner et al., 2014; Gorman & Green, 2016), have been suggested as predictors of high trait MMT. However, these cognitive factors can hardly explain the rewarding nature of MMT. This is because this explanation arbitrarily sets MMT as the default state and sets single-tasking as a state achieved by cognitive control, based on its assumption that cognitive control resources are limited and inhibiting task is effort consuming. Another issue is that the assumption of the cognitive control explanation, that self-control relies on limited resources, is questionable (Inzlicht, Schmeichel, & Macrae, 2013). It is suggested that the seemingly limited self-control could rather be a motivational issue of switching between “have-to” and “want-to”, instead of a resources or ability issue.

Furthermore, I would argue that MMT is usually not a default state, but a motivated state. To support this idea, we might need to consider an associated construct, boredom (Ralph, Thomson, Eastwood, & Smilek, 2014). Boredom, defined as a disengaging motivational state, whose function is to encourage the exploration of alternative goals (Eastwood, Frischen, Fenske, Smilek, 2012; Bench, & Lench, 2013), suggests that inattention or self-interference (deviation from single-tasking) is somehow initiated and driven by our motivation. It suggests that multitasking could also be a motivated action rather than set as a default state. From a dual system perspective of self-control and impulse (Hofmann, Friese, & Strack, 2009), we might be able to model this intriguing relationship, that single-tasking could be the default mode, disengagement (e.g. MMT or boredom) could be the motivated state. In addition, cognitive control could be the higher-level control to suppress the impulse/motivation and draw the agent back to single-
tasking for a longer-term goal. The goal of the current study is to examine the motivating process of MMT at the intermediate level.

Besides this cognitive control explanation, another explanation, exploratory attention (Ophir, Nass & Wagner, 2009) or breath-biased attention (as opposite of depth-biased attention; Lin, 2009), offers a novel and appealing approach to address this problem about the motivating nature of MMT. Specifically, Ophir, Nass, and Wagner (2009) mentioned briefly that high media multitaskers might be biased toward exploratory information processing (as opposed to exploitive information processing) because high media multitaskers are inclined to process irrelevant information. Uncapher and Wagner (2018) also posited that the different balance between exploration (biased toward the alternative source) and exploitation (biased toward task-relevant and known source) causes different sensitivity to task-irrelevant information and thus could lead to different MMT profiles. In the current study, I will propose an Exploration-Exploitation model that could account for the variation of MMT between individuals and will test this exploration account. To do this, I will bring up two possible models (Information Foraging Model and Exploration-Exploitation Model) to explain MMT, and then theoretically justify the second model, the exploration account of MMT, with theories from decision-making theories and reinforcement learning theories.

2.5 Model 1: MMT and Information Foraging Theory

In their book, The Distracted Mind, Gazzaley and Rosen (2016) proposed that people, born as information foragers, tend to multitask because of the novelty of switching media tasks. The novelty of a new task activates people’s reward processing to maximize information intake, which is evolutionarily advantageous because it promotes the exploration of the new environment. They used an Information Foraging model to describe and predict people’s MMT behavior (See Fig. 1; adopted from Gazzaley & Rosen, 2016, pg. 15).

Under the evolutionary perspective and developed from optimal foraging theory (Krebs, 1977), Information Foraging Theory (IFT; Pirolli and Card, 1995) is an ecological model to describe and explain people’s behavior assessing, seeking, and handling information sources. This theory is built upon on bounded optimization assumption, meaning that people strive to optimize the net gain within the immersed
environment (Pirolli and Card, 1999). As an optimality model, IFT has three major assumptions: *Decision Assumption* assumes that each action is based on a decision after processing the encountered information; *Currency Assumption* assumes that the choice of information foraging strategy is evaluated through the putative currency (i.e., information value) and choice principle (i.e., gain maximization, cost minimization, and stability); *Constraint Assumption* defines that relationship between decision and currency variables, which includes constraints that arise out of the task structure, like the interface technology, the abilities and knowledge of users.

There are several merits of this IFT explanation of MMT. First, from an evolutionary perspective, it brings up an optimality model of information seeking activity and assumes that people have the ability to maximize information intake (Gazzaley and Rosen, 2016; Coulter-Smith, 2018). Second, it is based on the *Decision Assumption* for people’s information seeking behavior, that each action is taken based on the decision-making process with analyzing and evaluating the information and the environment. Moreover, this decision-based model is a two-sided choice (i.e., stay or leave) model to describe information behavior, which is useful for us to build the next model of MMT, an Exploration Exploitation Model.

However, there are also several drawbacks with the IFT model of MMT. First, information foraging in media “patches” has some critical differences compared to food foraging in food patches, that IFT failed to bring up. For example, the value/resource of food patches is decreasing by nature because, based on marginal value theorem (Charnov, 1976), the food at a certain patch is limited, so the consumption on the food patch will inevitably lead to decreasing exploitation rate per cost unit on the patch. But for information patches, there is no such rule. Watching a movie will not necessarily make the remaining part of the movie less valuable per cost unit. Another difference is that the cost of leaving in information foraging should be much lower than the cost of leaving in food foraging. For example, switching a television channel is much less effort consuming than moving to a new food foraging habitat. Considering these two differences between media foraging and food foraging, the prediction and equations of IFT derived from food foraging theory should be adjusted and reframed to fit the media context.
Another problem of IFT is that it assumes that the value of the information is evaluated and computed by its relation to the embedding task environment, rather than the intrinsic property of the information (Pirolli & Card, 1999). However, I would argue that the value of information is evaluated based on both extrinsic value and the intrinsic value of the information. For example, the value of a stock news article highly relies on the stock market, which is the extrinsic value of the information, determined by the information’s embedding context. On the other hand, the value of video picturing how lions hunt gnus in Africa are largely relied on the intrinsic value of the information, which is activated by the information itself, such as informativeness, novelty, and uncertainty (Oudeyer & Kaplan, 2007). I think this is important because, to explain the general tendency toward MMT, we need to be more concerned about the intrinsic property of the media task rather than its embedding context. This argument about intrinsic (vs. extrinsic) motivation system will be further discussed in the last section of this literature review.

