ABSTRACT

Title of Dissertation:	THE DEVELOPMENT AND VALIDATION OF A HIERARCHICAL MULTIPLE-GOAL PURSUIT MODEL
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Individuals are faced with multiple goals in life, at work, and across these realms every day. Organizational psychologists have begun to address how individuals prioritize goals over time using computational modeling and simulation (e.g., Vancouver et al., 2010). However, they have focused on situations in which an individual must neglect one goal to prioritize another with certainty about the consequences of their actions. Further, the impact of higher-level motivations (e.g., values, identities), on more proximal goal choices remains to be incorporated into dynamic theories of goal pursuit. The current project advances this work by developing a *hierarchical* multiple-goal pursuit model (HMGPM), which proposes a hierarchical goal system based on Kruglanski and colleagues' (2002) goal systems theory. The HMGPM specifies qualitatively different levels in this system – *means, tasks*, and *distal goals* – and describes the mechanism by which they influence one another via *instrumentality.* A computational model is specified and subsequently simulated in a virtual experiment. Specifically, contexts are examined in which two tasks can be simultaneously pursued or prioritized one over one another under varying goal network structures and means instrumentality certainties. Specific conditions are then replicated in an empirical repeated-measures experiment in which participants act as university advisors and make schedules for hypothetical students. Simulation and lab study results revealed 1) when individuals have multiple tasks, they prefer a *multifinal* means that simultaneously accomplishes both, 2) when individuals have a single task, a multifinal means may be less appealing despite its instrumentality, and 3) uncertainty may further drive individuals to maximize their overall likelihood of progress using a multifinal means. Comparisons of the simulation and lab study results revealed 1) the process by which individuals choose means may not simply be driven by a utility-maximization rule at each decision point, and 2) individuals may discount a multifinal means' instrumentality via a different mechanism than previously theorized (e.g., Zhang et al., 2007). In sum, the current project advances our understanding of how individuals make choices between their many possible actions depending those actions' consequences, and their ability to predict those consequences, for their multiple goals.

THE DEVELOPMENT AND VALIDATION OF A HIERARCHICAL MULTIPLE-GOAL PURSUIT MODEL

by

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Chapter 1: Introduction and Theoretical Background

Significance

Work requires balancing multiple priorities. At work, 81% of managers report holding more than one position, and therefore having different goals, across multiple teams (Mortensen & Gardner, 2017). For many individuals, such as the 42% of women who reported reducing their work hours in order to care for family in a 2013 report by Pew Research Center, completing one goal often means sacrificing progress on another.

Organizational psychologists have recently been focused on advancing our understanding of how individuals make choices in their prioritization of these multiple goals. At the most basic level, achieving multiple goals requires making choices and engaging in behavior that successfully reduces the distance between where the goal-striver is and where the goal-striver wants to be on each of their goals. However, reality is unsurprisingly more complex. For example, in some situations, one goal may not need to be prioritized *over* another. Rather, an individual may be able to complete both simultaneously using the same behavior, such as when a parent works from home while caring for a child. Further, individuals do not only consider how their choices align with what they need to complete immediately, but also with what they may want to do in the future or even what values and identities they wish to uphold and express. Finally, achievement of multiple goals may require self-regulation even when the best course of action or the effects of an action toward those goals are unclear.

The recognition that individuals are more frequently pursuing multiple goals simultaneously rather than one goal at a time (Vancouver, Weinhardt, & Schmidt, 2010) has improved the external validity of motivation research in the organizational sciences. It has also emphasized the complexity that remains to be addressed in goal-pursuit processes. The current project further unpacks this complexity by investigating the influence of the specific factors of goal hierarchy and uncertainty on multiple-goal pursuit.

Thus far, multiple-goal pursuit research has examined contexts in which an individual prioritizes one immediate goal over another at any given time and knows how effective the possible actions toward those goals will be (e.g., Vancouver et al., 2010). The current project advances this research by incorporating the notion of a goal hierarchy, where the value of an individual's immediate goals is driven by their higher-level motivations. Further, it expands multiple-goal pursuit research into contexts in which individuals are not limited to pursuing one goal at the expense of another. Rather, they can behave in a way that helps them achieve multiple goals simultaneously. Finally, the current research addresses how individuals perceive the relationship between their current behavior, their immediate goals, and their more distal goals, how that impacts their choices in multiple-goal pursuit, and how uncertainty in the effectiveness of their actions may change those dynamics.

The current research takes a process-focused approach in order to better capture the complexity of multiple-goal pursuit. A computational model is advanced that incorporates mechanisms of goal pursuit with the notion of a goal hierarchy. A virtual experiment is conducted via simulations of this model in order to examine the impact of specific factors of interest in a controlled manner. A repeated-measures lab study is then conducted to examine the validity of the computational model. Before describing the computational model, simulations, and empirical study, relevant literature on multiple-goal pursuit and hierarchical goal networks is reviewed.

Multiple-Goal Pursuit

Self-regulation theories that describe an individual's behavior while maintaining pursuit of a goal have emerged as an important lens in the contemporary study of motivation in organizational psychology. Most recently, self-regulation theories have been applied to a multiple-goal context, in which an individual pursues multiple simultaneous goals under a deadline. These multiple-goal pursuit models tend to focus on the choices that individuals make between their goals over time. Generally, the characteristics that impact an individual's decision to pursue a goal are the expected consequences of attaining a goal, or its *value*, and the likelihood of attaining it, or its *expectancy* (e.g., Raynor, 1969; Vroom, 1964). A goal's *expected utility* is the combination of these two determinants. In the context of goal choice, individuals are posited to compare expected utilities of multiple goals when deciding which goal to pursue using a particular rule, such as maximization (Kanfer, 1990).

The current models of multiple-goal pursuit (e.g., Ballard, Yeo, Loft, et al., 2016; Kernan & Lord, 1990; Vancouver, Weinhardt, & Schmidt, 2010) integrate these factors of goal choice with dynamic theories of self-regulation. These theories specify how individuals update their behavior in order to move toward some desired end state. Carver and Scheier's (1982) theory of self-regulation is at the core of contemporary multiple-goal pursuit models. This theory proposes a cybernetic process with a negative feedback loop in which an individual compares their current state to their desired state, enacts some behavior based on that comparison, and re-evaluates their current state based on how their behavior impacted their environment. Through this iterative process, their current state ideally approaches their desired end state, representing goal attainment. While Carver and Scheier's (1982) theory proposed this feedback loop for a single goal, multiple-goal pursuit models apply separate negative feedback loops for each goal within the system. Further, by incorporating components from cognitive choice theories, these contemporary models provide a description of how an individual decides to enact a behavior toward one desired state versus an alternative following the comparison of their current states with their ultimate goals.

Vancouver, Weinhardt, and Schmidt's (2010) multiple-goal pursuit model (MGPM) specifies a negative feedback loop for each of two goals. For each goal within the MGPM, an individual compares their current level of performance in pursuit of the goal with the desired state, resulting in a *discrepancy*. This discrepancy is combined with a weighting term, called *gain*, that represents the extent to which an individual places subjective importance on the goal above and beyond their distance from attaining it. *Valence*, or the combination of discrepancy and gain, is itself combined with expectancy. *Expectancy*, or the individual's likelihood of attaining the goal, is a function of the individual's expected rate of goal attainment, the discrepancy, and the time remaining before the given deadline. Valence and expectancy combine to ultimately result in a goal's *expected utility*, which is compared to the alternative goal's expected utility. The goal with the highest expected utility is then chosen to be pursued. As the goals are pursued, their valences and expectancies are updated based on changes to their discrepancies and the time remaining before the deadline and the individual switches between the two goals depending on new comparisons of their expected utilities.

While Vancouver et al.'s (2010) maximization rule in the goal choice component of their model is consistent with prior theories of motivation, it is a simplified specification. Ballard and colleagues (2016) added a preference accumulation model based on decision-field theory (DFT; Busemeyer & Townsend, 1993) to better represent human decision making in the MGPM. In their updated multiple-goal pursuit model (MGPM*), each action (e.g., to pursue goal A or to pursue goal B) has an expected impact or consequence for each goal (e.g., pursuing goal A may result in successful movement only toward goal A or toward both goal A and goal B). Consistent with DFT (Busemeyer & Townsend, 1993), an individual shifts their attention between the consequences, weighing the utility of each action with respect to that particular consequence, until a preference is accumulated for one action over the other. That action is taken, some consequence is realized, and the individual loops through the goal comparison and choice processes described by Vancouver et al. (2010) and Ballard et al. (2016) until they achieve their goals, the deadline is reached, or a specified number of decisions have been made.

These models of multiple-goal pursuit have laid the foundation for the study of self-regulation in more complex contexts and have been used to examine a variety of motivational phenomena important to the organizational sciences, such as self-efficacy (Vancouver & Purl, 2017) and learning (Vancouver, Weinhardt, & Vigo, 2014). However, they remain only a piece of the broader goal pursuit picture. Specifically, these models of multiple-goal pursuit have only examined contexts in which individuals are forced to prioritize one goal over the other. While certain contexts may constrain the available actions an individual can take to pursue their goals in such a way that one action cannot help them complete multiple goals at once, many contexts do not. For example, an individual with a parenting goal and a work goal may be able to work from home while caring for their child, completing both goals at once. A researcher with a goal of learning a new analytical strategy and a goal of publishing a peer-reviewed article may develop a research project that allows them to complete both simultaneously rather than prioritize one over the other. This alternative context remains to be examined.

Further, current models of multiple-goal pursuit have incorporated the notion of subjective importance through the *gain* component of a goal's valence. The origin or derivation of this subjective importance remains unexplored. In some circumstances, the subjective importance of a goal may play only a minor role in an individual's motivation to pursue it over others. In others, it may have significant consequences for the choices an individual makes. For example, while an individual may have a large performance goal directly related to their work responsibilities, the influence of a desire to socialize or for belongingness may increase the subjective importance of planning a work-related social event to the point that the individual prioritizes it to the detriment of their performance goal. The current project develops a multiple-goal pursuit model that specifies this derivation of subjective importance from higher-level motivations, such as a desire to belong.

In order to extend current multiple-goal pursuit models to better capture contexts in which goal progress can be made simultaneously and higher-level motivations influence the subjective importance of these goals, the model developed here integrates the notion of a goal hierarchy with multiple-goal pursuit processes. Toward that end, prior research on goal hierarchies and a specific theory of goal systems (Kruglanski, Shah, Fishbach, et al., 2002) is reviewed next.

Goal Systems Theory

Goal systems theory (Kruglanski et al., 2002) is a theory of motivation that provides a parsimonious, general framework in which to structure a goal hierarchy. Goal systems theory proposes that the motivational constructs of *goals* and *means* can be arranged in a network with vertical and lateral connections between them, similar to cognitive associative networks in general. In these goal networks, a superordinate element, such as a goal, may be connected to more than one subordinate elements, or means. These are cases of *equifinality*, where a goal may be achieved via one of many routes. Further, a subordinate element, such as a means or a goal, may be connected to one or multiple superordinate elements. A subordinate element that is connected to a single superordinate element is *unifinal*, whereas a subordinate element that is connected to multiple superordinate elements *multifinal*. In other words, a lower-level means or goal may help achieve only a single higher-level goal in the case of unifinality or multiple in the case of multifinality. Figure 1 visually depicts generalized cases of equifinality, unifinality, and multifinality. The strength of these connections, or their instrumentality, is discussed in detail next.

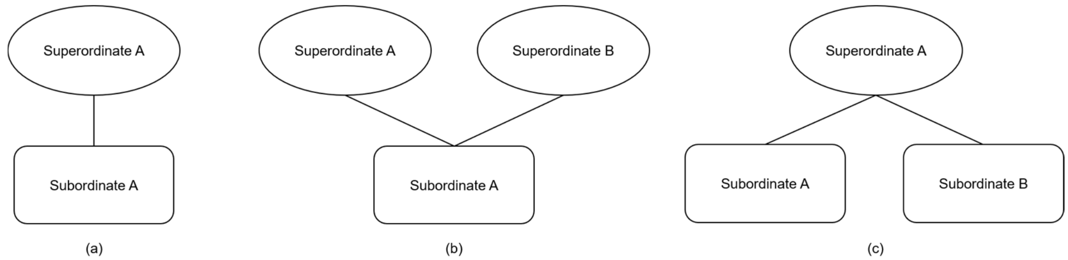

Figure 1. Representation of Unifinal, Multifinal, and Equifinal Goal Elements

Representations of a) unifinality, where a subordinate element is connected to a single superordinate element; b) multifinality, where a subordinate element is connected to multiple superordinate elements; and c) equifinality, where a superordinate element is connected to multiple subordinate elements.

Instrumentality

In cognitive associative networks such as this, the activation of one element in the system activates other connected elements through a spreading activation process (Anderson, 1983; Kruglanski et al., 2002). The extent to which any particular means or goal increases the accessibility of another connected means or goal in the network is determined by the respective connection's association strength.

Association strength is often developed and increased via co-occurrence of two elements in the network (Meyer & Schvaneveldt, 1976). For example, an individual who is able to work from home in order to watch their children when they are not in school would perceive the means of working from home as more associated with the goal of performing parental duties than an individual who is not able to work from home. Association strength may also increase between a means and a goal as the number of alternative means associated with that goal decreases (Gollwitzer & Brandstatter, 1997). For example, compared to an individual with a more flexible work schedule who can perform a variety of parenting tasks after work, an individual whose typical working hours are long may perceive the means of working from home as more associated with the goal of performing parental duties due to the lack of other viable means to that goal.

Co-occurrence is closely tied to functional effectiveness, since a more effective means is likely to be used more often in pursuit of a goal than a less effective means. Individuals often assume the opposite direction of causality, using the high association strength between a means and a goal as a heuristic that the means is effective at attaining the goal (Zhang et al., 2007). Goal systems theory refers to this connection between association strength and effectiveness as *instrumentality*, or the perceived extent to which a lower-level element in a system is effective toward the achievement of a given higher-level element (Kruglanski et al., 2002).

Instrumentality is an important component in well-known, more traditional motivational theories, such as Vroom's VIE theory (1964). According to VIE theory, a higher perceived instrumentality between an opportunity and a desired outcome increases an individual's motivation for that opportunity. In Raynor's (1969) theory of future orientation effects and achievement motivation, instrumentality has a similar influence on an individual's motivation to pursue a goal. According to Raynor (1969), an individual's perception of a goal is influenced by its likelihood of allowing one to pursue a subsequent goal in a contingent path. The higher the likelihood, the more positively the goal is evaluated.

In more contemporary research on goal choice, instrumentality has been studied as both association strength and perceived effectiveness. For example, a higher instrumentality or association strength between a means and a goal results in greater activation of that goal (Shah & Kruglanski, 2003). Orehek and colleagues (2012) find that locomotors, or individuals with a stronger preference for continual movement through an activity, prefer means with higher perceived instrumentalities. The authors suggest this preference is driven by the perception that a means with a higher instrumentality affords more movement toward a goal (i.e., is more effective).

The impact of perceived instrumentality on goal pursuit has also been shown in a workplace context. For example, employees are more likely to pursue work goals outside of regular work hours with laptops and phones when those devices (i.e., the means to their work goals) are perceived to be more instrumental (Fenner & Renn, 2010). Performance in pursuit of a bonus has been shown to be lower when employees are less certain that that their performance will earn them the bonus (i.e., lower perceived instrumentality; Wood, Atkins, Bright, & James, 1999). Similarly, viewing the accomplishment of a simple typing goal as more advantageous in terms of job security and coworker respect (i.e., greater instrumentality of a more proximal goal to higher-level goals) was related to greater improvement on that typing goal (Yukl & Latham, 1978). Further, perceiving training as more instrumental to performing on the job is related to actually applying that training (i.e., training transfer; Chiaburu & Lindsay, 2008). Perceived instrumentality is thus a critical component in goal networks and goal pursuit both in life and at work.

The structure of an individual's goal network also plays a critical role in how that individual pursues their goals and perceives the instrumentality of their means to those goals. As discussed, a means or a goal may be unifinal or multifinal to its respective higher level in a goal network. A unifinal means/goal is connected, or is instrumental, to a single higher-level goal. A multifinal means/goal is instrumental to multiple higher-level goals (Kruglanski et al., 2002). When individuals have multiple equally important goals, a means that serves all simultaneously (i.e., a multifinal means) tends to be preferred. For example, Chun, Kruglanski, Sleeth-Keppler, and Friedman (2011) observed that individuals who were primed with a positive Korean identity and were tasked with hiring a candidate for a job that was biological in nature preferred a candidate that demonstrated knowledge in both biology and Korean history. Similarly, Kopetz et al. (2011) observed that individuals primed with the goals of both food enjoyment and weight control preferred foods that were both flavorful and low-calorie.

While multifinality may seem preferable to unifinality due to a "bigger bang for your buck" heuristic, evidence suggests that it may also decrease the appeal of a means/goal. Zhang and colleagues (2007) describe this pattern as the *dilution effect* based on their observations that individuals' perceptions of the instrumentality of lower-level means/goals tended to diminish as the number of vertical connections they shared with higher-level goals increased (i.e., increased multifinality in the goal network). Evidence for the dilution effect was also reported by Kopetz and colleagues' (2011) study of food choice in which individuals primed with only the goal of food enjoyment preferred foods that were flavorful, but not low-calorie. Presumably, the instrumentality of foods that were both tasty and nutritional to the goal of food enjoyment was diluted because they served both the goal of "food enjoyment" and an alternative goal such as "having a healthy diet". Thus, when an individual has a single focal goal, a means that only serves that goal (i.e., a unifinal means) is preferred.

In a more direct test of this effect, Chun et al. (2011) observed that students asked to select the highest quality paper from two alternatives that were identical besides their color more frequently selected the control-colored paper versus the paper that was their university's color. The university-colored paper was viewed as serving multiple goals (selecting the highest quality paper and aligning oneself with the university) and therefore was perceived as less instrumental to the focal goal of selecting the highest quality paper.

The study of the impact of perceived instrumentality and the dilution effect more specifically has been limited to cross-sectional designs. These designs provide evidence for how instrumentality impacts goal choice, but less so how it impacts dynamic goal pursuit. Further, less focus has been given to how perceptions of instrumentality itself changes throughout goal pursuit. One focus of the current project is on the dynamics of perceived instrumentality, especially in a hierarchical goal network. Thus, literature on the *dynamics* of hierarchical goal networks is reviewed next.

Goal Pursuit in a Hierarchical Goal Network

Orehek and Vazeou-Nieuwenhuis (2013) propose that when an individual has two goals, one of which is of higher priority, the dilution effect should predict whether they choose to pursue them one at a time using two different unifinal means (i.e., a sequential strategy) or to pursue them simultaneously using a multifinal means (i.e., a concurrent strategy). They suggest that the weakened instrumentalities of a multifinal mean (the means that would help them attain their two goals simultaneously) will decrease its appeal to the pursuit of the higher priority goal (similar to the university-colored paper in Chun et al., 2011). Thus, they posit that an individual will follow a sequential goal pursuit approach by switching between unifinal means that are only instrumental to a single goal. However, the researchers also propose that as the perceived importance of two goals equalize, the dilution effect will become less pronounced and render a more concurrent approach to goal pursuit (i.e., multifinal means selection) attractive.

Steps have been taken to integrate goal networks and instrumentality into models of multiple-goal pursuit. Samuelson (2017) developed a hierarchical multiple-goal pursuit model (HMGPM) specifically to examine how the subjective importance (i.e., gain) of a goal is derived from higher-level goals and how it impacts multiple-goal pursuit. Simulations of the HMGPM resulted in patterns of goal-prioritization similar to those observed in studies on the dilution effect, reviewed above (Chun et al., 2011; Zhang et al., 2007). However, further integration of goal networks with self-regulatory theories of goal pursuit remains to be completed if a more comprehensive understanding of individual goal-pursuit is to be developed. The current project aims to continue that integration through further development of the HMGPM.