2.6 Model 2: MMT and Exploration vs. Exploitation Model

Adopting IFT’s decision assumption and optimality assumption, I will introduce an Exploration-Exploitation model, which potentially solves the problem of MMT as a two-choice decision problem (i.e., multitasking or single-tasking). Even though the idea of exploration has already been suggested as a possibility by Ophir, Nass, and Wagner (2009) as well as Uncapher and Wagner (2018), there was no in-depth explanation or empirical testing of this model, which I will explain in the following sections.

The question about exploration vs. exploitation has been brought up and examined in psychology, computer science, animal studies, and management studies (Hills et al., 2015). The basic idea of this dilemma between exploration vs. exploitation is that for a decision maker (a learning machine, a foraging organism, or a profitable corporation), even though the most optimal strategy to obtain the highest extrinsic reward is to constantly exploit the most extrinsically rewarding choice (i.e., exploitation), it is still necessary to temporarily sacrifice the most extrinsically rewarding option to explore the alternative options (i.e., exploration) for the information about the environment to improve future decisions (Daw et al., 2006; Cohen, McClure & Yu, 2007; Laureuro-Martínez et al., 2015; Knox, Otto, Stone & Love, 2011; Mehlhorn et al., 2015). It has been argued that even though the act of exploration is associated with
risk and uncertainty, the information that the agent obtains from exploration can lead to a better long-term performance in an uncertain world. A classic example to illustrate exploration-exploitation trade-off is ordering food in a restaurant. You can either choose the dish that you always enjoy (exploitation) or try out a novel and uncertain entrée (exploration) (Jepma & Nieuwenhuis, 2011). Hills et al. (2015) argued that this exploration vs. exploitation problem lies on various levels across different domains, from the individual level to an organizational level. For example, a corporation also needs to choose between exploiting existing market or taking efforts in exploring additional possible markets.

A commonly used approach, to model and justify this exploration-exploitation dilemma, is through reinforcement-learning. From a reinforcement-learning perspective, the decision-making process is considered as a continuous process. In this continuous process, the agent is always learning how to make decisions, through conditioning and updating knowledge. A general framework to represent this continuous decision process contains three parts: acts, states, and outcomes. Acts represent options that the decision maker must choose between, states represent the ways that the world would turn out, and outcomes represent the possible consequences of each act (Newell, Lagnado, & Shanks, 2015). Through each act, the agent will obtain an outcome, and get into a new state, based on the act. The outcome might deliver a reward or a punishment to the decision maker depending on the act and the underlying policy of how the outcomes are mapped on the acts. In this way, the learning process of obtaining information is important to the decision makers because they live in an uncertain world. The uncertain environment of decision-making means that the decision makers are uncertain about how the outcomes ultimately map onto their acts. Thus, the agent needs interact with the environment to obtain information and reduce the uncertainty to maximize future utilities.

Gottlieb et al. (2014) suggested that the computational decision-making model, Partially-Observable Markov Decision Processes (POMDPs; Kaelbling, Littman, et al. 1998; Dayan & Daw, 2008) might be helpful to justify the necessity of information sampling over directly obtaining the utility. This POMDPs formulation of decision-making process specifies that decision makers are performing tasks under a partially observable state, which means that the decision makers are uncertain about the outcomes
(reward or punishment) of their potential acts. So, instead of constantly directly obtaining utility, the decision makers would also choose to observe, through information sampling. The activity to collect information may be effort consuming, but it can help decision-making in a long-term, especially when uncertainty is high. This is because under an uncertain situation, observing action could increase the likelihood of reward of subsequent actions in the future. Empirically, Adomi, Shikauchi, and Ishii (2010) reproduced people’s behaviors in a maze task using a *Hidden Markov Model* within POMPDs framework, suggesting that people’s exploration-exploitation behavior is effectively adapted to an uncertain decision-making environment. In the current work concerning MMT behavior, I specifically look at the exploration-exploitation tradeoff within the decision-making process of an individual’s behavior and attention on media.

Within the continuum between exploration and exploitation, it is necessary for an agent to navigate deliberately between exploration and exploitation under an uncertain environment. One question is what the best strategy is to obtain optimal rewards from the continuous decision-making process. Computer scientists have developed several machine learning algorithms to solve this problem (Daw et al., 2006). For example, one of the decision strategies is to add a certain level of extra reward to the uncertain option which needs to be explored, which is called *uncertainty bonus* (Cohen, McClure & Yu, 2007). This putative algorithm seems also consistent with the phenomenon in media studies that people tend to process neutral stimuli as positive when first encountered, which is also called positivity offset (Ito & Cacioppo, 2005; Lang et al., 2013).

Empirical studies using behavioral methods and brain imaging methods have been developed to apply this Exploration-Exploitation Model to human behaviors. Daw et al. (2006) developed a non-stationary *four-armed bandit task* to model participants’ choices of either the same gambling “machine” (exploitation) or the new gambling “machine” (exploration) in a gambling game. They tested if human’s choices were complied with choices by the reinforcement learning algorithms (e.g., “greedy”, “softmax” or “uncertainty bonus”), and found that a “softmax” reinforcement learning model matched the behavioral data on the bandit task the best. Beesley, Nguyen, Pearson, and Pelley (2015) used eye-tracking data to
investigate human’s attention behavior (eye-gaze), which can also be modeled in this exploration-exploitation trade-off problem. Martinez et al. (2015) used fMRI data to associate brain activation and behavioral choices between exploration (associated with attention control cortical area which tracks alternative choices) vs. exploitation (associated with the reward-seeking cortical area) in a four-armed bandit task. Besides, dopaminergic system (reward circuit activated during exploration indicating novelty bonus algorithms; Wittmann, Daw, Seymour, & Dolan, 2008), integrative decision-making circuit (reward, risk, and uncertainty processing; Behrens et al., 2007), and Locus-Coeruleus Norepinephrine system (Adaptive Gain Theory predicting that LC-NE system activation mediates exploration behaviors; Aston-Jones & Cohen, 2005) have been suggested to play a critical role in this issue. Further details about the normative and descriptive explanation about how people navigate between exploration and exploitation would be given in the current thesis because that is out-of-scope of what we want to answer about MMT.