Research Statement

The current project aims to provide a broader conceptualization of individual multiple-goal pursuit by expanding on the previously developed HMGPM (Samuelson, 2017). The original development of the HMGPM incorporated the notion of a goal hierarchy into a model of self-regulation of multiple goals in order to more precisely specify subjective goal importance and allow for structural variety in the goal systems addressed by models of multiple-goal pursuit through uni- and multifinality. The current project further specifies the dynamics at the vertical connections, or perceived instrumentalities, in this goal hierarchy and examines goal pursuit in new goal network structures.

This novel theory of dynamic, hierarchical multiple-goal pursuit is described in the Model Description section. The current project first translates this theory into a computational model that represents the proposed relationships and mechanisms using quantitative algorithms and formulas. An advantage of this approach is the ability to examine the generative sufficiency and predictive validity of the theory to produce and account for observable patterns of multiple-goal pursuit behavior (Rand & Rust, 2011). To this end, simulations of the model are conducted in order to explore how the underlying mechanisms unfold over time and how the key factors of goal network structure and instrumentality certainty impact those dynamics. These simulation results are interpreted and subsequently guide an empirical study designed to examine the output validity of the proposed theory and model.

Two broad questions drive the current project. As discussed, there is little empirical or theoretical work integrating hierarchical goal networks with dynamic goal pursuit, especially from a behavioral perspective. Research on goal systems has tended to focus on single instances of means or goal choice (e.g., Chun et al., 2011; Kopetz et al., 2011; Orehek et al., 2012) or the cognitive associations between goal system elements (e.g., Zhang et al., 2007; Shah et al., 2002). Predictions regarding the influence of the goal system on actual pursuit have yet to be tested (Orehek & Vazeou-Nieuwenhuis, 2013). Further, research on self-regulation and multiple-goal pursuit has largely addressed patterns of switching between two goals in the absence of an option to achieve both simultaneously. The influence of higher-level goals and their connections to lower-level goals (i.e., goal network structure) on these patterns of switching is thus of interest. Consequently, a first research focus is guided by the following question:

> *RQ1: How and to what extent does goal network structure impact means choice during multiple-goal pursuit?*

The current project also aims to address how individuals evaluate the instrumentality of available actions in pursuit of their goals. Previous research has examined how goal network structure may impact instrumentality perceptions (e.g., Zhang et al., 2007) and how perceived instrumentality may impact choice of action (e.g., Chun et al., 2011), but the mechanism underlying the dynamics of that instrumentality perception and its interaction with more or less certain environmental feedback across goal pursuit is a new area of study. Thus, the second research focus of the current project is guided by the following question:

> *RQ2: How and to what extent does the certainty of instrumentality impact means choice throughout multiple-goal pursuit?*

The remainder of this paper is structured as follows. First, the updated HMGPM is developed and described. Following the model description, the simulations and their results are presented in Study 1. Study 2 presents the conditions of interest selected from Study 1 and the methodology used to examine them in a lab setting. The results of Study 2 are discussed within the context of the results generated by the simulations in Study 1. The paper is concluded with a discussion of the validity of the updated HMGPM and areas for future research and model development.

Chapter 2: Model Description

Samuelson's (2017) HMGPM built upon Vancouver et al.'s (2010) and Ballard et al.'s (2016) models of multiple-goal pursuit. As part of the current research, two extensions are incorporated into the HMGPM. The first update brings more precision to the levels of the goal hierarchy. In prior versions of the HMGPM, only two levels were specified: subordinate goals and superordinate goals. In the current version, three levels are specified: means, tasks, and distal goals. The second update specifies the dynamics of perceived instrumentality over time and, specifically, how individuals update their perceptions of the associations between vertically-connected elements in the goal system. The mechanisms and significance of both extensions are elaborated in the following sections.

Hierarchical Goal Network Structure

The hierarchical goal network structure in the HMGPM is based on Kruglanski and colleagues' (2002) goal systems theory. Goal systems theory provides a general hierarchical structure and research using goal systems theory has generally been agnostic toward the level of the vertical system within which the phenomena of interest lie. The HMGPM, on the other hand, specifies that levels of the system are qualitatively different. While a goal network may extend for many levels both up and down vertically (e.g., Carver & Scheier, 1982; Kruglanski et al., 2002; Powers, 1973;), there are three critically different elements in a goal hierarchy in the HMGPM. These elements are means, tasks, and distal goals.

A *means* is an action that can move an individual's current state closer to their desired state. A *task* represents an explicit, tangible desired end state. A task is tangible in that it has a *reference* that represents a specific number of units to be achieved. Finally, a *distal goal* is a desired end state that resides at the highest level in the generalized goal network structure. A distal goal represents a general motivational striving that acts as long-term influencers of an individual's behavior. The completion of a task may increase the sense that a related distal goal is satisfied; however, unlike tasks, distal goals do not have an explicit reference or number of discrete units that are to be attained. Rather, the satisfaction of a distal goal represents a shift in relative importance, or salience, towards other distal goals (Barrick et al., 2013). In summary, a *task* has an explicit, attainable reference attained via a *means* that represents one possible action taken in pursuit of that task. A *distal goal* is a higher-level goal that influences an individual's behavior and which decreases in importance via the completion of related tasks.

The number of tasks or distal goals to which a means or task, respectively, can be connected can vary. A single means, or action, may help attain multiple tasks. Similarly, a single task may help an individual satisfy one or many distal goals. A means or task that is connected to a single higher-level element is referred to as *unifinal* and a means or task that is connected to multiple higher-level elements is referred to as *multifinal* (Kruglanski et al., 2002). The number of upward connections of a means or task has implications for its perceived function in a goal network in the HMGPM, which is discussed in detail in the following section on instrumentality.

To summarize, the general hierarchical goal network structure in the HMGPM includes three distinct levels. At the lowest level reside *means*, which are specific actions that can be taken toward the completion of a specific *task* at the next highest level, which are subsequently associated with satisfying more abstract *distal goals* at the highest level in the network. Means and tasks may be unifinal (i.e., connected to a single task or distal goal, respectively) or multifinal (i.e., connected to multiple tasks or distal goals). Instrumentality lies at these vertical connections.

Instrumentality

Instrumentality is the association strength between two vertically connected elements in a goal system, or the perceived extent to which a means or task is effective toward the achievement of a task or distal goal, respectively (Kruglanski et al., 2002). Connections in a goal system are bidirectional, such that the lower-level element influences the higher-level element and vice versa (Kruglanski et al., 2002). Specifically, the lower-level element imparts a sense of achievement on the higher-level and the higher-level imparts a sense of utility or importance on the lower-level. Typically, the more instrumental a means or task is to a task or distal goal, the stronger the connection and the more influence flows between levels. While generally these principles hold at both levels of vertical connections (i.e., means to task and task to distal goal), they function differently due to an increase in abstraction at higher levels in a goal network. As such, the HMGPM distinguishes between two types of instrumentality: means instrumentality and task instrumentality.

Means instrumentality characterizes the vertical connection between a means and a task. The HMGPM proposes that the effectiveness, or instrumentality, of a means to a task is a function of two factors: 1) the degree to which it moves an individual's current state toward the desired end state in a given amount of time, and 2) the likelihood of it doing so. In this sense, means instrumentality can be represented as a *distribution* of possible task completion rates, where each possible progress rate has some probability of occurring.

Because the vertical connections within a goal system are bidirectional, characteristics of a task also influence its connected means. Specifically, the *valence* of a task, which is a combination of the number of units of the task remaining and the subjective importance (i.e., *gain*) of the task increases the *expected utility* of a means. Thus, a means connected to a task that is more subjectively important and has more remaining to be completed will have a higher utility.

Instrumentality between a task and a distal goal functions slightly differently. The HMGPM proposes that *task instrumentality* corresponds more closely to an association strength. Unlike a task, a distal goal does not have an explicit number of reference units to complete. An individual, for example, cannot observe the discrepancy between how much they currently feel a sense of belongingness and how much belongingness they wish to feel (a distal goal) in the same sense that they can observe the discrepancy between how many work events they have attended and how many work events they are required to attend (a task). However, an individual theoretically assesses the relative extent to which a specific task helps them satisfy a distal goal. For example, an individual who wishes to feel a greater sense of belongingness with their colleagues may assess attendance at work events as more or less associated with that desire for belongingness. Therefore, task instrumentality is conceptualized as a relative strength of association between task completion and satisfying distal goals in the HMGPM.

Similar to the flow of utility from a task to a means, importance flows from a distal goal to a task via instrumentality. Specifically, the relative importance of a distal goal impacts the degree to which a task is perceived as subjectively important. That is, it impacts its *gain* (Samuelson, 2017; Vancouver & Weinhardt, 2010). The more instrumental a task is to a distal goal, the more the distal goal's relative importance increases the task's gain.

Instrumentality Dynamics. Understanding the instrumentality at the vertical connections in one's goal network involves incorporating feedback from the environment into one's beliefs about that instrumentality. Goal systems theory proposes that goal networks behave conceptually similarly to associative cognitive networks (Kruglanski et al., 2002). Like in cognitive networks, associative connections between elements in a goal system may change based on observations collected from the environment. A frequent, strong sense of fulfilling one's role as a researcher when paired with the publication of a scientific article, for example, should serve to increase the degree to which publishing an article is perceived as instrumental to the distal goal of being a researcher due to a high co-occurrence (Meyer & Schvaneveldt, 1976). These updated instrumentalities based on feedback from one's environment inform future predictions about the connections within a goal network.

The HMGPM proposes to represent this mechanism through a simple Bayesian updating process. Bayesian or probabilistic models of human cognition assert that an individual's beliefs about the world are a function of their observations and their background theory/beliefs (Tenenbaum, Griffiths, & Kemp, 2006). Word learning in both children and adults, for example, can be described using a probabilistic reasoning model, where the probability that a new word has a given meaning is derived from example words that are known to have a similar meaning and the individual's prior understanding of that meaning (Xu & Tenenbaum, 2007). Similarly, there is evidence that much of cause and effect learning can be described as a Bayesian-like updating process (Gopnik, Glymour, Sobel, Schulz, & Kushnir, 2004; Tenenbaum, Griffiths, & Kemp, 2006; Rehder & Kim, 2006; Lu, Yuille, Liljeholm, Cheng, & Holyoak, 2008; Gopnik & Wellman, 2012). For example, Griffiths and Tenenbaum (2006) demonstrate that many "intuitive" judgments made by individuals, such as expected movie run times or the terms of U.S. representatives, align with predictions derived from the application of Bayes' theorem. In sum, a probabilistic approach is relevant to a broad array of cognitive processes (Tenenbaum, Griffiths, & Kemp, 2006; Oaksford & Chater, 2009) and provides a parsimonious model of how individuals might incorporate information from their environment (i.e., observed data) with their prior beliefs to generate predictions.

Under Bayes' theorem, an individual's expectation (the posterior probability) is a function of some prior probability and a likelihood based on observed data. With respect to instrumentality, the HMGPM proposes that an individual's perceived means or task instrumentality represents their prior probability. This prior may be influenced by a number of factors, such as the individual's previous experience with particular means-to-task or task-to-distal goal associations or, as proposed by Zhang et al. (2007), the number of vertical connections originating from the means or task (i.e., its multifinality).

The feedback an individual receives throughout goal pursuit represents the likelihood distribution in Bayes' theorem. These data about the observed instrumentality of a connection can be integrated with one's existing prior beliefs about its perceived instrumentality to produce a posterior distribution of possible instrumentalities. As an individual updates their posterior expectations, these updated instrumentality beliefs influence the next instance of goal choice.

In summary, the HMGPM expands on prior models of multiple-goal pursuit in three key ways. First, it specifies the differences between the hierarchical levels of a goal network. Rather than only specifying goals with actions that can be taken toward them, the HMGPM is precise about the differences between means, tasks, and distal goals. Second, this added specificity extends prior multiple-goal pursuit models into contexts where one means or completion of one task can impact multiple outcomes via multifinality. Finally, the HMGPM proposes a mechanism by which an individual learns the instrumentality of their goal pursuits. This mechanism and others in the HMGPM are described next.

Process Mechanisms

The processes in the HMGPM can be broken down into three sequential stages: (1) derivation of task gain, (2) means choice, and (3) goal network updates. A synopsis of the model is provided in Table 1 and a full description follows.

Table 1. *Hierarchical Multiple-Goal Pursuit Model Pseudocode*

Step	**Action**
1	Initialize time clock $T = 0$.
Task Gain	
2	Calculate each task's *gain* as a function of the *importance* of its connected distal goals and the *perceived task instrumentality* of it to each of those distal goals.
Means Choice	
4	Calculate each task's *valence* as a function of the number of units left to attain of the task goal (i.e., its *discrepancy*) and its *gain*.
5	For each means, calculate each connected task's *expectancy* as a function of the time remaining before the deadline, the amount of time it takes to attain one unit of that task goal via the given means (i.e., *means instrumentality*), and *time sensitivity* (i.e., the individual's sensitivity to deadlines).
6	Calculate each means' *expected utility* by combining its connected tasks' *valences* and *expectancies* associated with the use of that means.
7	Select the means with the greatest *expected utility*.
Goal Network Updates	
8	Based on the means chosen, determine the impact made on each task's *reference* as a function of the *true means instrumentality*.
9	Determine the change in each distal goal's *importance* as a function of the changes to each task goal's *reference* and the *true task instrumentalities.*
10	Update each means' *perceived means instrumentality* distribution and each task goal's *perceived task instrumentality* distribution based on the *true means* and *task instrumentalities* observed.
11	Sample *means instrumentalities* and *task instrumentalities* for each means' and task's connections to their higher-level elements, respectively.
12	Increment time clock $T = T +$ *expected lag* of means chosen in Step 5.
13	If $T <$ *deadline* and at least one task goal's *reference* > 0, repeat Steps 2 – 11.
14	End.

Note. T = current time.

Task Gain

Each distal goal *h* has an importance (*p*), representing its priority relative to other salient distal goals at a given time point (*t*). This importance is transferred to each of the distal goal's *k* connected tasks via that connection's instrumentality. Task instrumentality (*tc*) can take on any value between zero and one, representing the likelihood of successful attainment of the distal goal via the pursuit of the task goal. While instrumentality is dynamic, an individual's perception of an instrumentality prior to goal pursuit being carried out is determined by their previous experiences with or knowledge of the task. Thus, the initial perceived instrumentality will be lower if the individual's prior experience and knowledge suggests the task goal is less effective at helping them to attain the distal goal, and higher if the task goal is more effective.

Further, the impact of the dilution effect on initial perceived instrumentality is taken into consideration at this stage. Specifically, as the number of distal goals to which a task is connected increases, the perceived instrumentality of any connection between the task and one of the distal goals decreases (Zhang et al., 2007). In the current model, this effect is represented by scaling all the instrumentality connections between a task and its associated distal goals by the number of connected distal goals (i.e., dividing its instrumentality by the number of connected distal goals). In the derivation of gain (κ), instrumentality serves as a weighting term that determines the extent to which a distal goal's importance is transferred to a task's gain. A task's gain at each decision point *t* is thus the sum of all instrumentality-weighted importances.

$$\kappa_k = \Sigma[p_{kh}(t) \cdot tc_{kh}(t)] \quad (1)$$

Means Choice

Means choice is driven by the comparison of all available means' expected utilities. A means *j* has an expected utility (*u*) relative to each of its connected task goals *k*, and a total expected utility that is the sum of those expected utilities. Expected utility is the combination of the task goal's valence (*v*) and its expectancy (*e*) via the given means. Valence, representing the utility of acting on the task goal at a given time point, is the multiplication of the task goal's discrepancy (*d*), or the distance the individual is from completing the task (i.e., reference, *g*, minus current state, *c*)., and the task goal's gain. Thus, a task goal's valence is independent of the means.

$$v_k(t) = \kappa_k(t) \cdot [g_k(t) - c_k(t)] \quad (2)$$

Expectancy (*e*), representing the probability that the task goal can be completed in the time remaining via the given means, is calculated using the time available before the deadline (i.e., the difference between the deadline and the current time; *TA*), means instrumentality (*mc*), and time sensitivity (γ), representing the individual's reaction to deadlines. At this stage in the model, means instrumentality is the individual's belief about the amount of time it takes to attain a given number of units of the task goal via the means. The probability component of means instrumentality determines the sampling rate of possible values representing this belief. This latter component, as well as Zhang et al.'s (2007) dilution effect, operate in later stages of the model. Consistent with existing multiple-goal pursuit models (e.g., Ballard et al., 2016), these factors enter into a logistic function such that expectancy is 0.5 when the amount of time remaining equals the amount of time needed to complete the task goal via the given means and decreases as the amount of time needed overtakes the time remaining.

$$e_{jk}(t) = 1 / (1 + \exp[-\gamma(TA_k(t) - (d_k(t) \cdot mc_{jk}(t)))]) \quad (3)$$

Expectancy and valence are combined multiplicatively for each task goal for the given means, and the means' total expected utility is the sum of these products for each of its connected task goals *k* at each decision point *t*.

$$u_j(t) = \Sigma[v_k(t) \cdot e_{jk}(t)] \quad (4)$$

A maximization process similar to that used in earlier formulations of the MGPM (Vancouver et al., 2010) is used to determine an individual's means choice. Thus, the means with the greatest expected utility is chosen at each time point. Following this choice, the goal network is updated based on the consequences.

Goal Network Updates

Once a means choice is selected, a consequence in the form of task progress is realized. The amount of progress made on each task connected to the selected means is sampled from a likelihood distribution associated with that means' true instrumentalities. This sampled value (or values, in the case of a multifinal means) is used to update three components of the goal network. First, it is added to the current state of the connected task, representing progress toward the task reference.

Second, it is incorporated into the individual's perceptions of the means' instrumentality through a Bayesian updating process, where the individual's perceptions or expectations about the means' instrumentality are updated as more information becomes available. Through this process, the value is incorporated with the individual’s prior distribution for the means instrumentality. This results in a posterior distribution, which, depending on the variance of the prior and of the likelihood distributions, will gradually converge towards the true means instrumentality likelihood distribution with continued exposure. This posterior distribution determines the individual’s perceived means instrumentality in subsequent decisions

The third component that the sampled task progress impacts is the importance of any connected distal goal(s). As described above, progress made toward completing a task reduces connected distal goal(s) importance, or salience, via the connections’ association strength. Thus, a connected distal goal’s importance is reduced by the progress made toward a given task weighted by the task’s instrumentality to that distal goal.

The final update in the goal network structure is the task instrumentality. If no progress is made on a task, no feedback regarding its instrumentality to a distal goal can be observed and therefore its instrumentality is not updated. If progress is made, the consequence of the task’s progress for a connected distal goal’s fulfillment is determined based on the task’s instrumentality. Task instrumentality is a value between zero and one and represents the likelihood that positive feedback (i.e., task progress helped fulfill the connected distal goal) is realized or not. Thus, the consequence of positive feedback is sampled at a rate equal to the task’s true instrumentality. This sampled value of zero or one is then used to update the individual’s perceived instrumentality for that task to the connected distal goal. Because task instrumentality is a value between zero and one, the individual’s prior and posterior distributions of perceived task instrumentality are represented using beta distributions. The sampled value is incorporated with the prior distribution, resulting in a posterior distribution of perceived task instrumentality, which is used in subsequent runs of the simulation.