Another interesting and moderately relevant question is what drives exploration. Studies have suggested that participants’ decisions within exploration vs. exploitation trade-off follow the ratio choice rule or the Matching Law (Walker, Pelley, & Beesley, 2017). This means that the ratio of selected choices corresponds to the ratio of the reinforcement of each option. For example, option A would be selected twice as much as option B, if option A is reinforced twice as option B. Another account is uncertainty drives exploration (complying with uncertainty bonus algorithm), and it suggests that there would be a positive relationship between uncertainty and exploration. Notably, uncertainty is also the most fundamental assumption of the Exploration-Exploitation problem, because the function of information is to help against the uncertain decision-making context. If the context is certain, then there would be no reason for exploration. The uncertainty account has been supported by robust empirical evidence (Beesley, Nguyen, Pearson, & Le Pelley, 2015; Gold & Shadlen, 2007; Knox et al., 2012; Speekenbrink & Konstantinidis, 2015). Walker et al. (2017) tested these two accounts using a four-armed bandit task, and they found in a low uncertainty condition, the choices follow the optimization rule (exploitation), that participants constantly choose the most extrinsically rewarding option. But in a high uncertainty
condition, the choices follow the ratio choice rule (exploration). This means that the ratio of reinforcement and uncertainty together predicts people’s exploration vs. exploitation choice in the context of extrinsic rewards.

Moreover, this decision-based model could not only be applied to the decision-making of behaviors such as choosing a gambling machine in a multiple-armed bandit task, but could also be applied to the decision-making of attention (Beesley et al., 2015; Camara, Manohar & Hussein, 2013; Daddaoua, Lopes, & Gottlieb, 2016). Deco and Rolls’ review (2005) proposed a unified theory of attention, working memory and decision making, which suggested that reward-based decision-making could bias sensory information competition and thus effect perceptual attention. Also, the idea of attention control (top-down) stresses that attention, regarded as information sampling, is guided by decision-making process (Vandormael et al., 2017), which is implemented by our reward processing system, such as dopaminergic system (Gottlieb et al., 2014). Specifically, the drives of attention could be categorized into exploitation, which is determined by the extrinsic value of the information, and exploration, which could be determined by intrinsic properties of the information, such as novelty and uncertainty (Vandormael, 2017; Beesley et al., 2015). In the current study, I would build the linkage between the Exploration-Exploitation Model and MMT, and then I would apply this model to solve the research question in this study, that is why people media multitask. In this Exploration-Exploitation Model, I would propose multitasking corresponds to exploration, while single-tasking corresponds to exploitation. Then I propose that people who tend to MMT do so because of the drive to explore as opposed to exploit.

So, why would exploration correspond to MMT? In MMT, media users process multiple threads of information, compared to media single-tasking. The processing of these additional threads of information is regarded as the information processing strategy of exploration as opposed to exploitation because multiple-threads processing could be seen as self-interference and self-motivated disengagement from the primary task, the highest extrinsically valued task. Moreover, Gazzaley and Rosen (2016) suggested that the reason for MMT is because the novelty of the new task will activate people’s reward processing and make them switch to the new tasks frequently. Thus, I think the activation mechanism of MMT, as a
deviation from media single-tasking, is the drive toward exploration to obtain novel information while sacrificing the exploitation to maximize the extrinsic value. This account is compatible with the empirical negative effect of MMT on primary-task performance (Van Der Schuur, Baumgartner, Sumter, & Valkenburg, 2015), which suggests that MMT requires sacrificing exploiting the extrinsic value.

Four-armed bandit task (Daw et al., 2006), which is designed based on the Exploration-Exploitation Model, would be a good task to describe MMT. In this multiple bandit task, people make decisions among multiple options, whose reward rate is uncertain. Imagine that an agent’s media choice is like a four-armed bandit task (see Fig. 2). There are four options for the agent to choose between (i.e., reading a paper, watching a movie, listening to music, and checking social media). The extrinsic value of these four options varies in a moderately stochastic way, which means that the agent needs to explore the options to obtain intrinsic value (i.e., reducing the uncertainty about the current extrinsic value of the option). For example, the agent chooses to read a paper (exploitation) because the extrinsic value of the paper is high. While obtaining extrinsic value from the paper for a while, the uncertainty of the alternative options will motivate the agent to choose to check the other options, like social media, or listen to music, or check out a movie (exploration) for updating the knowledge about the extrinsic reward of these alternative options. The agent’s choice of continuing the same option (exploitation, staying reading the paper) would represent single-tasking, while the choice of different options (exploration; open a music app, open Netflix, or open Facebook app) would represent multitasking.

In this manner, I would predict that high media multitaskers, who are more likely to attend to new media tasks, might choose to explore more in a four-armed bandit task, than low media multitaskers. This individual difference hypothesis is highly consistent with the empirical findings about the low information filtering capacity of heavy media multitaskers, which means higher accessibility to the novel information (Ophir, Nass, & Wagner, 2009). This exploration account put the breadth-biased attention vs. depth-biased attention (Lin, 2009) into a context of exploration vs. exploitation model and argue that breadth-biased attention is exploration-bias in a decision-making context. Thus, I hypothesize that:
**H1) People who make more choices to explore vs. to exploit in a multi-armed bandit task would score higher in trait MMT.**

2.7 A Curiosity/Intrinsic-Motivation Approach to Explaining Exploration and MMT

The exploration account of MMT is essentially a motivation-based decision-making approach to address the question of why people multitask on media. Thus, an important term that should be clearly explained is the motivation of exploration. As illustrated in Information Foraging Theory, people’s media behavior can be task-relevant. Thus, its value can be determined by the embedding task context. Besides, as illustrated in the Exploration-Exploitation Model, people’s media behavior could also be task-independent and determined by the intrinsic property of the media content such as novelty and uncertainty. This is because, humans, as continuous decision-makers, need to obtain information to infer the hidden rule or policy (how the acts mapped on the outcomes), and thus need to be information seekers to learn the world and reduce uncertainty. These two distinct processes, obtaining information and obtaining utility, are the two distinct fundamental motivations (i.e., extrinsic motivation and intrinsic motivation) that drive people’s decision making and behaviors. Specifically, the intrinsic motivation that drives spontaneous exploration is also called *curiosity* (Berlyne, 1954; Oudeyer, Gottleb, & Lopes, 2016).