Following these updates to the goal network structure, another means choice occurs. This process continues until the deadline is reached or both tasks are complete, whichever occurs first. The specific parameter values used in the current simulation of the HMGPM are provided below in the description of Study 1.

Chapter 3: Study 1: Simulation and Virtual Experiment

Study 1 aimed to examine the impact of goal network structure (*RQ1*) and means instrumentality certainty (*RQ2*) on means choice using computational modeling and simulation. The model described above was translated into computer code using R (R Core Team, 2013).

Virtual experimentation was conducted via simulations of the model to evaluate conditions created by crossing the key factors of 1) goal network structure, 2) means instrumentality certainty, and 3) task reference difference. Before describing these conditions, a general overview of the simulation design, including the values of the parameters that were not manipulated based on condition, is provided.

Simulation Design

The simulated goal network structures all included three means and two tasks (Figure 2). The means included a unifinal means instrumental to task 1, a unifinal means instrumental to task 2, and a multifinal means instrumental to both tasks. This allowed for any potential pattern of means choice (e.g., switching between unifinal means, only using a multifinal means) to be observed. Including two tasks allowed for all potential combinations of task finality (e.g., unifinal-multifinal, unifinal-unifinal) and potential differences in task references to be evaluated. At each decision point, one of these means was selected based on the process described above in the pursuit of completing the tasks.

The number of distal goals was either one or two in order to manipulate the finality of the tasks, described in the goal network structure section below. Each task was assigned a reference, which indicated the number of units required to complete it. The reference for task 1 was always equal to 100 and the reference for task 2 was determined based on the task reference difference condition, described below. The deadline was set to 100 in all simulations, providing sufficient time to complete both tasks.

For each means instrumentality, task instrumentality, and dilution strength, a prior distribution and likelihood distribution was initialized. These distributions and their parameterizations, along with the resulting posterior distributions following the updating process, are described in more detail specific to each concept below. In general, the prior distribution represented the simulated individual's belief about the given instrumentality/dilution strength, centered around the perceived most likely value. The initial values of the perceived instrumentalities and dilution

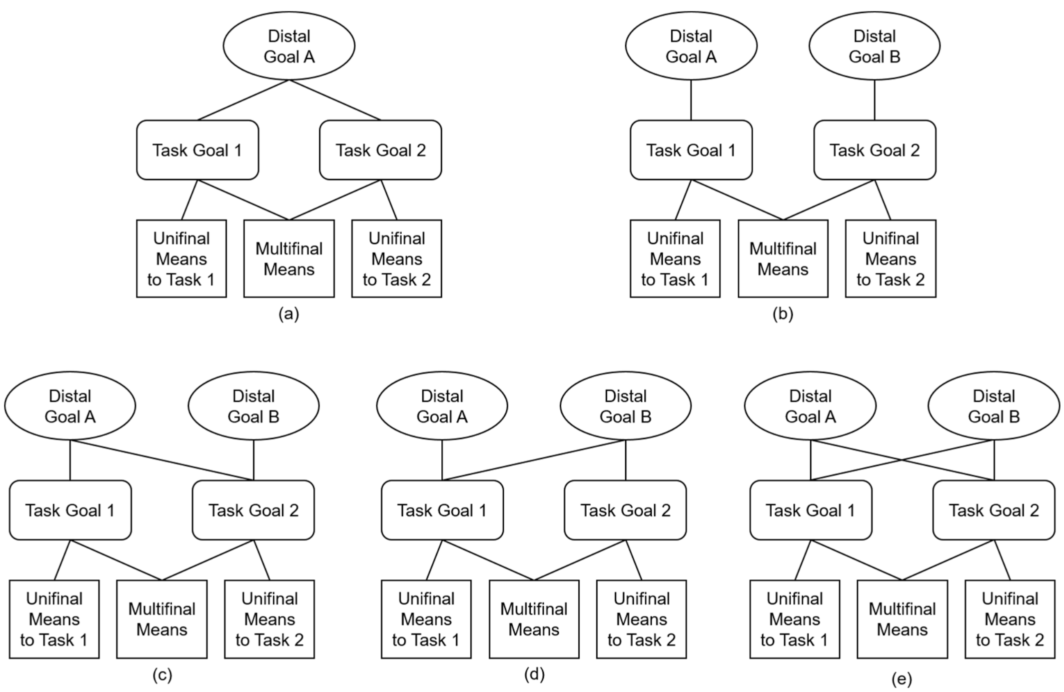

Figure 2. Goal network structures simulated in Study 1.

strength, which impacted means choice, were sampled from their respective prior distributions. The likelihood distributions represented the "true" state of the given concept, centered around the true most likely value. The realized consequences of goal pursuit (i.e., the extent to which the selected means impacted progress, whether progress on the task goal had a positive effect on the distal goal, and whether the means instrumentality was truly diluted) were sampled from these likelihood distributions. The posterior distributions represented the updated distributions once these realized consequences were incorporated into the prior.

Means Instrumentality

The likelihood, prior, and posterior distributions for means instrumentalities were represented using normal distributions. The likelihood distribution for the true means instrumentality was represented by a normal distribution with a mean of three and a variance between zero and 25, depending on the means instrumentality certainty condition. This translated to an average reduction in discrepancy between the simulated individual's current state and the task reference of three when the means was selected. This value was static throughout the simulation.

The prior distribution for the perceived means instrumentality was represented by a normal distribution with an initial mean of one and a variance of 1,000 in order to approximate a lack of prior information. This allowed the influence of means instrumentality certainty on the dynamics of perceived means instrumentality to be better isolated. This distribution translated to an expectation of an average reduction in discrepancy of one when the means was selected. This value was dynamically updated via the Bayesian updating mechanism described above as tasks were completed. Specifically, the mean and variance of the posterior distribution of perceived means instrumentality, also represented by a normal distribution, reflected information about the means true instrumentality incorporated into the prior distribution.

Task Instrumentality

The likelihood, prior, and posterior distributions for task instrumentalities were represented using beta distributions. Beta distributions are continuous probability distributions bounded by zero and one. A beta distribution takes two parameters, α and β, that defines its shape. The first, α, is the number of observed "successes" in a given sample. The second, β, is the number of observed non-successes. In terms of task instrumentality, this translates to the number of observations of task progress helping to fulfill a distal goal and the number of observations of task progress not helping to fulfill a distal goal, respectively.

The true task instrumentality of each task to its connected distal goal(s) was initialized as 0.3. This translated to a 30% likelihood that positive feedback (i.e., task progress helping to fulfill the connected distal goal) was realized when task progress was made. Because higher values result in a more "peaked" or narrower distribution, a sample size of 1,000 was chosen to derive the shape parameters for this beta distribution. This resulted in true task instrumentality being represented by a beta distribution with $\alpha = 301$ and $\beta = 701$, or one tightly distributed around the mean value of 0.3. This distribution was static throughout the simulation.

The perceived task instrumentality of each task to its connected distal goal(s) was initialized as 0.1. This translated to an expectation of a 10% likelihood that positive feedback would be realized when task progress was made. To derive the shape parameters for this beta distribution, the sample size of two was chosen in order to approximate a lack of prior information, or a "flatter" distribution. This resulted in perceived task instrumentality initially being represented by a beta distribution with α = 1.2 and β = 1.2. This distribution was dynamically updated via the Bayesian updating mechanism described above as tasks were completed and feedback regarding the distal goal was observed. Specifically, observed successes and non-successes were incorporated into the prior to generate a posterior distribution represented by a beta distribution with shape parameters that resulted in a distribution that converged on the true task instrumentality.

Dilution Strength

The likelihood, prior, and posterior distributions for dilution strength were also represented using beta distributions, where the probability of "success" represented the likelihood that a non-diluted instrumentality was observed. For all instrumentalities, the true dilution strength was one. In other words, a means' or task's instrumentality was not weaker in reality simply due to its number of vertical connections. To calculate the shape parameters of the likelihood distribution, a sample size of 100 was used. This resulted in the likelihood distribution being represented by a beta distribution with α = 101 and β = 1. This distribution was static throughout the simulation.

The perceived dilution strength, or the degree to which a means' or a task's perceived instrumentality was weakened by its number of vertical connections, was initialized as the inverse of the number of vertical connections. In the current simulations, that number was either one (i.e., unifinal) or two (i.e., multifinal). For unifinal means or tasks, this translated to a lack of dilution. For multifinal means or tasks, this translated to a dilution strength of 0.5, meaning its perceived instrumentality was initialized as half of its expected value. To calculate the shape parameters of this prior distribution, a sample size of 50 was used, representing relatively higher confidence in dilution, given prior research on this effect. This resulted in the likelihood distribution being represented by a beta distribution with α = 26 and β = 26.

The above parameter values, other than where noted, were used across all conditions of the virtual experiment. The parameter values that depended on the condition of the simulation (number of distal goals, means instrumentality certainty, and task reference difference) are discussed next.

Virtual Experiment

Goal Network Structure

Goal network structure was manipulated by changing the number of distal goals in the network and the finality of connected tasks (i.e., the number of vertical connections between the task and the distal goals). Distal goals are broad motivational strivings that may be more or less salient to an individual at any given time. Depending on the context, multiple simultaneous distal goals (e.g., being a successful accountant and a good mother) or a single distal goal (e.g., being a successful accountant) may be salient. While the HMGPM is able to address contexts involving more than two distal goals, a minimum of two is required to evaluate the impact of goal network structure on means choice. Thus, simulated goal networks included either one or two distal goals. In goal networks containing a single distal goal, both tasks can only be connected to that distal goal and are thus both unifinal. In goal networks containing two distal goals, task goals may be unifinal or multifinal. The resulting combination of distal goal and task finalities resulted in five unique goal network conditions in the simulation (Figure 2).

Means Instrumentality Certainty

Means instrumentality certainty was manipulated via the variance (σ) of the likelihood distributions of each true means instrumentality. For each simulation, a value was randomly sampled from a uniform distribution between zero and 25. A variance of zero represented no variance in the true means instrumentality likelihood distribution. A maximum value of 25 was chosen because within the means instrumentality range of 0-5 (the range of possible reductions in task discrepancy with each means choice), this variance resulted in each means instrumentality value having an approximately equal likelihood of being observed, representing a condition of full *uncertainty.*

Task Reference Difference

For each simulation, a value representing the difference between the references of each task goal within the goal system ($g_D = g_1 - g_2$) was randomly sampled from a uniform distribution between zero and 25. When $g_D > 0$, task 1 was assigned the larger reference, g_1. For example, when $g_1 - g_2 = 25$, g_1 was assigned 100 and g_2 was assigned 75. Previous simulations of the HMGPM suggested this range of values was sufficient to observe the impact of unequal task references (Samuelson, 2017).

Prior simulations of the HMGPM (Samuelson, 2017) provided evidence for little variance in outcomes across simulations within conditions. Based on these prior simulations, 10,000 individuals were simulated within each of the five goal networks, resulting in a total of 50,000 simulated individuals. This simulation size allowed for the full parameter space for each of the two continuous factors to be adequately sampled.

Analysis Strategy

To facilitate evaluating the impact of task reference difference and means instrumentality certainty on means choice, categories representing lower and higher ranges of the sampled values were created for each of these factors. Task reference differences were categorized into four different ranges: no difference ($g_D = 0$), small difference (g_D = 1-9), moderate difference (g_D = 10-17), and large difference (g_D = 18-25). Means instrumentality certainties were also categorized into four different ranges: no variance ($\sigma = 0$), small variance (σ = 1-8), moderate variance (σ = 9-18), and large variance (σ = 19-25).

Outcomes were calculated at the aggregate level. In order to examine means choice, the percentage of simulated individuals that selected each of the three possible means (unifinal to Task 1, unifinal to Task 2, and multifinal) at each decision point was calculated within conditions. All other outcomes were averaged across simulated individuals at each decision point within condition. These outcomes included the expected utility of each means and the mean of the posterior distribution of each means instrumentality.

Results

Simulated individuals engaged in a range of 28 to 61 decisions before completing both task goals. Figures 3 and 4 represent the total number of decisions simulated individuals engaged in across the five goal network structures and in the 16 conditions created by crossing task reference difference categories and means instrumentality certainty categories. Conditions with equal task references are high means instrumentality certainty have fewer simulations in general due to their categorization based on a single value of each. Only four simulated individuals engaged in 60 or more decisions and 99.98% of simulated individuals engaged in 55 or fewer decisions. Thus, decisions 1 through 55 were used in the following analyses. However, note that beyond approximately decision 40, fewer and fewer simulations were still engaging in decisions. This is especially the case in conditions of equal task references and high means instrumentality certainty as a result of the categorization. Thus, aggregation and the presented simulation results at these decision points and in these conditions are slightly less stable. The results are organized around the two focal research questions.

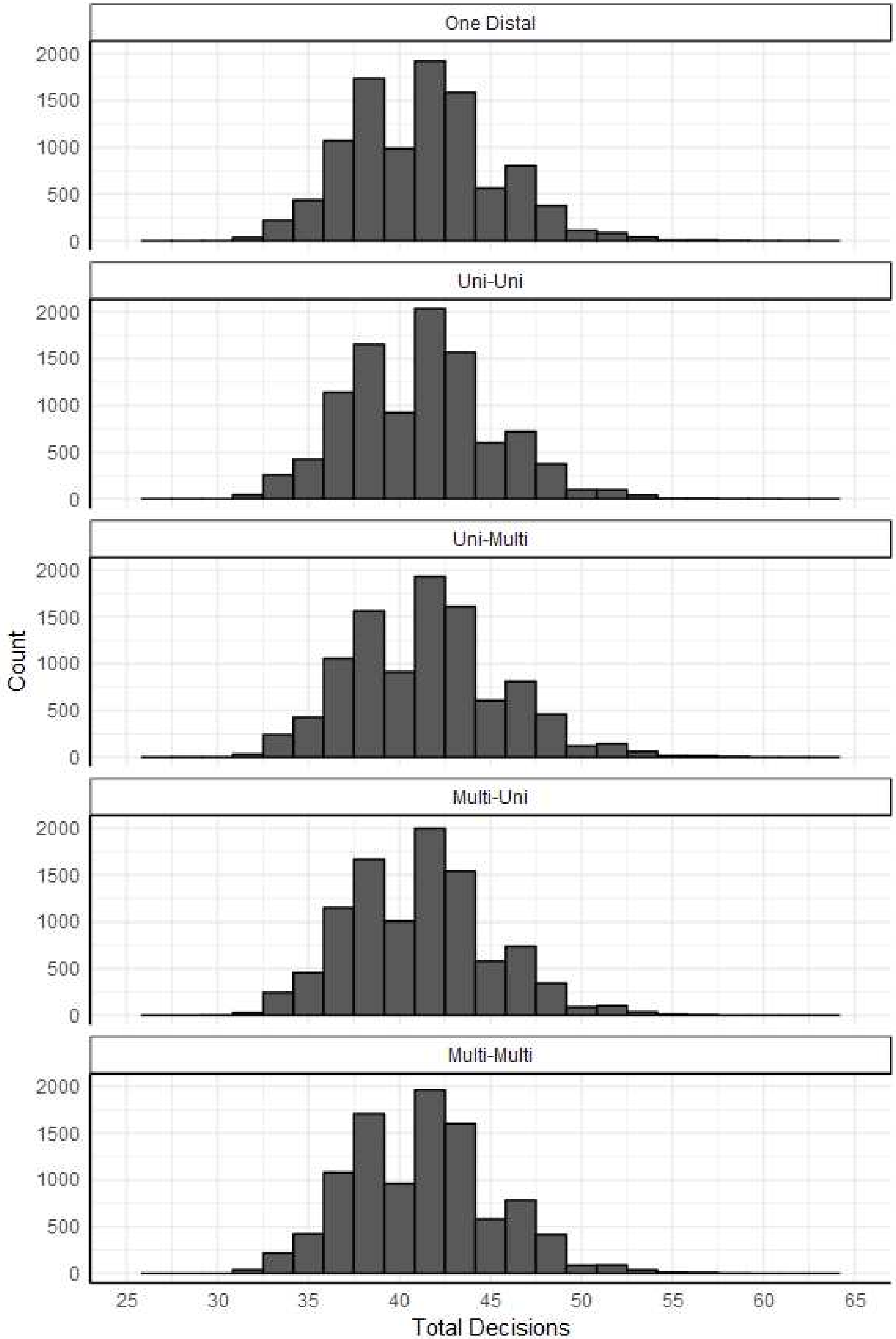

Figure 3. Study 1 Final Decision Counts by Goal Network Structures

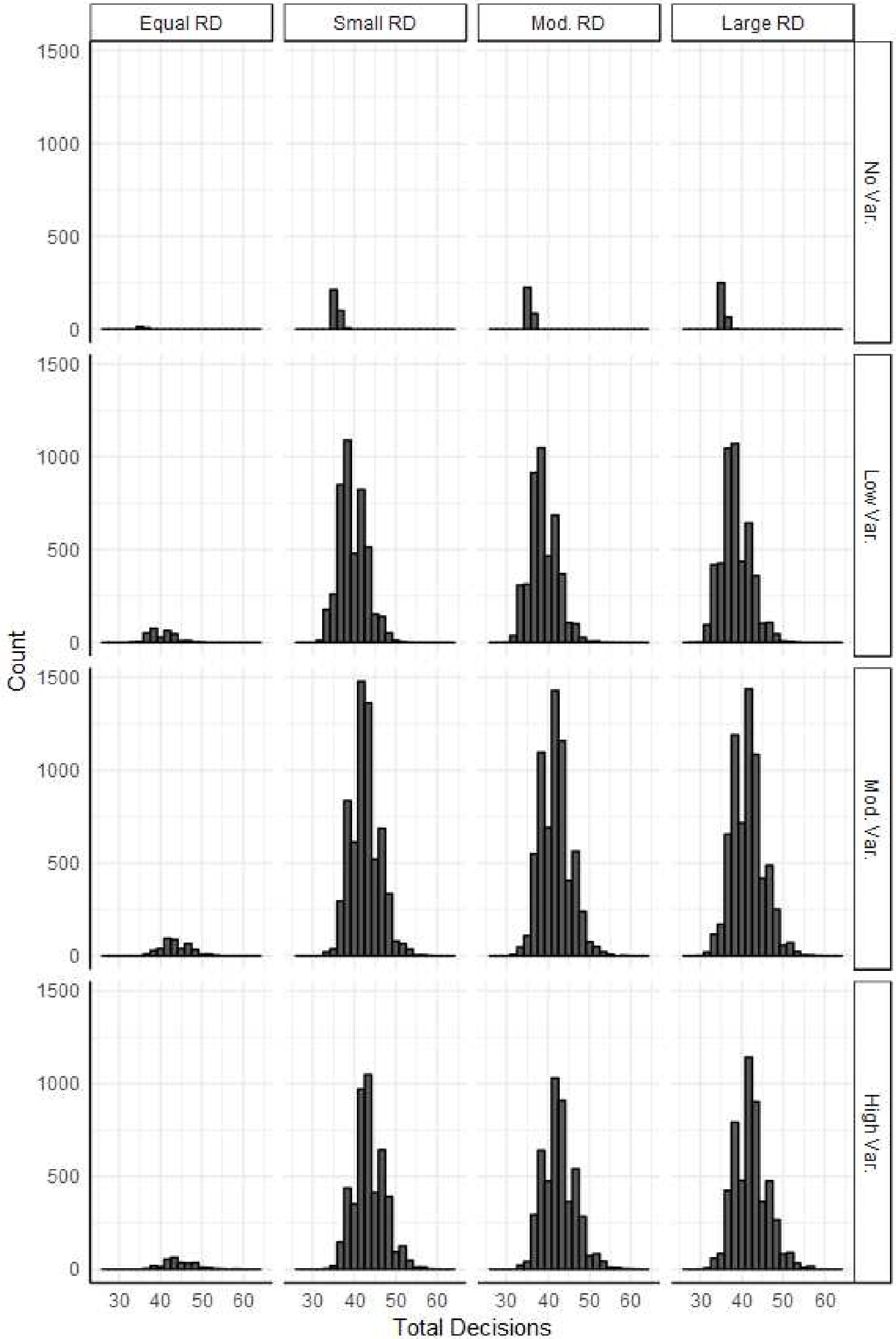

Figure 4. Study 1 Final Decision Counts by Task Reference Difference and Means Instrumentality Certainty

Research Question 1

The first research question considered how and to what extent goal network structures impacts means choice during multiple-goal pursuit. Figure 5 summarizes the pattern of means choice observed in the simulations across the five goal network structures. In general, the results demonstrate that goal network structure did not impact the pattern of means choice. That is, whether the two task goals were both unifinal, both multifinal, or unifinal and multifinal exerted little influence on the pattern of means selection across goal pursuit. In all five goal network structures, the overwhelming majority of simulated individuals prioritized the multifinal means that was instrumental to both tasks at each decision point until approximately half way through goal pursuit. This pattern is discussed in greater detail with respect to task reference differences below.

Though the percentage is considerably smaller than the selection rate of the multifinal means, the second most frequently chosen means tended to be the unifinal means connected with task 1. Figure 5 averages over task reference difference. Due to the range of task reference differences sampled in the parameter sweep, task 1 had a higher reference than task 2, on average. This higher task 1 reference slightly increased the selection rate of the unifinal means to task 1.

A subtle difference in this pattern was observed in the unifinal-multifinal goal network structure, where there is a higher selection rate of the unifinal means for task 2 than the unifinal means for task 1, particularly in early decision points. This difference is driven by task goal multifinality. In the unifinal-multifinal goal network structure, task 2 derives subjective importance (i.e., gain) from two distal goals, whereas task 1 derives subjective importance from only one distal goal. While the multifinal means is positively impacted by the subjective importance of both tasks, this unequal subjective importance at the task level differentially impacts the two unifinal means. The multifinality of task 2 increases the utility of the unifinal means for task 2 compared to the utility of the unifinal means for task 1 (Figure 6) and thus increases its initial selection rate. Vice versa, in the multifinal-unifinal network structure, the multifinality of task 1 increases the utility of the unifinal means for task 1, which increases its selection rate (in combination with the higher task 1 reference on average). In other words, an individual with two distal goals, such as a female data scientist with a competence goal and a desire to represent her gender group in her industry, may slightly prioritize a means that helps her accomplish a task connected to both distal goals, such as developing a workshop for young female coders. However, if she has a means that will allow her to simultaneously finish that task and a second one, such as building a dashboard for her company, the simulation suggests she would overwhelming prefer that means.

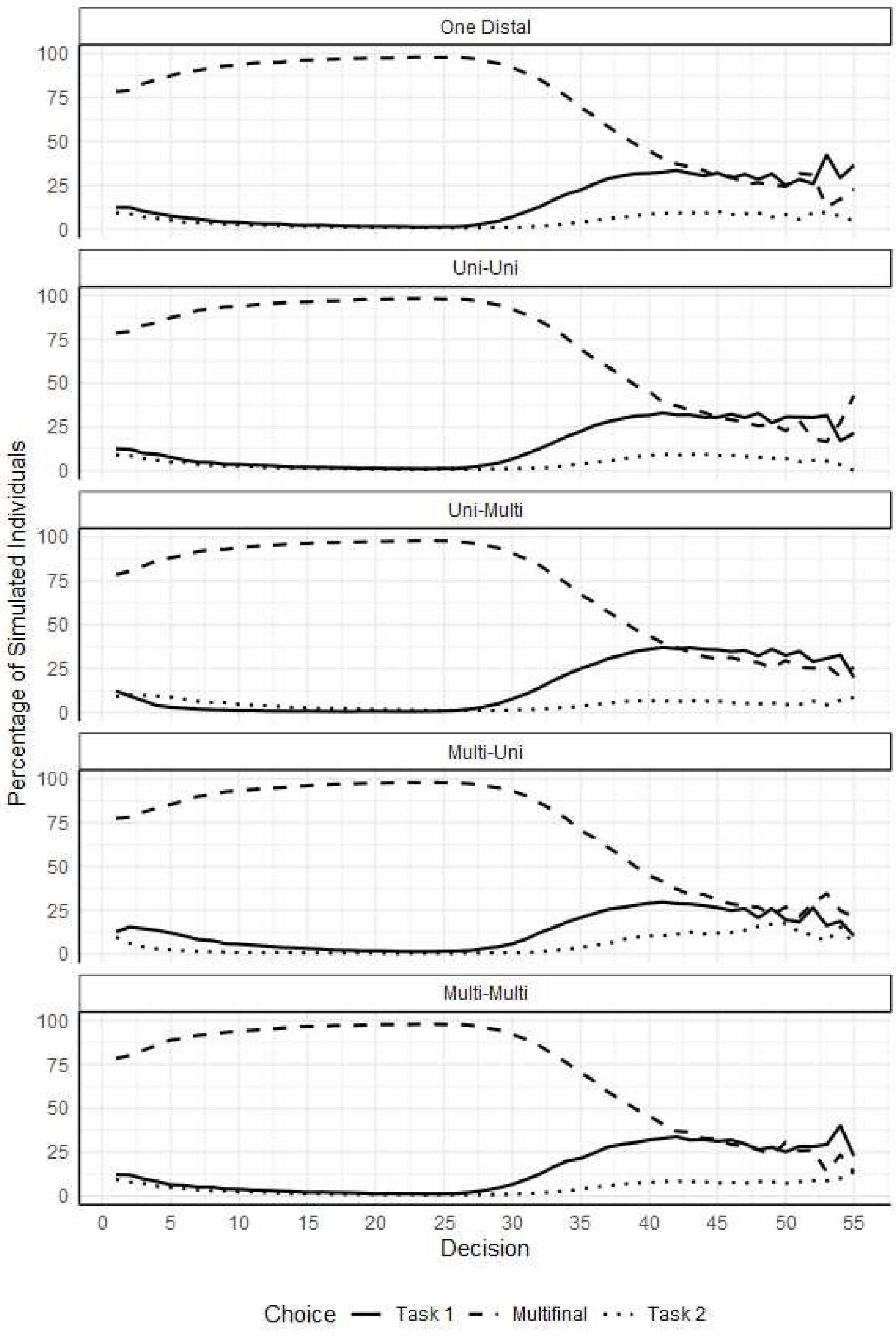

Figure 5. Study 1 Means Choice by Goal Network Structure

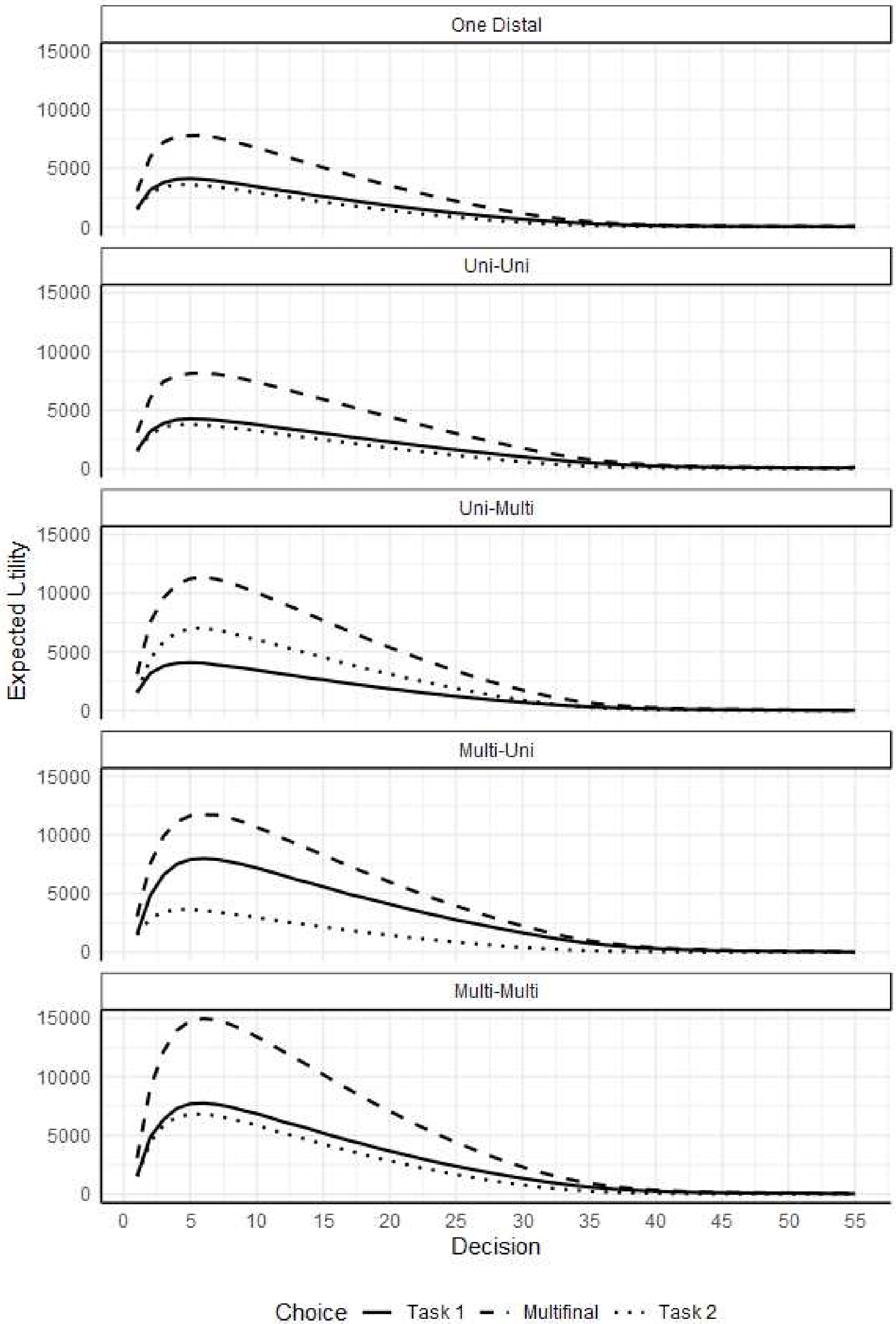

Figure 6. Study 1 Means Expected Utility by Goal Network Structure

As alluded to above, differences in task reference also impacted means choice through their influence on the utility of means. Specifically, the expected utility of a means connected to a task with a high reference is higher, especially if the individual's current state is far from that reference. This increases the likelihood of an individual selecting that means. Thus, the impact of task reference difference was also examined in each of the five goal network structures in order to address *RQ1*.

Figure 7 represents means choice over goal pursuit within the four categories of task reference difference in each goal network structure. One major insight can be gleaned from this figure. The slightly increased selection rate of the unifinal means for task 2 in the unifinal-multifinal goal network structure was more apparent when the task references were initially equal ($g_D = 0$). Similar to the explanation provided above, this pattern is driven by the multifinality of task 2. When task references are equal, the multifinality of task 2 results in a larger perceived utility for the unifinal means connected to task 2 relative to the unifinal means for task 1, resulting in a slight increase in its likelihood of being selected. However, if task 1 has a higher reference, the impact of that higher reference on the utility of the multifinal means outweighs the influence of the higher subjective importance flowing from the distal goals to task 2. In other words, if the data scientist has a relatively equal amount of both her tasks of developing a workshop and creating a dashboard to complete, she may only show a slight preference for a unifinal means to the workshop compared to a multifinal means that accomplishes both. If she is behind on creating the dashboard, the simulation suggests she will be even more likely to attempt to complete both tasks at once.

In sum, the analyses for *RQ1* revealed that goal network structure had relatively little impact on means choice. Simulated individuals overwhelmingly and consistently selected the multifinal means in the first half of goal pursuit. Across all goal network structures, simulated individuals no longer showed a preference for the multifinal means in the second half of goal pursuit, once one task was complete. However, the results did indicate that goal network structure exerted a small but consistent influence on means choice selection, specifically in the unifinal-multifinal structure compared to all others, when the output needed to complete multiple task goals was more similar.

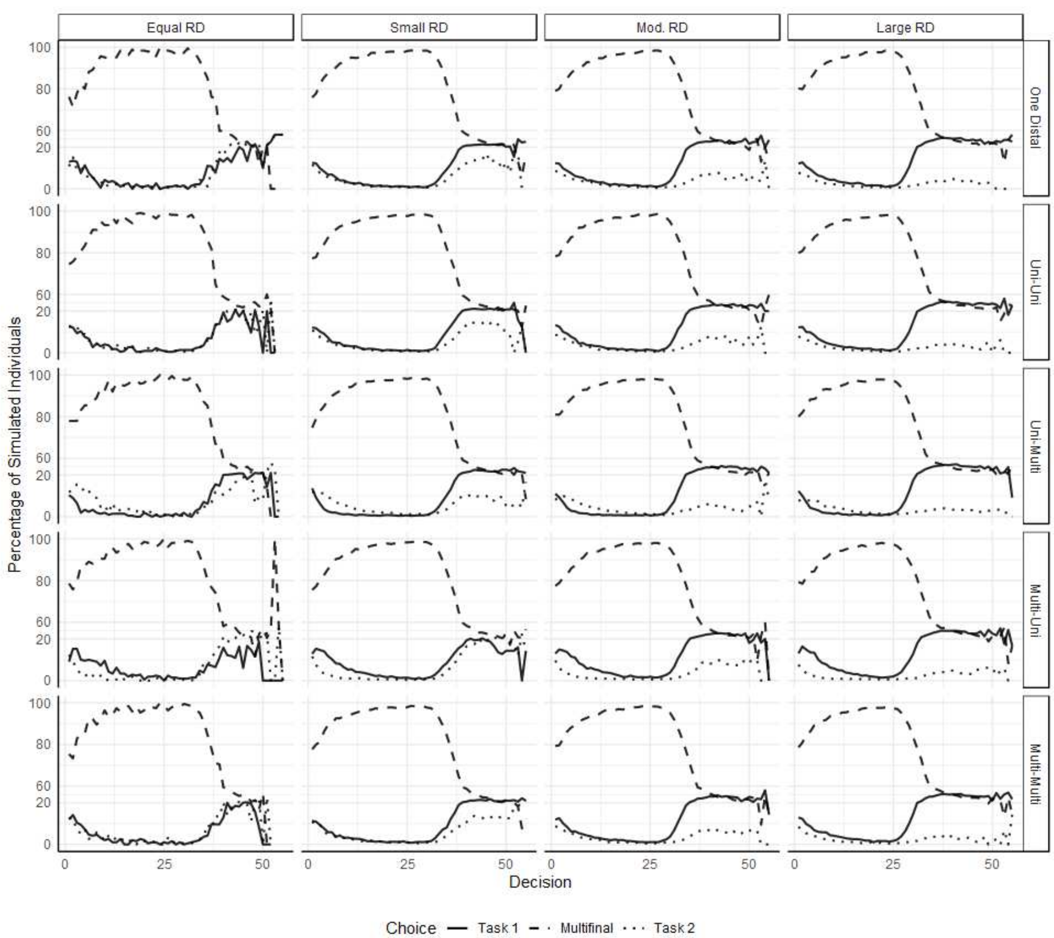

Figure 7. Study 1 Means Choice by Task Reference Difference

Research Question 2

The second focal research question examined how and to what extent the certainty of means instrumentality impacts means choice during multiple-goal pursuit. Figure 8 summarizes simulated individuals' means choices over time within four categories of means instrumentality certainty across all five goal network structures. In general, the degree of certainty in means instrumentality tended to exaggerate the patterns previously observed across goal network structures shown in Figure 5. For example, when means instrumentalities were more certain (i.e., less variance in how much of the task goal they completed), selection rate of the multifinal mean increased rapidly, even reaching 100% in conditions of no variance. However, as the degree of certainty in means instrumentality decreased (i.e., greater variance), the multifinal mean was selected slightly less and the unifinal means selected slightly more often. For example, the pattern of results for the unifinal-multifinal goal network structure demonstrate that greater variance in means instrumentalities resulted in a relative increase in the selection rate of the unifinal means for task 2 and an accompanying decrease in the selection rate for the multifinal means.

This pattern emerged as a result of the simple Bayesian learning mechanism that simulated individuals used to update perceptions of a means' instrumentality. Figures 9 and 10 depict the convergence of the perceived means instrumentalities (represented by the posterior in the Bayesian updating process modeled) towards the true means instrumentalities across conditions of means instrumentality certainty. Recall that the true means instrumentality for all means to each of their respective task goals was set to three (i.e., on average, discrepancy on the task goal(s) was reduced by three each time a means was selected). Under conditions of lower means instrumentality certainty, simulated individuals converged less on this true means instrumentality. In other words, the simulated individuals' expectations about the means

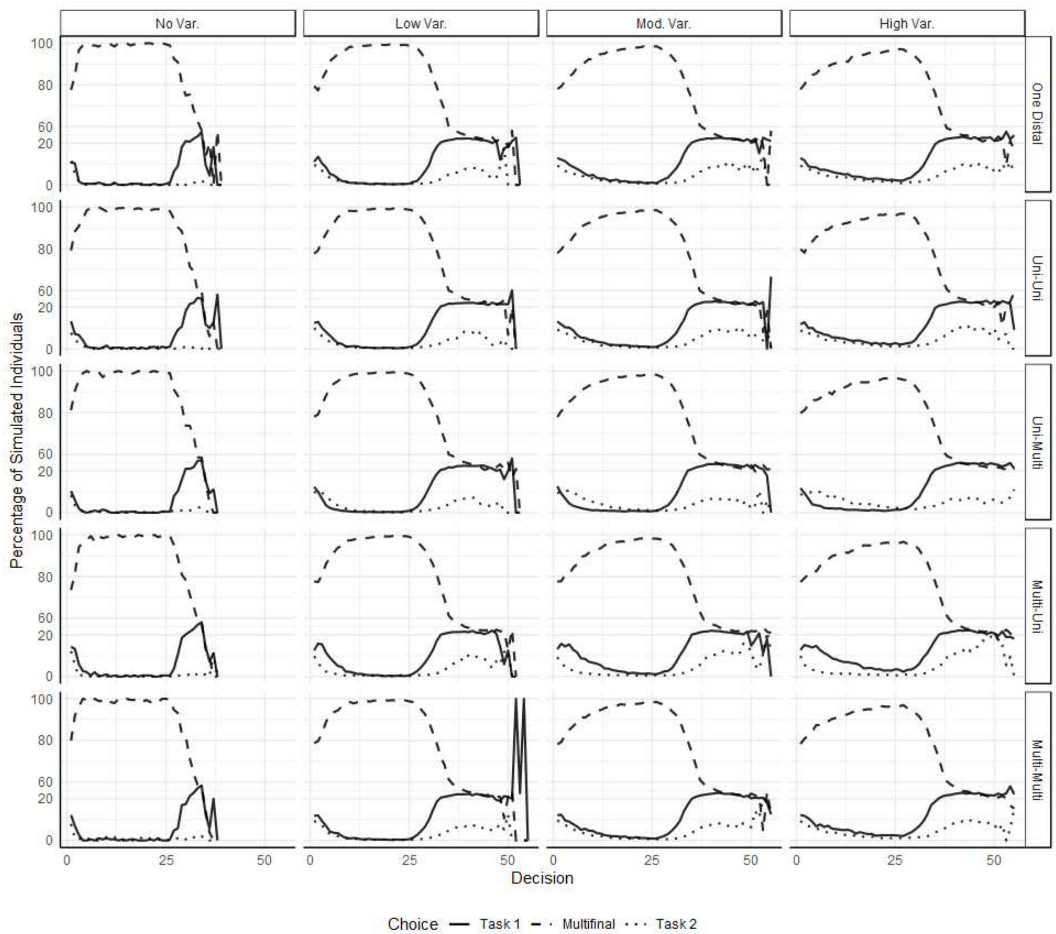

Figure 8. Study 1 Means Choice by Goal Network Structure and Means Instrumentality Certainty

instrumentality, or their prior, impacted the degree of convergence to a greater extent under conditions of uncertainty than certainty.