In psychology, the common approach to distinguish intrinsic and extrinsic motivation is through the concept of instrumentalization (Ryan & Deci, 2000):

“Intrinsic motivation is defined as the doing of an activity for its inherent satisfaction rather than for some separable consequence. When intrinsically motivated, a person is moved to act for the fun or challenge entailed rather than because of external products, pressures or reward.” (Ryan & Deci, 2000, pg. 56)

The intrinsic motivation fosters *curiosity*, which is an intrinsically motivated exploration and learning process (Oudeyer and Kaplan, 2007). For example, from a developmental psychology perspective, young infants’ curiosity and learning behavior, like trying to grasp, throw, bite, squish or shout at new objects, is argued as driven by the intrinsic motivation because there is no external drive to do so (Oudeyer, Gottleb, & Lopes, 2016). Adults could also often be intrinsically motivated to engage in
behaviors like solving puzzles, painting, gardening, reading novels, watching television, and many other media-related behaviors. The motivation for exploration and learning is especially distinct from extrinsic drives, like money, hunger or pain (White, 1959). Extrinsic motivation is defined by Ryan and Deci (2000; pg. 56) as:

“Extrinsic motivation is a construct that pertains whenever an activity is done in order to attain some separable outcome. Extrinsic motivation thus contrasts with intrinsic motivation, which refers to doing an activity simply for the enjoyment of the activity itself, rather than its instrumental value.” (Ryan & Deci, 2000, pg. 56)

Notably, the divorce of intrinsic motivation from extrinsic motivation in terms of instrumentalization does not separate intrinsic motivation from the extrinsic value entirely, as illustrated in the last section. Systematically, the intrinsically motivated exploration could also benefit the extrinsic value in a long-term, but I would argue that intrinsic motivation and extrinsic motivation are still computed through separate motivation systems. For example, the intrinsic motivated exploration and learning behavior of a young infant, even though it benefits the extrinsic values in the long term as the infant is learning, still does not serve any extrinsic value. These longer-term benefit on extrinsic value justifies the design of the intrinsic motivation system and make it reasonable as an optimality model.

Several information features, including surprises, novelty, intermediate complexity, knowledge gap, and error in prediction could elicit intrinsic motivation (Barto, Mirolli, & Baldassarre, 2013; Oudeyer & Kaplan, 2007; Schmidhuber, 1991) and thus enhances exploration for the intrinsic value of information as opposed to enhancing the exploitation of extrinsic value. Thus, in our proposition of an Exploration-Exploitation Model of MMT, I am arguing that the novel information occurred in MMT could be intrinsically rewarding and could activate the exploration for broader information intake.

The distinction between intrinsic motivation (non-instrumental) and extrinsic motivation (instrumental) on media processing is important to examine people’s media behaviors. For example, people may be attracted by political news about the presidential election in a newspaper. The value of the political news is mainly determined by the embedding task of the political information -the presidential
election. In this case, reading the political news is regarded as an instrumental behavior for the election task, thus the motivation toward the political news is mainly extrinsic motivation. On the other hand, people may be also interested in solving a puzzle in the newspaper. Since there is no instrumental value of the puzzle, this motivation should be regarded as intrinsic motivation, which could be elicited by intermediate difficulty, novelty or uncertainty.

There has been evidence of neuroscientific support for the relationship between novelty, intrinsic motivation and reward of exploration (for a review, please see Kidd & Hayden, 2015). DeYoung (2013) proposed that the general function of dopamine is to promote exploration, defined as “any behavior or cognition motivated by the incentive reward value of uncertainty”, based on entropy model of uncertainty. Minderman et al. (2009) found that the dopaminergic midbrain, comprising the Substantial Nigeria and Ventral Regimental Area (SN/VTA), is activated by predicted novelty stimuli as well as unpredicted novelty stimuli. This evidence reflects that SN/VTA activation is related to people's motivational tendency toward novelty, which drives exploratory behavior (Wittmann et al., 2007).

Furthermore, curiosity, not just as a state influenced by stimulus factors (Berlyne, 1954), could also be an individual difference factor, defined as “desire for acquiring new knowledge and new sensory experience that motivates exploratory behavior” (Litman & Spielberger, 2003; pg. 75), that consistently impacts people’s exploratory behavior and attention. Risko, Anderson, Lanthier, and Kingston (2012) showed that high trait curiosity people will engage in a more widespread saccadic exploration of visual scenes. Baranes, Oudeyer, and Gottlieb (2015) showed that higher trait curiosity is associated with faster anticipatory shifts of gaze to the expected location of the answer, and trait curiosity could be accurately assessed by trained machine using only gaze patterns. Previous studies have suggested that this trait curiosity is associated with seeking novelty and could be guided by the dopaminergic system activation. Zald et al. (2008) found that trait novelty trait is negatively associated with D2-like receptor availability in the midbrain. So, they propose that high novelty seeker is associated with accentuated dopaminergic response to novelty that induces dopamine release for novelty.
Interestingly, studies on animal models have also examined trait curiosity and exploratory behavior. Patrick, David, Pinaud, Henri, and Weimerskirch (2017) have shown that the exploration tendency (information searching) vs. exploitation tendency (foraging for food) is consistent within animal individuals. They found boldness as a trait could predict the animals’ exploration tendency. Besides, both human and animal studies suggested that novelty seeking level is associated with D4 dopamine receptor genes (Benjamine et al., 1996).

In the previous section, I hypothesized that the high vs. low media multitaskers have a different tendency on their choices in an exploration-exploitation dilemma context because the exploration-exploitation model could be the underlying mechanism to determine people’s multitasking or single-tasking behavior. Based on the argument above about the association between trait curiosity and exploratory behavior/attention, I further propose that curiosity could be associated with people’s trait MMT.

_H2) People’s trait curiosity will be positively associated with trait MMT._
CHAPTER 3
METHODOLOGY

3.1 Participants

109 participants were recruited from the Advertising Research Participation System, a participant-pool affiliated to the Department of Advertising at the University of Illinois at Urbana Champaign. Upon completion of the study, one-course credit and lottery opportunity to win two Amazon gift cards ($20) were rewarded to the student. Responses from five participants were removed because their responses in the four-armed bandit task followed systematically abnormal patterns. Specially, one participant answered almost all the same, and other four participants responded in systematic patterns repeatedly. Thus, these five responses were recorded as measure failure and removed from the dataset, which leaves 104 responses in the dataset.