However, across all conditions of means instrumentality certainty, individuals were far less accurate in their perceptions of true means instrumentality for either of the unifinal means compared to the multifinal means. This pattern is driven by the overwhelming preference simulated individuals showed for the multifinal means: because the multifinal means was selected more frequently, even under conditions of low certainty (Figure 8), simulated individuals had more opportunities to update their perceived instrumentality based on observed feedback.[1] Notably, the perceived instrumentalities of both unifinal means converged on their true instrumentalities to a greater extent under conditions of lower certainty. This is driven by the slightly elevated selection rates of these means in conditions of lower means instrumentality certainty (Figure 8) which allowed simulated individuals to more frequently incorporate observations of the unifinal means instrumentalities into their perceptions.

In sum, the *RQ2* analyses indicated that conditions of low certainty in the instrumentality of means exaggerated effects of goal network structure and task reference difference. Further, the general preference for a multifinal means increased the information simulated individuals could incorporate into their expectations about the multifinal means' instrumentality, increasing the rate at which their expectations converged on reality.

Discussion

The simulation results indicated that neither goal network structure nor task reference difference exhibited an appreciable impact on

[1] Note that at later time points in Figure 9, where there are fewer simulations to aggregate, the perceived instrumentality appears to be lower. This is driven by the continued Bayesian updating process for means' instrumentalities to Task 1. Because of the higher average Task 1 reference, the simulation is still completing Task 1 by these time points, meaning the degree to which it converges is still susceptible to realized feedback. On the other hand, Task 2 is complete by these time points (Figure 10). Thus, the means' instrumentalities to Task 2 remain at the same level for the rest of the simulations.

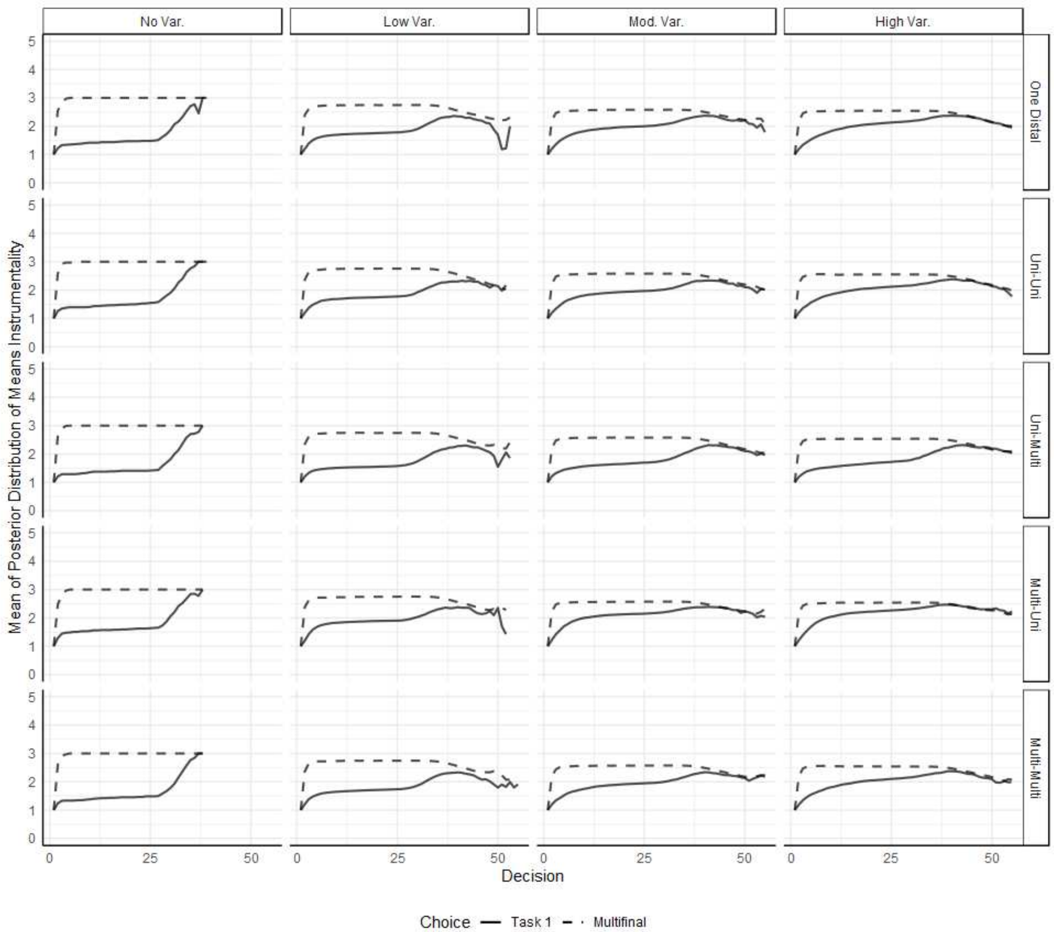

Figure 9. Study 1 Mean of Posterior Distribution for Means Instrumentality to Task 1 by Goal Network Structure

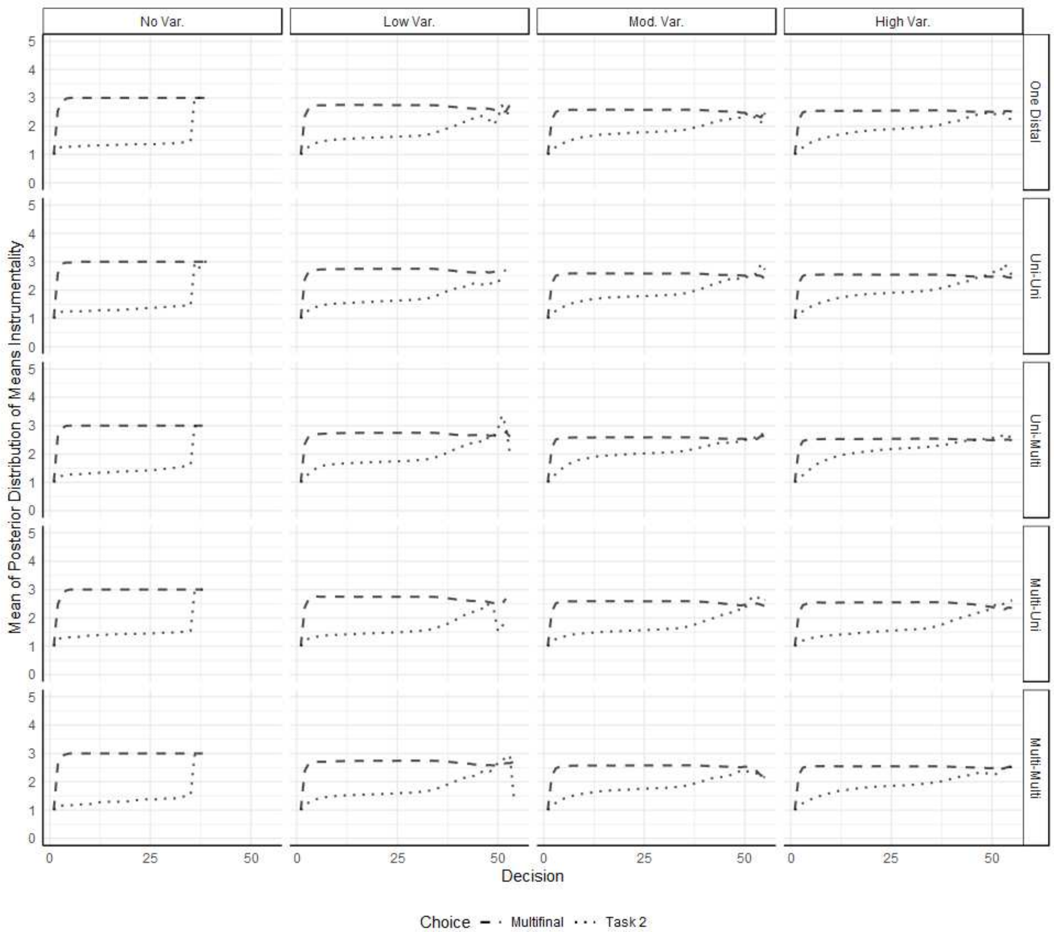

Figure 10. Study 1 Mean of Posterior Distribution for Means Instrumentality to Task 2 by Goal Network Structure

means choice. These findings stand in contrast to expectations derived from prior literature. For example, Orehek et al. (2013) suggest that having a focal goal, operationalized in the current study as a task goal with a higher reference, should increase the preference for a unifinal means to that task goal. This prediction was not supported by the current simulations: simulated individuals exhibited a general preference for the multifinal means regardless of differences in task goal reference. Only in the unifinal-multifinal goal network structure paired with a higher task reference difference was even a slight difference in means selection observed.

However, even under these conditions, simulated individuals overwhelmingly chose the multifinal means during goal pursuit when they had two tasks to complete. These findings raise the question of how focal an immediate task goal must be in order to observe a higher preference for a unifinal means.

The predicted pattern of increased preference towards a unifinal means connected to an important focal goal presides on the assumption of a dilution effect, wherein the utility of a multifinal means is negatively impacted by its connection to an alternative less important task goal (Orehek et al., 2013; Zhang et al., 2007). In the current simulation, dilution was operationalized as a reduction in means instrumentality that was directly proportional to the number of task goals that mean served. Thus, the instrumentalities of the multifinal means to its two connected task goals in the present simulation was weighted by 0.5 (versus 1 for each of the unifinal means). Although this parameterization seemed plausible based on existing theory, no previous research was available to inform the nature of this parameter value. It is possible that under a different representation in which the dilution of a multifinal means is even greater, a preference for a unifinal means could be observed.

To examine these possibilities, an exploratory simulation and virtual experiment was conducted that used a larger range of task reference differences and dilution strengths in order to examine their impact on means choice over goal pursuit.

Chapter 4: Exploratory Simulation

All five goal networks simulated in Study 1 were also simulated in this exploratory simulation (Figure 2). The simulation design and all values for parameters that were not manipulated as part of the virtual experiment were consistent with the description provided in the Simulation Design section of Study 1. In order to simplify the interpretation of these results of these exploratory simulations and because the results of Study 1 suggested that the full range of means instrumentality certainties from zero to 25 is not necessary for examining this factor's impact on means choice, categorical levels of means instrumentality certainty were created. The choice of parameter values for task reference difference, means instrumentality certainty, and dilution strength are detailed next.

Virtual Experiment

Task Reference Difference

In Study 1, the maximum task reference difference of 25 did not impact means choice and prioritization of one task goal over the other. Thus, a wider range of parameter values was explored within each of the five goal networks in the exploratory virtual experiment. Specifically, integer values of task reference difference (g_D) were sampled from a uniform distribution with a minimum of zero (i.e., equal task goal references) and a maximum of 95 (e.g., task 1 reference = 100, task 2 reference = 5).

Means Instrumentality Certainty

Four values from the continuous range of true means instrumentality likelihood variances simulated in Study 1 were selected in the exploratory virtual experiment. These values represented situations of no variance in means instrumentality rates ($\sigma = 0$), small variance ($\sigma = 8.25$), moderate variance ($\sigma = 16.25$), and large variance ($\sigma = 25$).

Dilution Strength

A larger dilution strength may impact means choice by reducing the initial utility that the multifinal means derives from both task goals via lower perceived means instrumentalities. To probe this factor further and to examine how strong of a dilution effect may be required to observe an impact on means choice and task goal prioritization, three values were selected for the mean of the prior distribution of the perceived dilution: high dilution (0.1), moderate dilution (0.25), and low dilution (0.5).

Fully crossing the five goal networks, four means instrumentality certainties, and three dilution strengths resulted in 60 conditions. Given the stability in trajectories observed in prior simulations, 5,000 individuals were simulated in each of these conditions, resulting in a total of 300,000 simulated individuals. This simulation count allowed for sufficient examination of the full continuum of task reference differences within each condition.

Analysis Strategy

To facilitate evaluating the impact of task reference difference, categories representing lower and higher ranges were created. These ranges represented conditions of no difference ($g_D = 0$), small difference ($g_D = 1\text{-}25$), moderate difference ($g_D = 26\text{-}50$), large difference ($g_D = 51\text{-}75$), and very large difference ($g_D = 76\text{-}95$).

Similar to Study 1, outcomes were calculated at the aggregate level. In order to examine means choice, the percentage of simulated individuals that selected each of the three possible means (unifinal to Task 1, unifinal to Task 2, and multifinal) at each decision point was calculated within conditions. All other outcomes were averaged across simulated individuals at each decision point within condition. These outcomes included the expected utility of each means and the mean of the posterior distribution of each means instrumentality.

Results

Simulated individuals engaged in a range of 28 to 74 decisions before completing both task goals. Figures 11 through 13 represent the number of decisions engaged in by simulated individuals across goal network structures, the crossed means instrumentality certainty and task reference difference conditions, and dilution strengths. The high means instrumentality certainty (i.e., no variance) condition tended to have a low decision count due to the consistent sampling of task progress driven by the lack of variance in the sampled value. Only two simulated individuals engaged in 74 or more decisions and 99.84% of simulated individuals engaged in 65 or fewer decisions. Thus, decisions 1 through 65 were used in the following analyses. However, note that beyond approximately decision 45, fewer and fewer simulations were still engaging in decisions. This is especially the case in conditions of equal task references as a result of the categorization. Thus, aggregation and the presented simulation results at these decision points and in these conditions are slightly less stable.

Task Reference Difference

Figure 14 summarizes simulated individuals' means choices over time within these five categories for each goal network structure. Across goal network structures and task reference difference categories, the multifinal means was again most frequently chosen by simulated individuals in their early decisions. However, preference for the multifinal means decreased over time in conditions with higher task reference differences, with a corresponding increased preference for the unifinal means for task 1. Further, the magnitude of task reference difference increased the speed at which these preferences changed. In this case, this pattern of effects is driven by the smaller task 2 reference in conditions of higher task reference difference. The reference of task 1, g_1, was always equal to 100, meaning the reference of task 2, g_2, equaled 100 – g_D. In other words, the task 2 reference increasingly approached zero in conditions of higher task reference difference. Thus, the higher the task reference difference, the smaller the task 2 reference

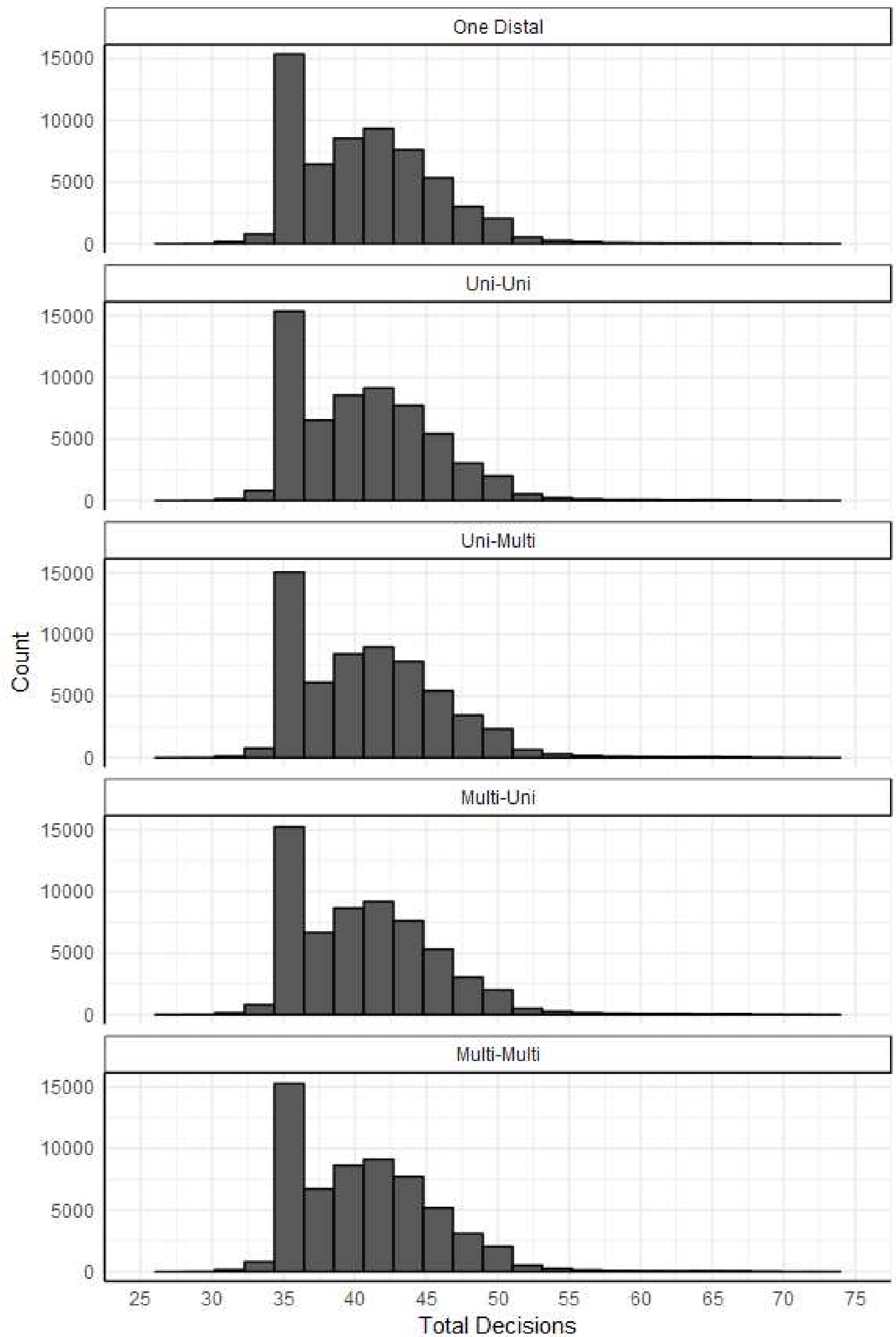

Figure 11. Exploratory Simulation Final Decision Counts by Goal Network Structure