3.2 Study Design

This study is designed to test the association between trait MMT, a tendency toward exploration (vs. exploitation), and curiosity. In our study, participants first completed a version of the “four-armed bandit task” measuring their tendency toward exploration vs. exploitation in a gambling task context. Then, they completed a questionnaire measuring their trait MMT, trait curiosity and demographic information. Distinct from previous study design (like in Ophir, Nass, & Wagner, 2009), I did not separate the participants into two groups (i.e., high media multitasker vs. low media multitasker). Instead, I treat trait MMT as a unimodal continuous random variable, thus I collected data from all the participants for further analysis.

3.3 Measure of Variables

*Exploration (vs. Exploitation) Tendency:* To assess the participants’ tendency toward exploration (vs. exploitation), a “Pick A Door Task” was adjusted from the Four-Armed Bandit Task in Daw et al. (2006). In this task, the participants were instructed to choose one of the four-colored rectangles (representing 4 doors) presented on the screen, to obtain a payoff, through pressing corresponding keys (i.e., “Q”, “W”, “E” or “R”) on the keyboard. While the “Four-Armed Bandit” refers to choosing one of
four images that are supposed to represent slot machines in the original task design, this may be confusing to participants, thus I adapted the look to be rectangle “door” for them to choose (see Fig. 3). The parameters of rewarding points under each “door” were set as a decaying Gaussian random walk function (an example of the underlying rewarding points was given in Fig. 4). The task was designed to simulate the uncertain decision-making context. In this context, the participants were uncertain about the underlying policy of the rewards, so they need navigate between exploitation to obtain the highest reward and to exploration to obtain information to infer the underlying policy of the rewards, to optimize their overall rewards. Previously, this task has been used to understand decision-making pattern under uncertainty within individuals, however, it should also be able to show individual differences on the tendency toward exploration (vs. exploitation) under uncertainty.

In this task, the participants need to complete one training session (including 4 trial) and four test sessions (seventy-five trials for each session) with breaks between each session (Daw et al., 2006). During the break, the participants were shown points earned during the last session. The participants were informed that their goal is to obtain as much payoff as they could through the 300 trials. To motivate the participants and attract their attention to the task, I also informed them that the two participants who earned the highest points will be rewarded an Amazon gift card ($20). However, the chance to win the gift cards was equal for every participant because I did not associate their response data with their personal information. I informed them that the selection would be randomized during the end debrief section of the study. This procedure was approved by the IRB committee.

During the Pick A Door task, participants’ choices of the “door” were recorded. The choice of continuing choosing the same “door” as they had chosen on the previous choice was dummy coded as exploitation (0) and the choice of a different “door” from the previous one was dummy coded as exploration (1). For example, if the participant chooses “Q” first, and then the choice of “Q” in the following trial would be coded as exploitation (0), but the choice of “W”, “E”, or “R” would be coded as exploration (1).
Trait Media Multitasking: The measure of Trait MMT is a combination of two scales (see Appendix). The first scale is adopted from Duff et al. (2014), which is a 2-item scale (5-point-Likert ranging from “Never” to “Often”) asking general frequency of MMT behaviors: “How often do you multitask in general? (e.g., talk to a friend while watching TV)” and “How often do you use multiple media at the same time? (e.g., use a computer while watching TV).” The second scale is a 15-item scale (5-point-Likert ranging from “Never” to “Often”), which was adopted from the Short-Media Multitasking Index (Baumgartner et al., 2017). The questions asked participants about how frequently they concurrently engage in two different media tasks (e.g., watching television while reading) in their daily life. Specifically, the scale asks about 15 combinations of six different media tasks (i.e., watching television, listening to music, reading, texting, online communication, talking on the phone). I choose two scales to measure a single variable is because I think there are limitations on both scales (see also Segijn, Xiong, and Duff, 2018). For the 15-item scale developed from Baumgartner et al. (2017), the repetitive and boring nature of the questions might burden participants who just finished the boring Pick A Door Task, which lasts for about 15 minutes. Moreover, our proposal is that high media multitaskers are inclined to exploration (vs. exploitation) and process irrelevant information compared with low media multitaskers. So, the repetitive nature of the scale might cause a systematic difference in measure of trait MMT because high media multitaskers might pay less attention to the questions, which will lower the reliability and validity of this measure. On the other hand, the two-item general scale from Duff et al. (2014) also has a limitation due to its limited number of questions. Fewer questions diminish the variability of the variable and sensitivity of the measure, compared with the measure with more questions, and thus lower the reliability of the measure (Abdelmoula, Chakroun, Akrout, 2015). Concerning on limitations of these two measures, I decided to measure MMT using these two scales, and then combine them together (by averaging the two statistics) to represent the variance of these two scales and thus diminish the limitations of these two scales. Multiple measures of the same construct are considered as more advantageous than a single measure, because multiple-response measures are generally more reliable than single-response measures (Price, Jhangiani & Chiang, 2015). Thus, they suggested that
researchers can combine different measures of one single construct, as long as the individual variables are correlated with each other.

**Trait Curiosity/Exploration:** The Curiosity and Exploration Inventory (see Appendix; Kashdan, Rose, & Fincham, 2004) was utilized to measure participants’ trait exploration. This 7-item scale (7-point-Likert scale ranging from “Strongly Disagree” to “Strongly Agree”) is divided into 2 factors: exploration (the pursuit of novelty or uncertainty) and Absorption/Flow (fully engaged in a task). In the current study, this scale is intended to measure participants’ subjective and affective feeling of their general preference to exploration as opposed to exploitation, and only the exploration dimension was utilized as the measure of trait curiosity. Even though I also asked questions in Absorption dimension, the response to these questions was not analyzed because this study conceptualizes curiosity as a unitary construct, rather than a multi-dimensional construct. Also, the putative Absorption (fully engaging in a task; state of flow) dimension is out of our interest about curiosity as intrinsically motivated exploration.

**Demographic Information:** Demographic items (age, ethnicity, gender, enrollment status, and class standing) were collected by a questionnaire (see Appendix).

3.4 Procedure

Participants in the laboratory were first provided informed consent and then were seated at a computer terminal. The researcher helped them login into Psychopy software (Peirce & MacAskill, 2018), and let them complete the Pick A Door Task on the software. After they have completed the task, they were automatically redirected to a Qualtrics questionnaire, where they completed the two Media Multitasking scales, Curiosity and Exploration Inventory, and demographic questionnaires sequentially. The items of both Trait Media Multitasking scale and Curiosity and Exploration Inventory were randomized to avoid order bias, but I did not randomize the scale order. Once they completed the questionnaires, the data collection was completed. In the end, the participants were thanked and dismissed.
3.5 Analysis

As an initial step, to take trait tendency toward exploration (vs. exploitation) into the analysis, each individual’s probability of choosing to explore (vs. to exploit) in the Pick A Door Task was computed. Then, I transformed the probability variable into a logit variable, by logging the odds ratio of the probability, as the measure of a tendency toward exploration. This is because the logit model is considered as a better choice than a probability model in linear regression analysis when the probability response follows a binomial distribution (Liao, 1994). In this way, we can extend the boundaries of the probability variable from \([0, 1]\) to \((-\infty, +\infty)\), and avoid the marginal effect of the probability model, which contradicts to the linear relationship assumption of linear regression analysis.

Next, the two MMT scales, the two-item scale (Cronbach’s alpha = .654) and the 15-item scale (Cronbach’s alpha = .866) were entered to obtain statistic for MMT variable. Notably, the reliability analysis of the two-item scale indicates low reliability, which means that these two items do not load together well in a single variable. I decided to drop the first question (asking frequency of attending to media task while doing any other task) and maintain the second question (asking frequency of attending to media task while attending to another media task) because our definition of MMT restricts the type of the tasks to be only media tasks. Then, I averaged the statistics of the single-item (after drop the first item) and the 15-item scale, to obtain the statistic of MMT variable. Combining statistics from these two measures is considered valid given the correlation between these two measures is acceptable (\(r = .467\)).

Lastly, the Curiosity variable was entered for analysis. This variable is measured through Curiosity and Exploration Inventory (Kashdan, Rose, & Fincham, 2004), which divides curiosity into two dimensions, Exploration (tendency to seek out new information and experiences) and Absorption/Flow (tendency to fully engage in the rewarding experiences). This categorization of curiosity contradicts to our unitary conceptualization of curiosity, and the definition of Absorption (engaging in the task) is also contradicting to the concept of curiosity (intrinsically motivated exploration). With this concern, I decided to drop this dimension of absorption while maintaining only exploration dimension as a measure of curiosity (Cronbach’s alpha = .675).
CHAPTER 4

RESULTS

104 responses (80 females) were analyzed after the completion of the data collection. The descriptive demographic statistics (please see Table 1 for demographic information) indicated that 80% of the participants were females. So, we conducted an one-way ANOVA analysis to investigate if gender impacted the hypothesis testing. The results revealed that gender has insignificant effect on trait MMT (F [1,102] = .445, \(MSE = .429, p = .502\)), trait tendency toward exploration (F [1,102] = .443, \(MSE = .580, p =.507\)), as well as trait curiosity (F[1,102] = .515, \(MSE = .588, p = .475\)).

For descriptive statistics of trait variables (trait MMT, trait tendency toward exploration, and trait curiosity), please see Table 3. Hypothesis 1 predicts that people who make more choices to explore vs. to exploit in a Pick A Door task will score higher in trait MMT. A regression of MMT (\(M_{media\ multtasking} = 2.814, SD = .653\)) on tendency toward exploration in the Pick A Door Task (as a logit statistic, \(M_{exploration\ in\ bandit\ task} = - .808, SD = .760\)) accounts for 4.9% of the variance in tendency toward exploration (F [1, 102] = 5.236, \(MSE = .554, p = .024\)). Thus, the tendency toward exploration in the Pick A Door Task is a significant predictor of trait MMT (\(\beta = .221, p = .024\); see Fig. 5 for the scatter-point plot). Considering that I took an analysis procedure to combine and average two distinct statistics from two scales to obtain a single construct, this method might have introduced p-hacking concerns. I also conducted simple linear regression analysis for the association between trait tendency toward exploration and the two statistics (from the two scales) separately. The regression of trait tendency toward exploration on trait MMT (from the one-item scale of Duff et al., 2014) revealed significant correlation (F[1, 102] = .019, \(MSE = .114, p = .019\)). However, the regression of trait tendency exploration on trait MMT (from the 15-item scale developed from Baumgartner et al., 2017) revealed insignificant association between the two variables (F[1, 102] = 1.828, \(MSE = .376, p = .179\)).

Hypothesis 2 predicted that MMT will be positively associated with trait curiosity. A regression of MMT on trait curiosity (\(M_{curiosity} = 5.349, SD = .765\)) was performed, and there is no significant relationship between MMT and trait curiosity (F [1, 102] = .263, \(MSE = .430, p = .610\)). Notably, the reliability of this
measure is considerably low (Cronbach’s alpha = .675), and dropping any item does not lead to Cronbach’s alpha increase. Besides, I also conducted regression analysis for the possible association between the Absorption dimension of curiosity and trait MMT, and find an insignificant association between the two variables \( F[1, 102] = 1.461, MSE = .425, p = .230 \).
CHAPTER 5
DISCUSSION

This study aims to offer an exploration account of MMT by suggesting the Exploration-Exploitation Model as the underlying mechanism of why people choose to media multitasking. This account reflects Uncapher and Wagner’s (2018) call for studies on the underlying mechanism of MMT. It is also built upon on previous proposals about the potential relationship between MMT and exploration (Ophir et al., 2009; Lin, 2009; Uncapher & Wagner, 2018), as well as the information foraging proposition of MMT (Gazzaley and Rosen, 2016).

Like Information Foraging Theory, the Exploration-Exploitation account of MMT is based on three assumptions: Decision assumption which assumes that people’s MMT behavior is based on their decision; Optimality assumption which assumes that people’s behavior/attention on media is based on economical optimality principle; Currency assumption which assumes that the media tasks to be chosen are evaluated by information value and implemented by a motivational system. Like Use and Gratification Theory, this exploration approach is also motivation-based. It posits that MMT occurs when people are driven by intrinsic motivation elicited by novelty and uncertainty of the new tasks, and then deviate from exploitation (single-tasking) to exploration for new tasks (MMT).

To support this exploration account of MMT, I performed an empirical test on two hypotheses about individual differences between high media multitaskers and low media multitaskers. Our result supported the first hypothesis about the positive relationship between MMT and tendency toward exploration in a Pick A Door Task, but it did not support our second hypothesis about the positive relationship between MMT and curiosity, regarded as a tendency toward intrinsically motivated exploration and learning.