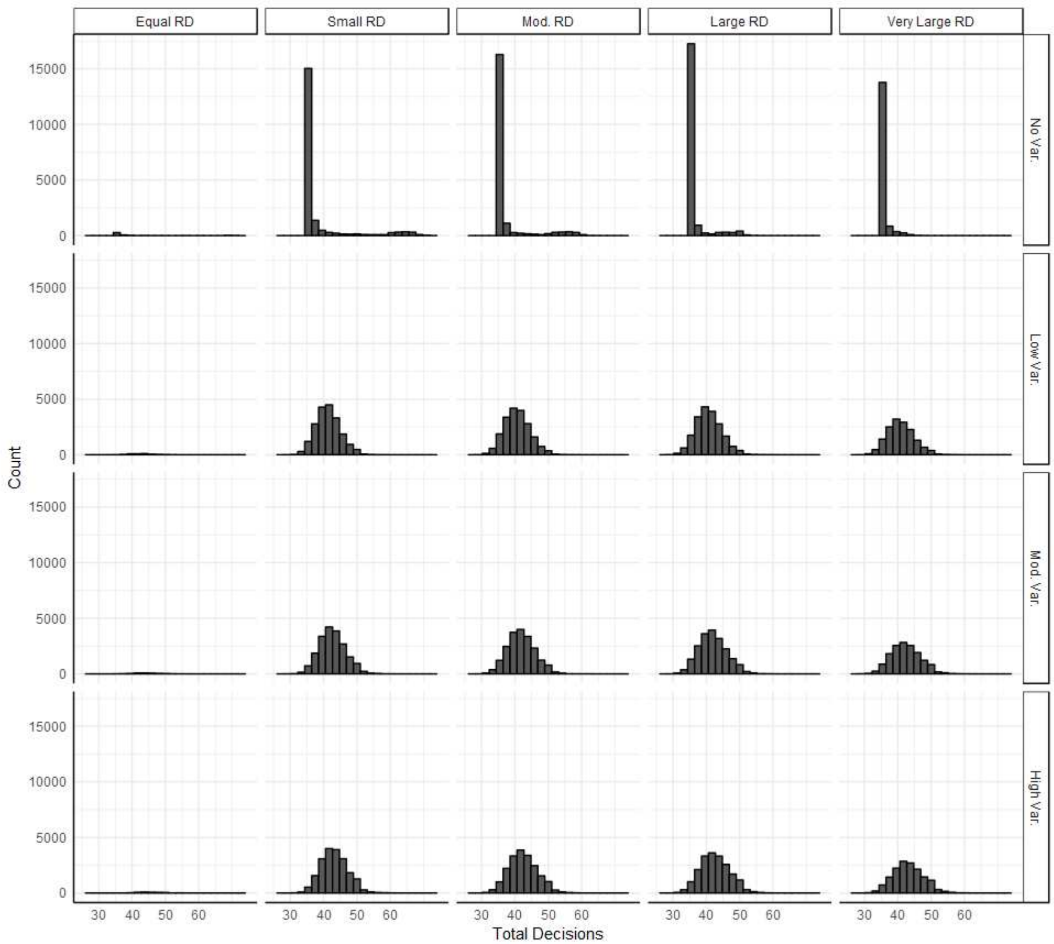

Figure 12. Exploratory Simulation Final Decision Counts by Task Reference Difference and Means Instrumentality Certainty

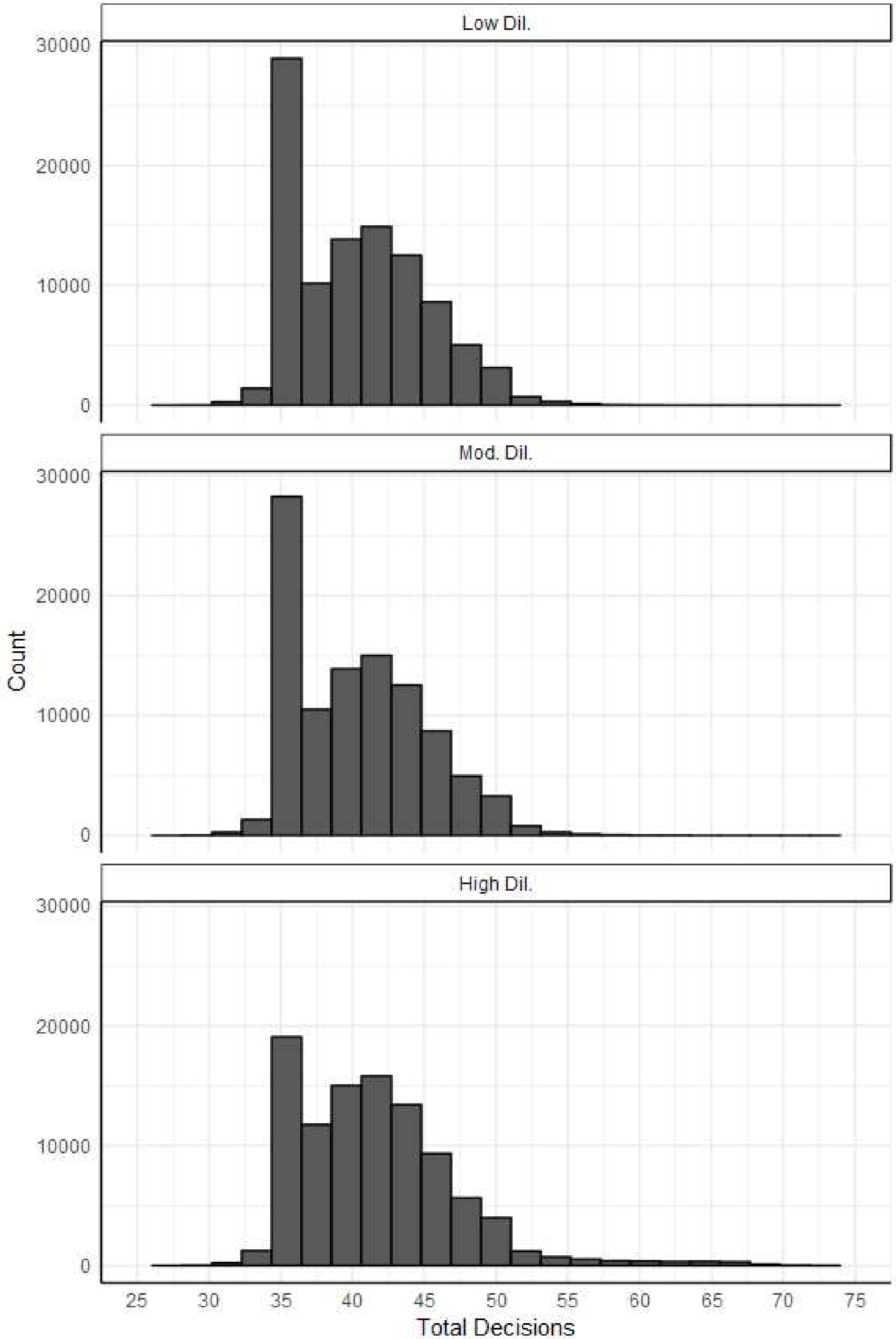

Figure 13. Exploratory Simulation Final Decision Counts by Dilution Strength

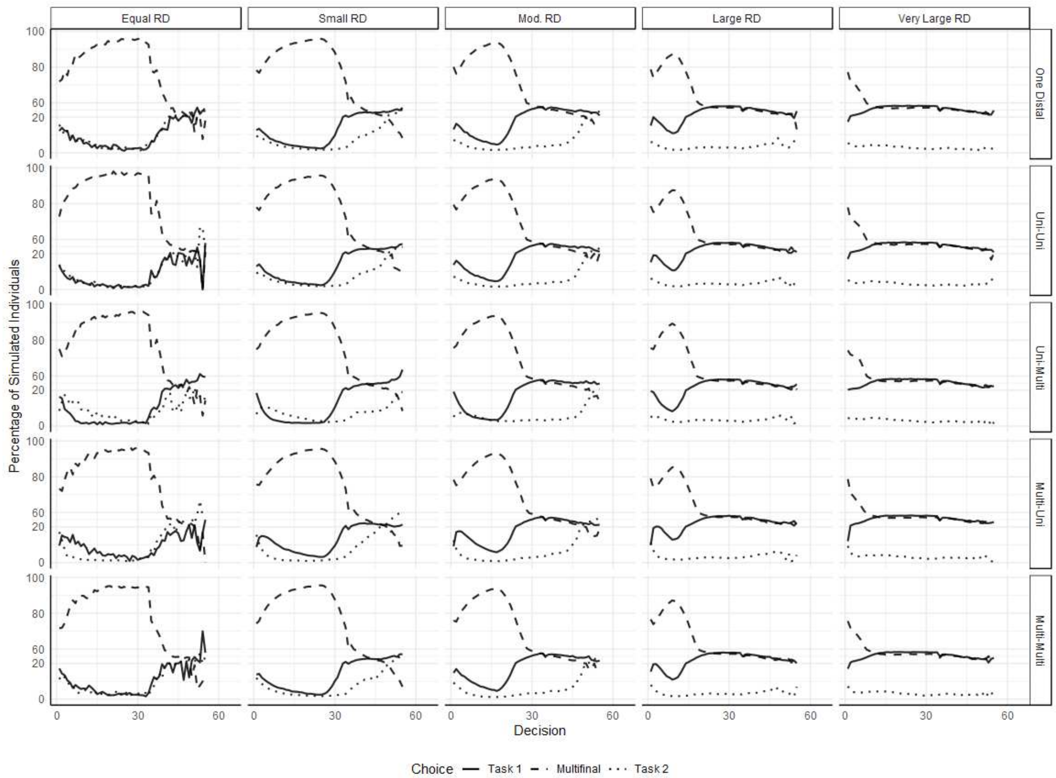

Figure 14. Exploratory Simulations Means Choice by Goal Network Structure and Task Reference Difference

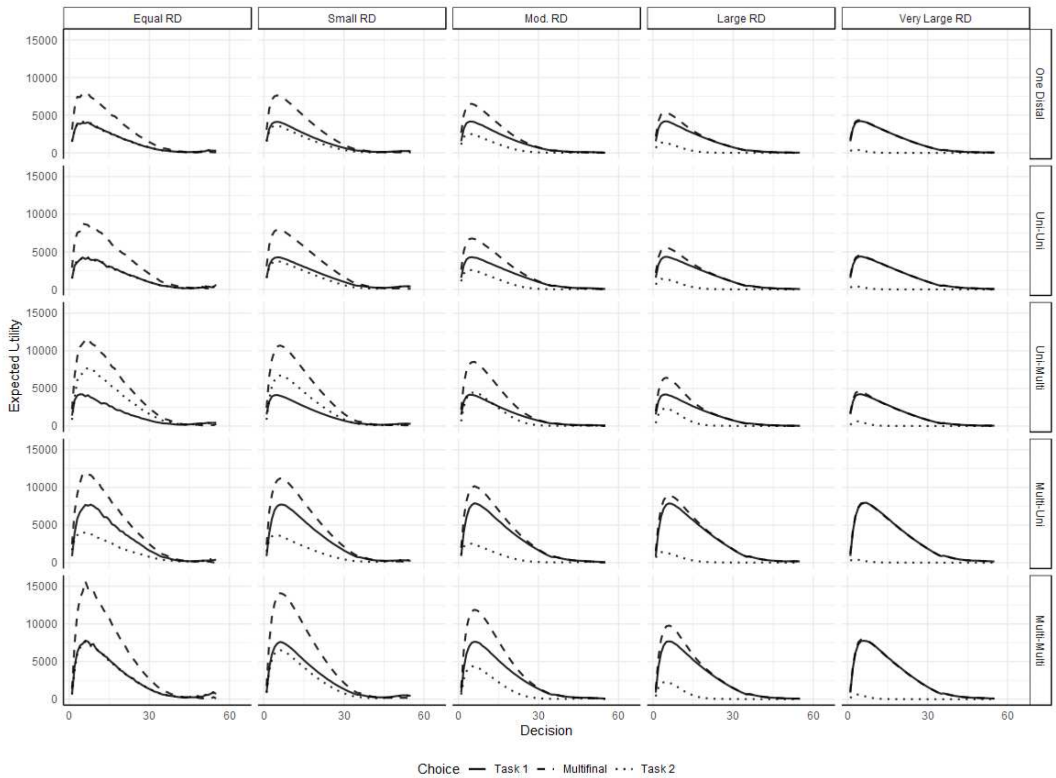

Figure 15. Exploratory Simulation Means Expected Utility by Goal Network Structure and Task Reference Difference

and the less time required to complete task 2. As the task 2 reference approached zero, the utility of the multifinal means became almost entirely driven by the importance of task 1. As a result, the utility of the multifinal means eventually converged to the utility of the unifinal means to task 1 (see Figure 15; compare to Figure 6). When the utility of two means to a task goal are equal, the model randomly selected between those means. Thus, the selection rate of the multifinal means and the unifinal means to task 1 were each approximately 50%.

In Study 1, task reference difference did not appear to impact means choice. The exploratory simulations revealed that this parameter does impact means choice, but only at relatively extreme magnitudes. A large difference between task references results in one task being completed earlier in goal pursuit than the other (as long as the multifinal means is selected), leaving only one task remaining. With only one task to complete, a unifinal means is equally as valuable as a multifinal means, decreasing the preference for the multifinal route to task completion.

Dilution Strength

Figure 16 summarizes the effects of dilution strength on means choice across the five goal network structures. In general, a higher dilution strength tended to increase the selection of the unifinal mean for task 1 relative to the original simulation. However, the majority of simulated individuals again still selected the multifinal mean early in goal pursuit at all levels of dilution strength. In concert with means instrumentality certainty, the stronger dilution effect decreased the initial perceived instrumentality and subsequent perceived utility of the multifinal mean by decreasing the degree to which the multifinal means derived value from either task goal (Figure 17). Nevertheless, the negative impact to the multifinal means' utility was not strong enough to make it less attractive than the alternative means until only one task remained.

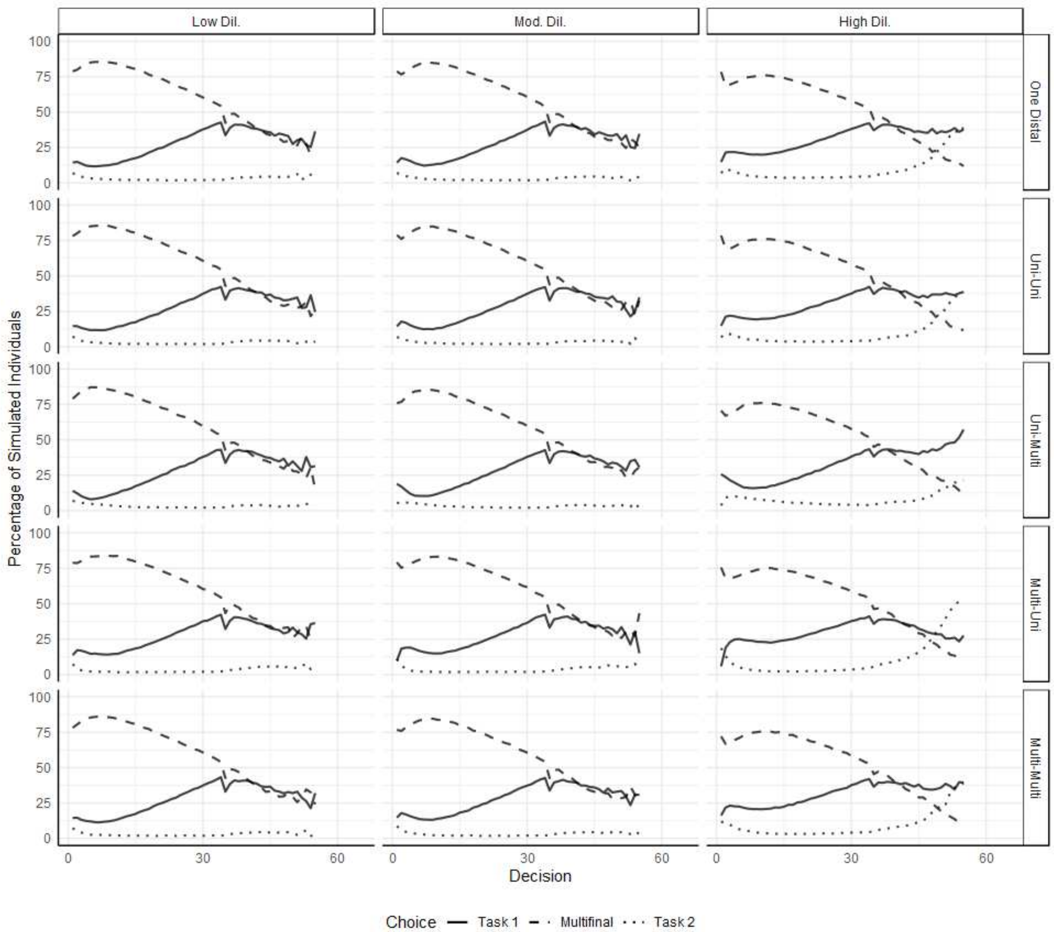

Figure 16. Exploratory Simulation Means Choice by Goal Network Structure and Dilution Strength

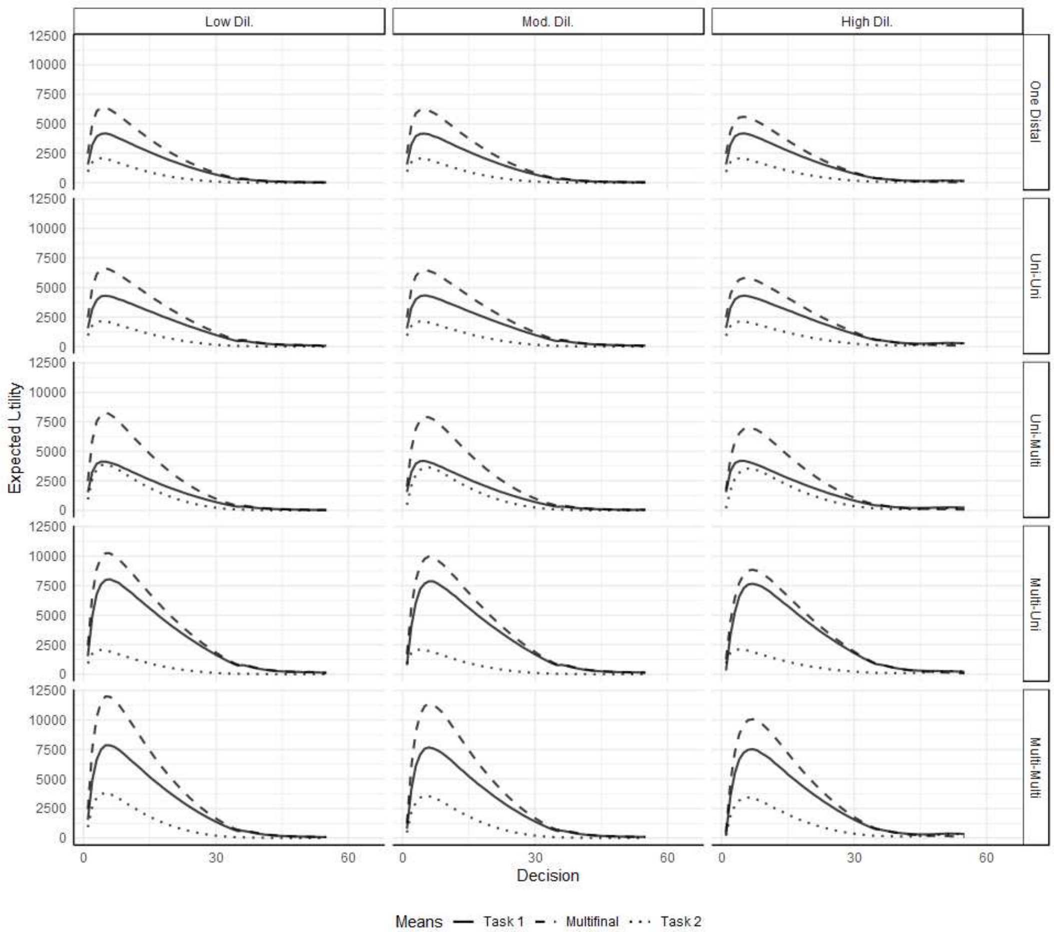

Figure 17. Exploratory Simulation Means Expected Utility by Goal Network Structure and Dilution Strength

Discussion

These exploratory simulations aimed to further probe the impact of task reference difference and dilution strength on means choice. With respect to task reference difference, the simulation results suggest that as long as there is an alternative task with some reference, even if small, a multifinal means that simultaneously accomplishes both the focal and alternative tasks will be preferred. Only once the alternative task is complete will a unifinal means to the focal task emerge as an appealing route to goal pursuit. If two tasks are equally as focal (i.e., have equal references), a multifinal means will be preferred throughout goal pursuit.