There could be several interpretations of this result. First, this insignificant result is considered questionable given the low reliability of this scale (Cronbach’s alpha = .675), which might lower the validity of this result. Also, the mean of curiosity statistic (5.349 out of 7) revealed that the sampled population is generally high in curiosity, which might indicate low generalizability of this result.

Second, assuming there is no Type-II Error, it could be possible that the motivation driven exploration-
exploitation mechanism may not exist because the test indicated insignificant relationship between curiosity (intrinsically motivated exploration and learning) and MMT. This means one fundamental assumption, the Decision assumption, may not hold for this exploration account of MMT. The significant relationship between exploration tendency in the Pick A Door Task and MMT could be due to other variables, such as information filtering, working memory capacity or self-control, instead of people’s decisional tendency or motivational tendency toward exploration. However, there is no empirical evidence or theories to support this interpretation, that cognitive control may influence decision-making on a multiple-armed bandit task. On the contrary, as I have illustrated in the literature review section, it appears that decision-making process controls cognitive control rather than the opposite.

The most possible interpretation is that motivation toward MMT is not solely driven by intrinsic motivation, but by an interaction between intrinsic motivation and extrinsic motivation of the information. The assumed independence between intrinsic and extrinsic motivation holds true based on the proposition that the participants are uncertain about the extrinsic value of the unattended task/choice. However, this assumption might not hold true because, even though people are uncertain about the exact extrinsic value of the unattended options, they could still expect that the options have extrinsic value based on previous experiences, which would then elicit extrinsic motivation. Thus, I would doubt that there is no pure intrinsically motivated behavior in the Pick A Door task or in daily media tasks. In other words, information behaviors, like MMT or performing the Pick A Door Task, might be both extrinsically and intrinsically motivated behavior, but curiosity only captures the intrinsically motivated aspect of information behaviors. Gottlieb and Oudeyer (2018) suggested that curiosity-driven information seeking occurs under a non-instrumental context, but information seeking behaviors can take place under an instrumental context as well. I think MMT and the Pick A Door task are more likely under instrumental contexts rather than non-instrumental contexts, because people have different sorts of extrinsic needs on media as illustrated by U&G, and the Pick A Door task creates a gambling game context which sets money as an extrinsic reward. Even though under these instrumental contexts, the drives of exploration should still be determined by the intrinsic value of the information, the insignificant relationship between curiosity and MMT indicates that
the intrinsic value of the information might need to interact with the extrinsic value of the information to activate people’s exploration behavior under an instrumental context.

5.1 Limitation and Future Direction

The major limitation in the current study is that the proposed Exploration-Exploitation model of MMT is only partially supported. This is because the measure of trait MMT, by combining two distinct scales to measure a single construct, is questionable. Specifically, the combined variable and the separate variable (from the one-item scale; Duff et al., 2014) indicated a significant association between trait MMT and trait tendency toward exploration, but the separate variable (from the 15-item scale; Baumgartner et al., 2017) did not reveal significant association between the two variables. Thus, future studies are needed to replicate the finding with other valid measures of trait MMT. There is still an argument in the literature on how to measure MMT (Sejign, Xiong, & Duff, 2018), so our measure of MMT (by combining two scales) needs further evidence to prove valid. Moreover, the conceptualization and operationalization of trait curiosity is also questionable in this study. First, the measure for curiosity has low reliability in this study. I noticed that there is an updated version of this measure, Curiosity and Exploration Inventory-II (Kashdan et al., 2009), so the future study may want to utilize this updated scale to measure curiosity. Second, Kashdan, Rose, & Fincham (2004) recognized trait curiosity as a multidimensional construct, which comprises exploration and absorption. However, based on the Exploration-Exploitation decisional-making context, the absorption dimension (engaged in the task) should be identified as exploitation which is the opposite of exploration. So, in this way, the absorption would conflict with the conceptualization of curiosity, as intrinsically motivated exploration. Future studies may want to investigate the conceptualization of curiosity, as either a unitary construct or a multi-dimensional construct.

For the measure of a tendency toward exploration in the Pick A Door Task, the problem is that the task is not designed to measure individual differences but to measure performance within individuals. In order to fit the goal to measure individual differences, this bandit task obviously needs adjustment. The current design use software to generate random numbers as parameters (i.e., the payoff of each “door”) for the test takers, which means the trait test is different for each individual to a certain degree. I think the
future study could adopt a pseudo-random process to generate the parameters for each “door” and set the parameters in the task all the same for each participant. This adjustment is to minimize random error occurred in the random number generation process, which produces an unnecessary pure error.

Also, a possible future direction could also develop experiments to empirically test this Exploration-Exploitation model of MMT. The current empirical testing is about the correlation between individual difference variables rather than an experiment with manipulative state variables. So, we cannot confidently infer any conclusion about the causal mechanism of MMT from the testing the correlation among individual differences, because the association cannot imply causal relationship involving MMT. Thus, future study is recommended to use experimental design to further verify this Exploration-Exploitation account of MMT.

Besides, I failed to find the relationship between MMT and curiosity (i.e., intrinsic motivation activated exploration and learning), which need a following-up study to find out how intrinsic motivation drives exploratory behaviors in an instrumental context, like MMT. Even though previous evidence indicated the similar dopaminergic system activation by both extrinsic value and intrinsic value of the information, there has been no study looking at whether the influence of intrinsic motivation and extrinsic motivation on exploratory behavior/attention follows additive model or non-additive model. So, following research can study how extrinsic value and intrinsic value of information together influence people’s information seeking behavior.

I also consider the instrumental valuation, which is not captured through the Pick a Door Task, might also play a significant role to determine media users’ multitasking behaviors. In this case, if we accept the idea that people’s information seeking behavior (like MMT) is driven by the interplay between both intrinsic and extrinsic value/motivation, then the instrumental values might help the explain the rest part of the error occurred in the association between tendency toward exploration and trait MMT. Future studies might want to clearly distinguish intrinsic value and extrinsic value of the media tasks before they could answer the questions about how intrinsic value and extrinsic value shape people’s media use behaviors.