With respect to dilution strength, the simulation results suggest that a stronger dilution strength, operationalized as the extent to which a multifinal means' instrumentalities are weakened by its connection to multiple tasks, does decrease the relative selection rate of a multifinal means. However, even under a relatively potent dilution strength, a majority of simulated individuals still did not opt for the unifinal over multifinal means.

Chapter 5: Study 2: Model Validation

Given that the simulation results were not consistent with some of the findings and propositions of previous research on hierarchical goal choice (e.g., Orehek et al., 2013), it was important to evaluate whether the patterns produced by the HMGPM reflect the decision-making and goal pursuit processes of real individuals. Consequently, a validation study was conducted. Due to the infeasibility of empirically examining all the conditions simulated in Study 1 in a single study and because the observed patterns of means choice were largely unaffected by the manipulations in the virtual experiments, select levels of the factors of interest (goal network structures, task reference differences, and means instrumentality certainties) were examined. One particularly effective means for guiding such decisions is to identify a unique pattern of results from the simulation and to recreate those in an experimental design. In the present scenario, the (slightly) elevated preference for the unifinal means to the *less important* task 2 in the two distal goal, unifinal-multifinal goal network structure under conditions of high task reference differences and low means instrumentality certainty suggested this combination of factors would provide a useful diagnostic condition. For comparison purposes, the most basic goal network structure (one distal goal to which each of the tasks were unifinal) with a task reference difference of zero and high means instrumentality certainty was selected.

Based on these selections, a 2 (goal network structure: 1 distal goal, 2 distal goals) x 2 (task reference difference: high, low) x 2 (means instrumentality certainty: high, low) research design was used to empirically validate the results of the simulation of the HMGPM presented in Study 1. The impact of these factors was examined using an in-lab scheduling task, in which participants were given goals of creating a certain number of schedules for different colleges in a hypothetical university.

Two goal network structures (one distal goal versus unifinal-multifinal) and two levels of task reference difference (equal versus unequal) were crossed, creating four between-subject conditions. Two levels of means instrumentality certainty (low versus high) were also examined using a within-subject design. Means instrumentality certainty was selected to be manipulated within person because it reduced the cost of data collection by increasing the number of observations collected from each participant. Further, of the three factors, the within-person manipulation of means instrumentality certainty allowed for the best control and lowest potential for confounds across trials. In order to contextualize the discussion of the measures and procedure, a description of the task and the operationalization of the factors of interest is provided first.

Task Description

The experimental lab task was built using Aptima's Dynamic Distributed Decision-Making (DDD) simulation software. DDD was developed for the purposes of researching team decision-making in military contexts (e.g., Littleton & Freeman, 2003; MacMillan, Entin, Hess, & Paley, 2004; Torenvliet & Culligan, 2008), however, the software provides a flexible platform that can be used to examine individual or team decision making in general. The task developed in DDD represented a scheduling system for a hypothetical university (Northeast Institute) at which the study participant was recently hired as an academic advisor (Figure 18). Similar scheduling tasks have been employed in previous research on multiple-goal pursuit (e.g., Schmidt & DeShon, 2007; Schmidt & Dolis 2009), though the current iteration was modified to allow manipulation of goal network structure and means instrumentality certainty.

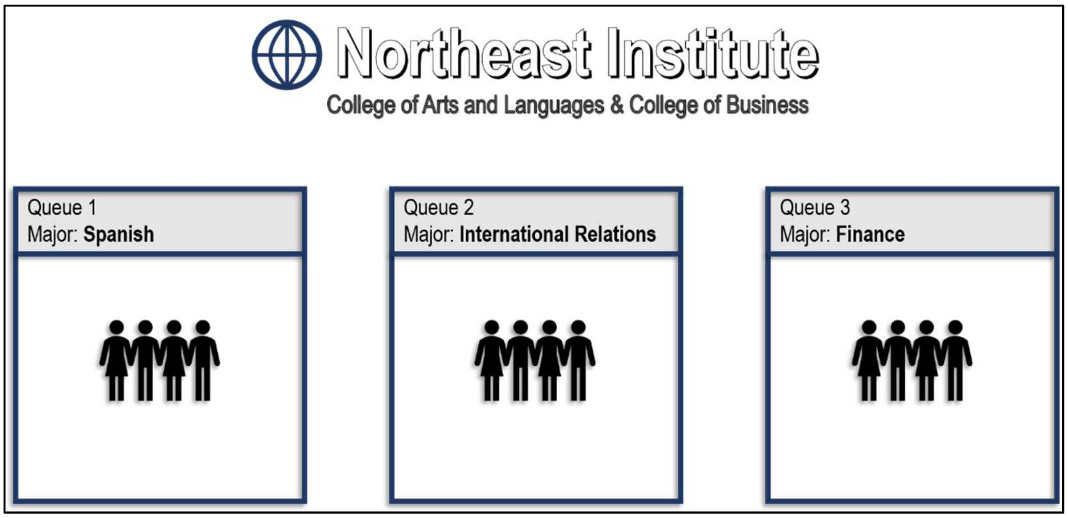

Figure 18. Study 2 Depiction of Scheduling System Developed in DDD

In the task, participants are given queues of students from different majors needing assistance with preparing their academic course schedule. The fictitious students are described as taking classes in different colleges of the university depending on their major. In the current study, each fictitious student could be from one of three different majors (Finance, Spanish, or International Relations) and take classes in two different colleges (College of Business, College of Arts and Languages). Finance majors took classes only in the College of Business, Spanish majors took classes only in the College of Arts and Languages, and International Relations majors took classes in both the College of Business and the College of Arts and Languages.

The task displayed three icons representing these three queues of students labeled by major. Study participants were tasked with creating a certain number of schedules from the College of Business and a certain number from the College of Arts and Languages. The specific number of required schedules varied by experimental condition as described below. The task displayed these goals as well as the number of schedules the participant had created for each of the two colleges. These values updated in real-time as the study participant created schedules for the fictitious students. In order to create schedules, participants simply selected one of the queues of students with their mouse and were not required to select specific courses or assign courses to specific time slots as is often done in similar scheduling tasks. These functions were not necessary for examining the foci of interest in the current study.

Goal Network Structure

Research suggests that identities serve as higher-level motivations that generally guide everyday behavior (Howard, 2000; Oyserman, 2001, 2007; van Knippenberg, 2000). The manipulation of goal network structure was thus controlled by priming role identities relevant to the scheduling task. In the single distal goal condition, participants were assigned to the role of academic advisor for Northeast Institute. In the unifinal-multifinal two distal goal condition, participants were also told to imagine they had graduated from the College of Arts and Languages at Northeast Institute prior to joining as an academic advisor. Thus, participants in the single distal goal condition only had the work role goal of academic advisor, whereas those in the unifinal-multifinal condition had the work role goal of academic advisor and an affiliation goal related to the College of Arts and Languages. Figure 19 provides a depiction of these goal network structures.

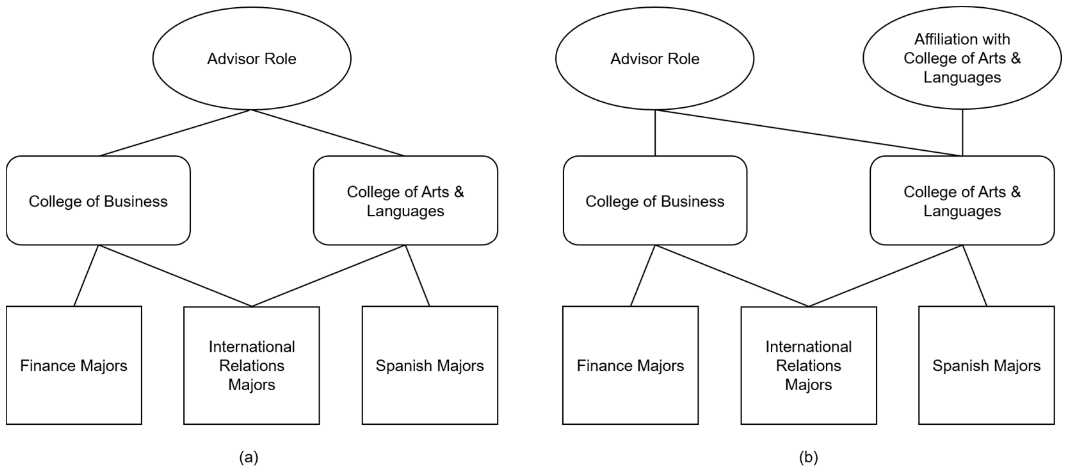

Figure 19. Representations of Study 2 Goal Network Structures

Depictions of the a) single distal goal network structure and b) unifinal-multifinal goal network structure develop for the scheduling task in Study 2.

Task Reference Difference

Consistent with their operationalization in the HMGPM, task goals require discrete explicit reference values. In the current study, task goal reference values were operationalized as the number of schedules a participant needed to create for a given college at the Northeast Institute. In all conditions, participants were assigned separate goals for the College of Business and the College of Arts and Languages. In the equal task reference condition, participants were given the goals of creating 100 schedules for the College of Business and 100 schedules for the College of Arts and Language. In the unequal task reference condition, participants were given the goals of creating 100 schedules for the College of Business and 25 schedules for the College of Arts and Language. These task references were selected to correspond to the parameter values for the equal and large task reference differences conditions examined in the simulations. Further, these tasks could be completed in a reasonable amount of time before the deadline, thus reducing the influence of time pressure on means choices.

Means Instrumentality Certainty

Means instrumentality is the number of units of a task goal that a specific mean, or action, can accomplish in a given time period. Means instrumentality certainty is the degree to which that number varies each time the action is performed (i.e., the variance of the likelihood distribution). In the current study, each time a participant selected a queue of students from a specific major to schedule, the number of schedules created for the associated colleges updated by some number. In the high certainty condition, the number of schedules created with each action was always three, such that there was no variance in the means instrumentality likelihood distribution. In other words, when a participant selected a student from the queue of Finance majors, the number of schedules completed for the College of Business increased by three; when they selected a student from the queue of Spanish majors, the number of schedules completed for the College of Arts of Languages increased by three; and when they selected a student from the queue of International Relations majors, the number of schedules completed for the College of Business and College of Arts and Languages *both* increased by three.

In the low certainty condition, variance was maximized by making the likelihood of any possible means instrumentality (i.e., between zero and five, replicating the model conditions) equal. Thus, each time a participant selected a student from a specific major, the number of schedules completed for the associated college(s) changed by a value randomly sample between 0-5. Thus, in both conditions, the average means instrumentality for a given means to its respective task goals was three, but the degree of variance in task goal achievement for every action taken was greater in the uncertain condition.

Method

Participants

Participants were recruited from the University of Maryland participant pool via SONA Systems. Participation required approximately 1 hour, for which participants were compensated with 1 SONA credit or $10. A total of 163 participants completed the study. 69.33% of participants were female and one identified as gender non-conforming/gender fluid. 35.58% of participants were White, 31.29% Asian, 17.18% African American, with the remaining 15.95% identifying as Latino/a, Middle Eastern, multiracial, or an unlisted race. 7.36% of participants identified as Hispanic. On average, participants were 20.46 years old (SD = 3.58) and the majority were in their first (31.90%) or second year (27.61%) of college (two participants were not students).

Due to computer recording errors, data from four participants could not be recovered. Thus, the final sample size analyzed was 159.

Measures

Participants completed a series of questions before and after completing the scheduling task that served as manipulation checks or outcomes of interest. These questions broadly assessed participants' perceptions of means instrumentality, expectancy of completing the task goals, and the salience of the distal goals.

Means Instrumentality Certainty. Means instrumentality certainty was assessed before and after completing each trial of the task as a manipulation check that the high or low variance of the means instrumentalities was salient to participants. Specifically, this item assessed participants' perceptions of the reliability of the scheduling system used in the task. Participants were asked, "How reliable do you expect the scheduling system to be in the next trial?" and "How reliable was the scheduling system in the last trial?" Participants responded using a 5-point Likert scale from "Not at all" (1) to "Extremely" (5).

Expectancy of Task Completion. A deadline of 3 minutes and 30 seconds was selected for each trial in order to ensure that participants were not under time pressure to complete the tasks and had a high expectancy of completing each one. To assess this expectancy, participants' expectations of successfully completing each assigned task goal was assessed prior to each trial using the question, "How likely are you to achieve your scheduling goal for the [College of Arts and Languages/Business]?" Participants responded using a slider scale that ranged from 0% to 100%.

Distal Goal Salience. As a manipulation check that participants in the unifinal-multifinal goal network structure condition were aware of their second distal goal, the salience of each distal goal was assessed before and after each trial. Specifically, participants were asked "How affiliated do you feel [with the role of advisor at the Northeast Institute/with the College of Arts and Languages]?" Participants responded on a 5-point Likert scale, where each option depicted a circle representing the participant (labeled "You") and a circle representing the distal goal moving from completely not overlapping (1) to completing concentric (5). An example of this item is provided in Appendix A.

Perceived Means Instrumentality. Perceived means instrumentality was assessed before and after completing each trial of the task in order to evaluate whether participants updated their perceptions of means instrumentality as they completed the tasks. These items assessed participants' perceptions of the instrumentality of each means to each task. Specifically, participants were asked pre-trial, "During the next trial, how many schedules for the [College of Arts and Languages/Business] do you expect to be able to create each time you choose to schedule [Spanish/Finance/International Relations] majors?" The modifications, "During the last trial…" and "…were you able to create…" were made in order to assess participants' post-trial perceptions. Responses were open-ended and participants could answer with any positive integer.

Procedure

One to four participants participated per scheduled study session. Once participants arrived to the lab, they were randomly assigned to one of the four between-person conditions that determined their goal network structure and task reference difference. All participants completed two trials of the task, with one trial involving high means instrumentality certainty and the other low certainty. To control for possible order effects, the order in which participants completed mean certainty conditions was counterbalanced.

Participants were seated at an individual computer station and completed an informed consent form. Following consent, participants read instructions for the scheduling task, which described their role as an advisor and, if they were assigned to the two distal goal/unifinal-multifinal condition, described them as having graduated from the College of Arts and Languages prior to becoming an advisor. Following these instructions, participants watched a video, which lasted two minutes and fifteen seconds, explaining the task and the controls in the scheduling system.

After the video, participants completed a practice trial under the supervision of the experimenter to ensure the participant knew how to operate the task. In the practice trial, participants were given the goals of completing 10 schedules for each of the two colleges (20 total schedules). The means instrumentality of each queue of students was certain (i.e., no variance) and was equal to one. Before completing the practice trial, the experimenter instructed participants to click on each of the queues in order to make sure the system was functioning correctly and to ensure the participants understood how to interact with the system. Participants were then given three minutes and thirty seconds to complete the practice trial.

Following the practice trial, participants were given their goals for trial 1 based on their task reference difference condition. Additionally, participants completing the low means instrumentality certainty condition were told the scheduling system had been unreliable of late in order to increase awareness of the means variance and improve fidelity of the task. Immediately prior to beginning trial 1, participants completed all pre-trial measures described above. The experimenter then started the system for trial 1 and participants were given three minutes and thirty seconds to complete the trial.

Following trial 1, participants completed all post-trial measures described above. They were then given their goals for trial 2 and were told that the system had been unreliable or had been fixed, depending on the information they had been given in trial 1 and the means instrumentality certainty of trial 2. Participants then completed the pre-trial measures. The experimenter then started the system for trial 2 and participants were given three minutes and thirty seconds to complete the trial.

Following trial 2, participants completed the post-trial measures. Finally, participants provided demographic information regarding their gender, age, race/ethnicity, year in school, major(s) (if applicable), and the colleges with which they were affiliated at the University of Maryland (if applicable). Participants were thanked for their time and were compensated with 1 SONA credit or $10.

Analysis Strategy

Two specific outcomes were assessed at each decision point across each trial: means choice and discrepancy for each task. To examine means choice, the percentage of participants that selected each of the three possible means (unifinal to Task 1, unifinal to Task 2, and multifinal) at each decision point was calculated within conditions. DDD captured a participant's current state toward each task at each decision point. For each task, discrepancy was calculated by subtracting a participant's current state from the task's reference. To assess this outcome, discrepancy was averaged across participants at each decision point within condition.

T-tests were used to assess all other outcomes that were assessed pre- and/or post-trial.

Results

Manipulation Checks

Goal Network Structure. Independent of goal network structure, participants' average feelings of association with their role of advisor after reading the cover story (i.e., pre-trial 1) were 3.67 (SD = 1.10). An independent-samples t-test confirmed that participants who were told to imagine they had graduated from the College of Arts and Languages reported feeling more affiliated with that college after reading the cover story ($M = 3.67$, $SD = 1.18$) compared to those who were not told they had graduated from either college ($M = 3.23$, $SD = 1.17$; $t(157) = -2.39$, $p < 0.05$, $d = 0.38$). These results provide evidence that the manipulation of goal network structure was successful: all participants had a salient distal goal of being Northeast Institute's advisor, but only those in the goal network structure with two distal goals had a second salient affiliation goal driven by their connection to the College of Arts and Languages.

Means Instrumentality Certainty. A paired-samples t-test confirmed that, on average, participants rated the scheduling system as less reliable following their low means instrumentality certainty trial ($M = 2.21$, $SD = 1.09$) compared to following their high means instrumentality trial ($M = 3.40$, $SD = 1.29$; $t(158) = 10.15$, $p < 0.05$, $d = 0.81$). These results provide evidence that the manipulation of means instrumentality was successful and that participants were aware of the variability in feedback they received from the system.

Patterns of Multiple-Goal Pursuit

Participants engaged in a range of 34 to 70 decisions before completing both task goals. Figures 20 and 21 represent the total number of decisions participants engaged in depending on their goal network structure condition and their means instrumentality trial by their task reference difference condition. 97.88% of participants engaged in 60 or fewer decisions. Thus, decisions 1 through 60 were used in the following analyses. Note, however, that beyond approximately decision 45 in most conditions, fewer and fewer participants were still engaging in decisions, potentially increasing the instability of aggregates at these points. The results are organized around the two focal research questions and the comparison of the patterns in the empirical data to those in the simulated data.