5.2 Contribution and Implication

The current thesis may contribute to our understanding of MMT, especially about the cognitive
mechanism of MMT. Specifically, MMT is framed in a two-sided decision-making model, Exploration-Exploitation Model. It is suggested that people’s MMT behavior takes place when they decide (consciously or unconsciously) to explore (vs. to exploit). Moreover, the current study brought cognitive decision-making theories and reinforcement learning theories into media studies. I believe the normative decision-making approach could possibly contribute to many other research questions about empirical media behaviors, like boredom, State of Flow, or mind-wandering. Besides, this study also introduced the intrinsic/extrinsic motivation approach to explain media behaviors. Even though the hypothesis about intrinsic motivation (curiosity) and MMT is not supported in this study, I still believe it might be fruitful for future studies to look at how intrinsic value of information, such as novelty, surprises, intermediate difficulty, or uncertainty, influences media processing.

For empirical implication, the improved understanding of MMT definitely contributes to the practices in the media industry. As for advertising professionals, the possible mechanism of MMT as exploration decision-making can help them understand the consumers and audiences better. So, they can make advertising strategies and promote the products or healthy lifestyle based on this idea. For example, it is possible for an Amazon Echo device to detect if people were in the exploration-like states, such as bored, and then promote advertisements adaptively (Jain, 2018). Moreover, media content producers, such as Youtubers, may want to be more concerned about the novelty and uncertainty of their media contents, to attract people’s attention from their original primary tasks.

5.3 Conclusion

In general, our empirical result supported the exploration-exploitation model of MMT. The underlying mechanism of MMT may be people’s decision-making tendency toward exploration (vs. exploitation). However, our second proposal that MMT is driven by intrinsic motivation, elicited by intrinsic information properties such as novelty or uncertainty, is not supported, as revealed by the insignificant association between curiosity and MMT. This suggests that the intrinsic property may interact with the extrinsic property of the information to influence people’s exploratory behaviors under instrumental context such as MMT or exploration choices in a gambling task. The Exploration-Exploitation mechanism of MMT needs
further verification, and the proposition about the interaction between intrinsic value and extrinsic value also needs future studies to investigate.
### TABLES AND FIGURES

#### Table 1

Frequencies and Percent of Demographical Statistics

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Figure 1

A Representation of Optimal Foraging Model (Adopted from Gazzaley & Rosen, 2016)
Figure 2

A Four-Armed Bandit Task Model of Media Tasks

Listening to Music

Reading Papers

Watching a Movie

Checking Social Media

Extrinsic Value

Music  Papers  Movie  Social Media
Figure 3

Pick A Door Task (Adjusted From the Four-Armed Bandit Task; Daw et al., 2006)

Now you can press "Q" or "W" or "E" or "R" to open a door you want.

You have got: $0.61
Figure 4

An Example of Decaying Payoff of Each “Door”
Figure 5

Regression of MMT on Tendency Toward Exploration in Pick A Door Task (Hypothesis 1)
REFERENCES


APPENDIX: QUESTIONNAIRES

Demographic questions

1. What is your age? Please type the number of your age. (open-ended question)

2. Ethnicity (or Race): Please specify your ethnicity:
   (Caucasian (or White); African American (or Black); Hispanic American (or Latinos); Asian American (or Pacific Islanders); Native American (or American Indians); Mixed race or ethnicity; African; Hispanic; Asian; Others; Prefer not to answer)

3. What is your gender?
   (Male; Female; Other; Prefer not to answer)

4. Class standing: What is your class standing?
   (Freshman; Sophomore; Junior; Senior; Master/Doctoral; Professional Student; Continuing Education Student; Non-Degree seeking)

Media multitasking Measure (modified from Baumgartner et al., 2016)

1. How often do you watch video content (TV, YouTube, movies, etc) while listening to music?

2. How often do you watch video content (TV, YouTube, movies, etc) while reading (reading or doing homework)?

3. How often do you watch video content (TV, YouTube, movies, etc) while doing online communication (e.g. emailing, or sending messages/posting on Facebook, Instagram, Snapchat or etc. But not including Facebook chat)?

4. How often do you watch video content (TV, YouTube, movies, etc) while texting or instant messaging (including Facebook chat)?

5. How often do you watch video content (TV, YouTube, movies, etc) while talking on the phone (including video chatting with phone)?

6. How often do you listen to music while reading (reading or doing homework)?

7. How often do you listen to music while doing online communication (e.g. emailing, or sending messages/posting on Facebook, Instagram, Snapchat or etc. But not including Facebook chat)?
8. How often do you listen to music while texting or instant messaging (including Facebook chat)?
9. How often do you listen to music while talking on the phone (including video chatting with phone)?
10. How often do you read (reading or doing homework) while doing online communication (e.g. emailing, or sending messages/posting on Facebook, Instagram, Snapchat or etc. But not including Facebook chat)?
11. How often do you read (reading or doing homework) while texting or instant messaging (including Facebook chat)?
12. How often do you read (reading or doing homework) while talking on the phone (including video chatting with phone)?
13. How often do you do online communication (e.g. emailing, or sending messages/posting on Facebook, Instagram, Snapchat or etc. But not including Facebook chat) while texting or instant messaging (including Facebook chat)?
14. How often do you do online communication (e.g. emailing, or sending messages/posting on Facebook, Instagram, Snapchat or etc. But not including Facebook chat) while talking on the phone (including video chatting with phone)?
15. How often do you text or instant messaging (including Facebook chat) while talking on the phone (including video chatting with phone)?
16. How often do you multitask in general? (e.g., talk to a friend while watching TV)?
17. How often do you use multiple media at the same time? (e.g., use computer while watching TV)?

Responses are indicated on four-point scale labeled “Never”, “A little of time”, “Some of time”, “Most of time”.

Curiosity and Exploration Inventory (CEI; Kashdan, Rose & Fincham, 2004)

Using the scale shown below, please respond to each of the following statements according to how you would usually describe yourself. There are no right or wrong answers. (7-point-Likert scale ranging from Strongly Disagree to Strongly Agree).

1. I would describe myself as someone who actively seeks as much information as I can in a new
situation.

2. When I am participating in an activity, I tend to get so involved that I lose track of time.

3. I frequently find myself looking for new opportunities to grow as a person (e.g., information, people, resources).

4. I am not the type of person who probes deeply into new situations or things.

5. When I am actively interested in something, it takes a great deal to interrupt me.

6. My friends would describe me as someone who is “extremely intense” when in the middle of doing something.

7. Everywhere I go, I am out looking for new things or experiences.