Research Question 1. The first research question examines how and to what extent goal network structure impacts means choice during multiple-goal pursuit. Figure 22 summarizes participants' means choices over time in the two goal network structures aggregated across task reference differences and means instrumentality certainty. Similar to the simulation in Study 1, goal network structure did not strongly influence observed patterns of means choice. Further, these results show that during the initial decisions (i.e., through approximately decision 13), the multifinal means was selected by the highest percentage of participants in

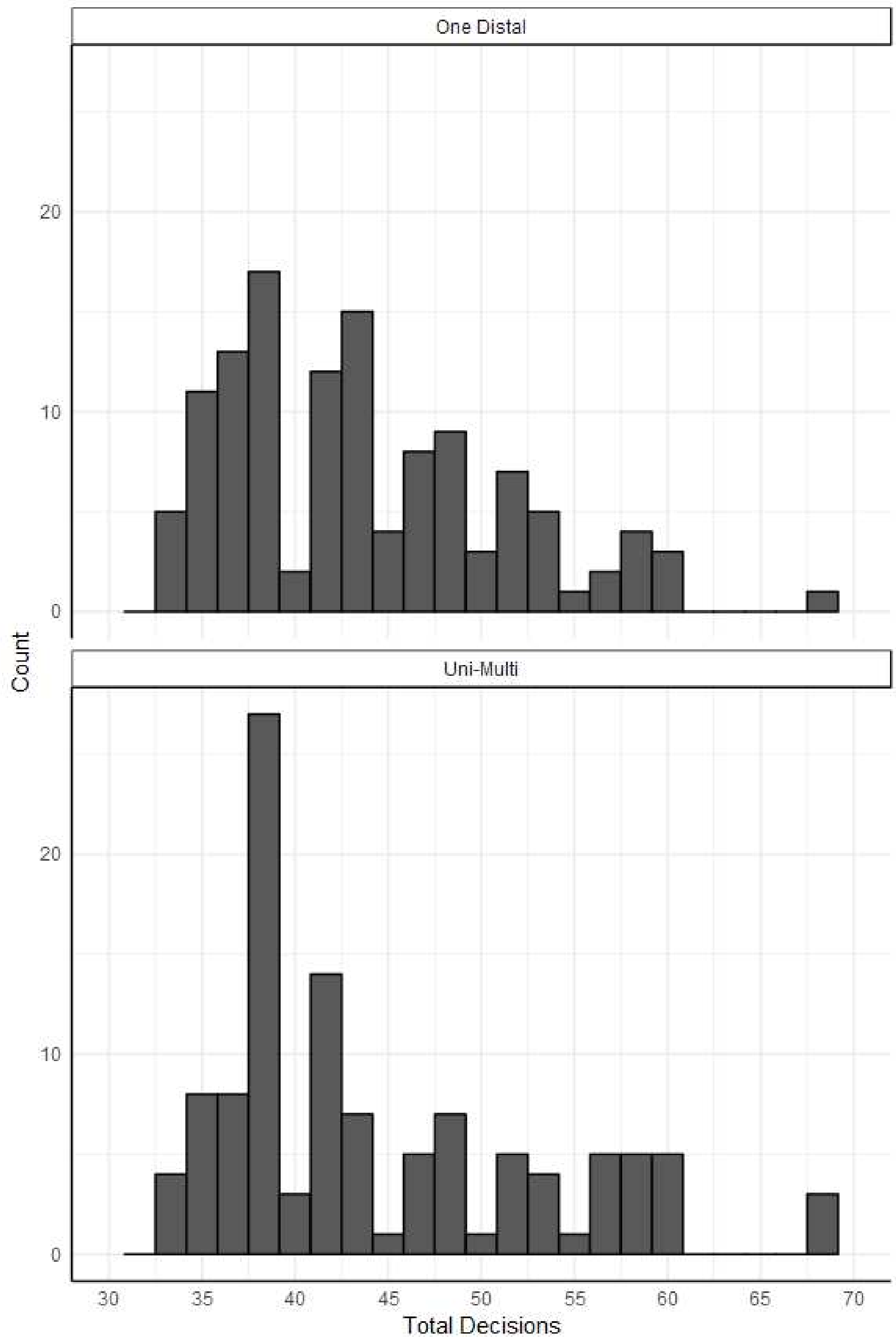

Figure 20. Study 2 Final Decision Counts by Goal Network Structure

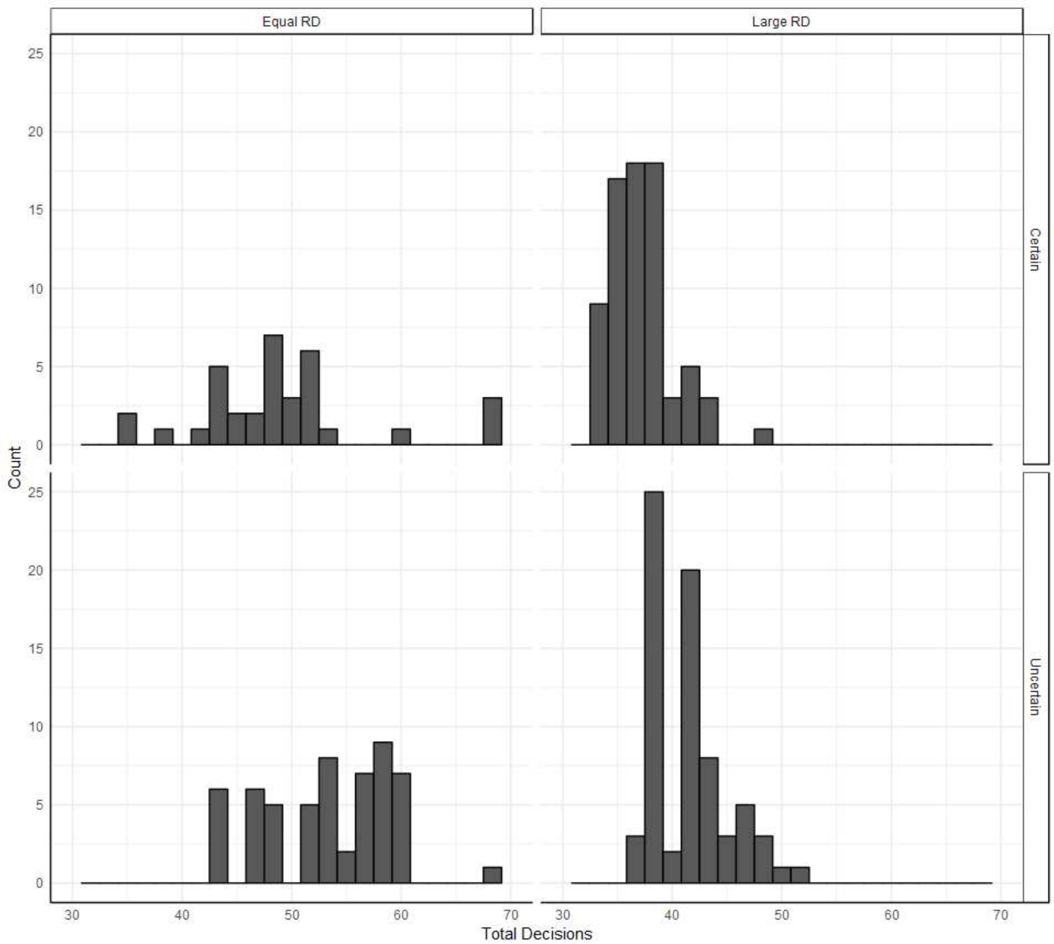

Figure 21. Study 2 Final Decision Counts by Task Reference Difference and Means Instrumentality Certainty

both goal network structures. Though not endorsed to the same degree, this initial pattern is consistent with the simulation results from Study 1 (compare to Figure 5). However, and unlike the previous simulation results, more participants switched to using the unifinal means to schedule Finance majors to the College of Business (i.e., equivalent to the unifinal means for task 1 in the simulation) for the remainder of goal pursuit.

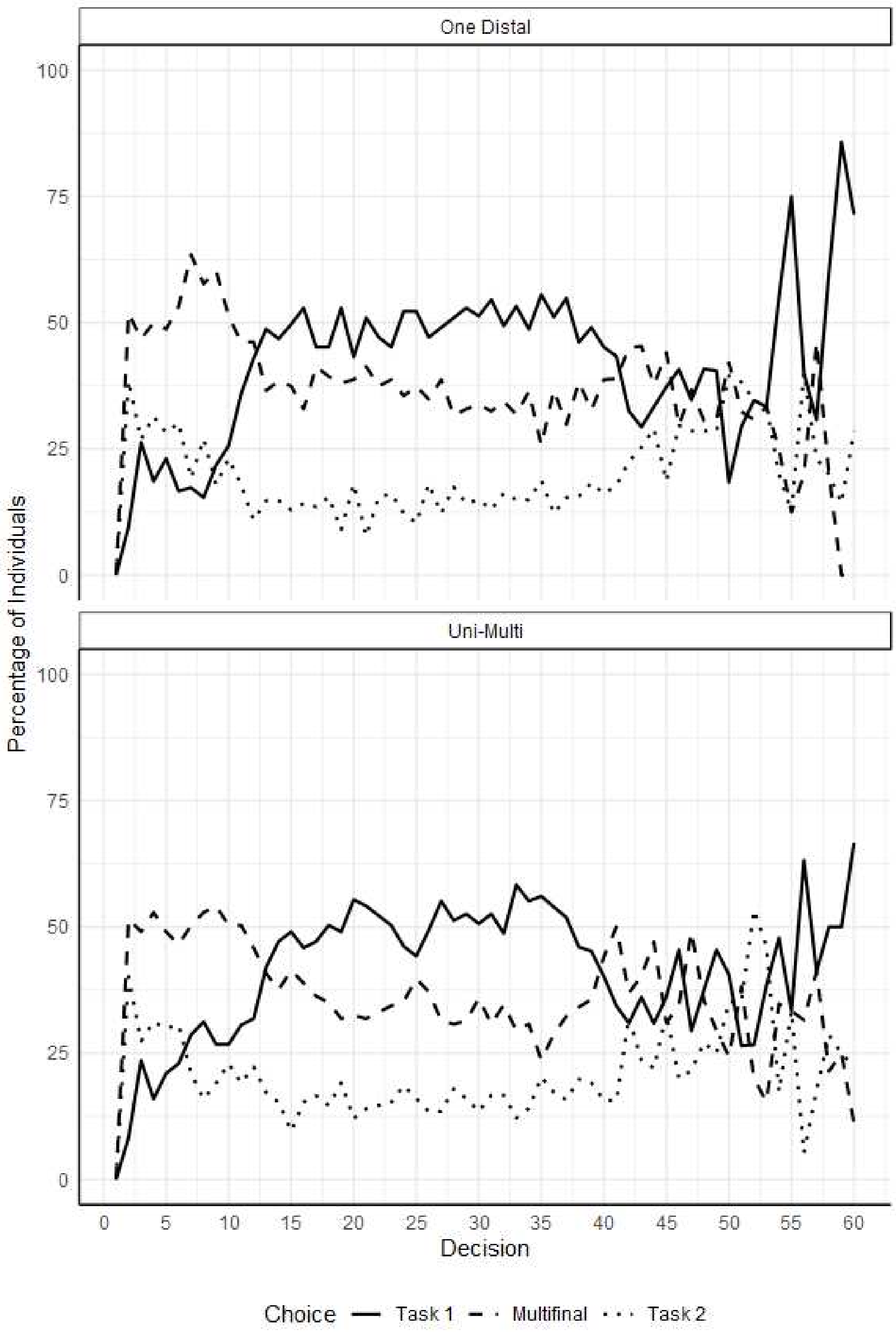

Figure 22. Study 2 Means Choice by Goal Network Structure

The follow-up simulations suggested that task reference differences may contribute to the pattern of participants' means choice. Specifically, the simulation suggested that when the task reference difference is large, a greater percentage of simulated individuals eventually switched to the unifinal means for task 1 (equivalent to the queue of Finance majors in the lab study) from the multifinal means once task 2 was complete. However, when task references were equal, simulated individuals maintained their preference for the multifinal means.

To examine whether this difference in patterns of means choice was replicated in the lab data, Figure 23 summarizes participants' means choice over time within the four conditions created by crossing the goal network structure and task reference difference. These data reveal a similar pattern of means choice to that produced by the HMGPM (compare with Figure 7). When participants had an equal number of schedules to create for both Colleges (i.e., task reference difference = 0), the (slight) majority of respondents opted to stick with the multifinal means by scheduling students from the International Relations major throughout goal pursuit, thus allowing them to accomplish both task goals simultaneously. In contrast, when participants had fewer schedules to create for the College of Arts and Languages (25 schedules) than for the College of Business (100 schedules), the majority initially selected the International Relations major. Once this less demanding task was completed (usually occurring near time 15, see Figure 24), the majority

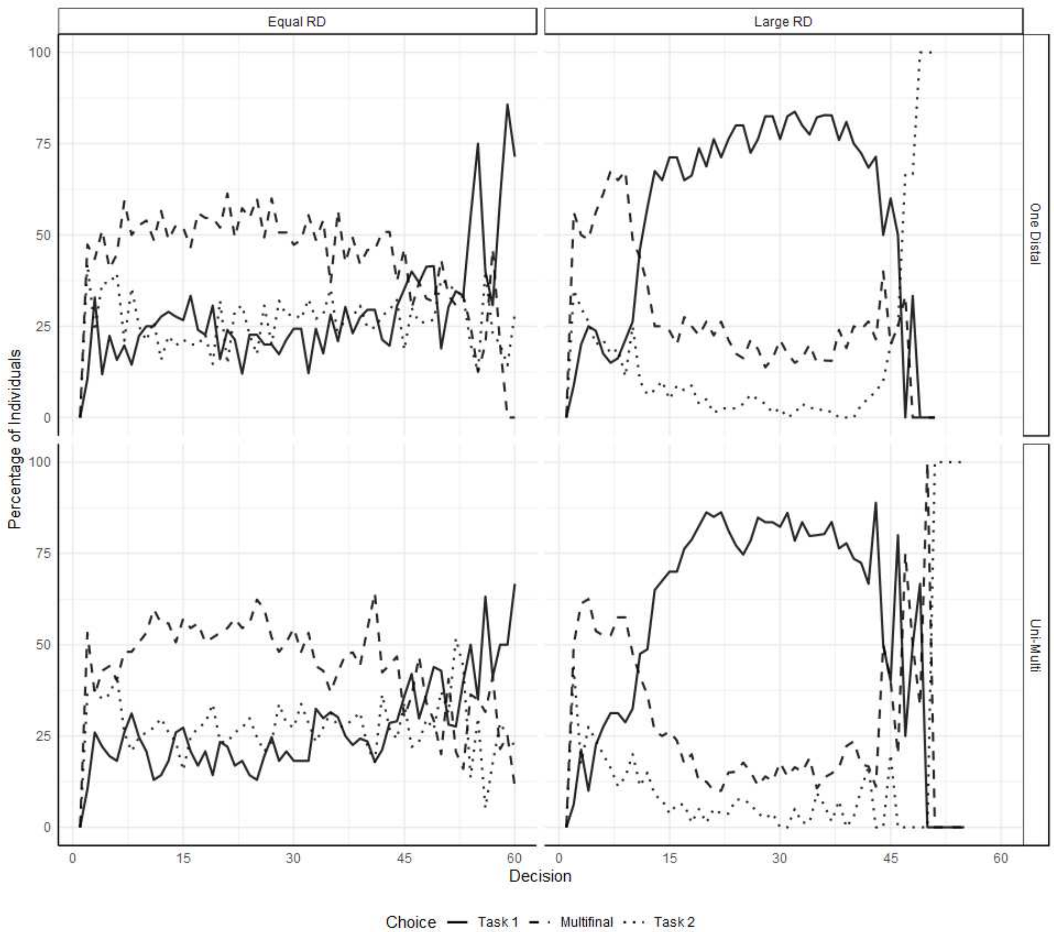

Figure 23. Study 2 Means Choice by Goal Network Structure and Task Reference Difference

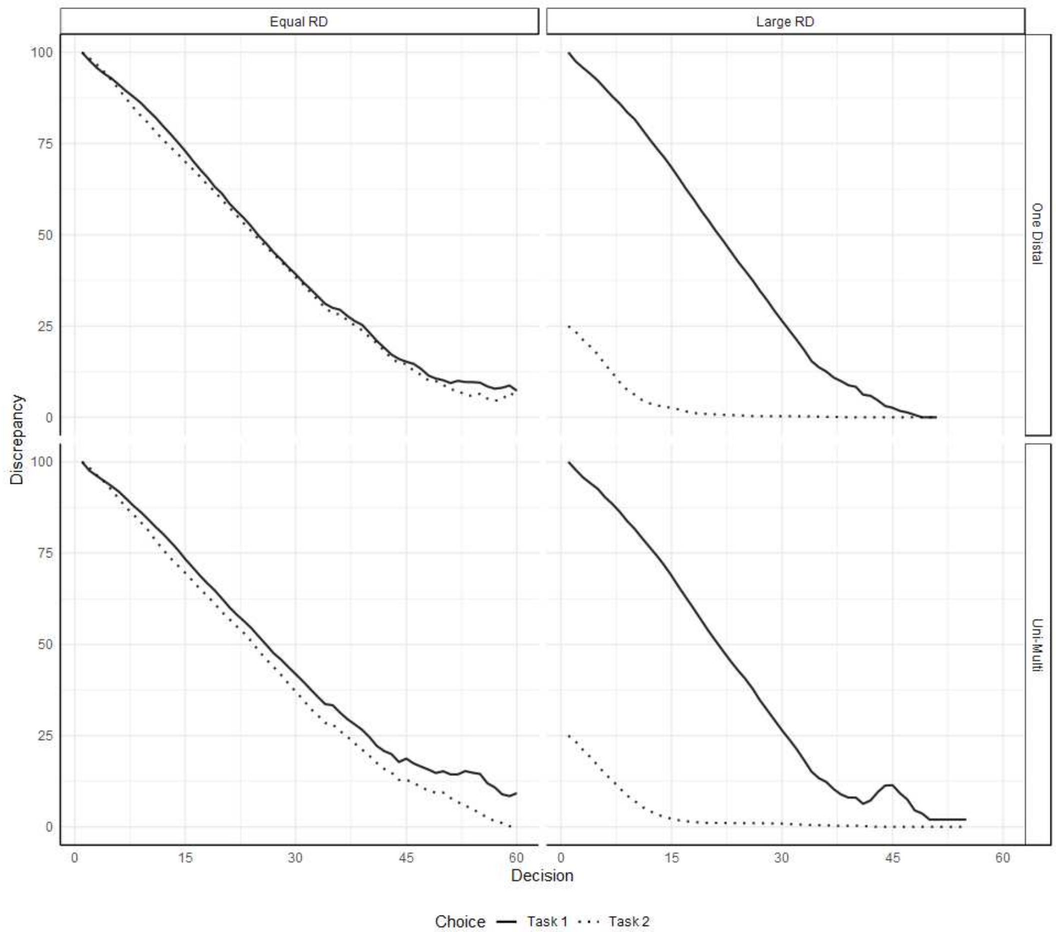

Figure 24. Study 2 Task Goal Discrepancy by Goal Network Structure and Task Reference Difference

switched to selecting the queue of Finance majors (i.e., the unifinal means for the College of Business task goal).

While the patterns of means choice predicted by the simulation results are generally consistent with the patterns observed in the lab, there are two notable differences. First, there was an immediate initial divergence in the selection of the three possible mean choices in the simulation, such that the majority (~75%) of simulated individuals selected the multifinal mean at the first decision point and that percentage increased throughout goal pursuit. In the empirical data, the immediate, overwhelming preference for the multifinal mean was not observed. Rather, the selection preference for the multifinal means did not diverge from the alternatives until somewhere between decision 2-6, depending on the condition. This pattern may suggest that participants were engaging in some form of experimentation with the various means choices before attempting to maximize their efficiency and productivity by selecting the multifinal means.

This result is not inconsistent with the simulated results, per se, in that both participants and simulated individuals eventually prioritized the multifinal means. However, the simulations did not predict this early experimentation. This may be due to a difference in the decision criteria applied by participants over time compared to simulated individuals. From the beginning of goal pursuit, simulated individuals' means choices were driven by a simple utility-maximization rule, which identified the multifinal means as the most valuable despite the dilution of its instrumentalities (Figures 5 and 14). Participants in the lab study may have engaged in a simple utility-maximization process only after experimenting with all possible means choices. Alternatively, dilution may have played a more significant role in lab participants' evaluation of the means choices compared to simulated individuals. It may also simply be that participants preferred trying each queue of students to confirm they understood the scheduling system before carrying on with their goal pursuit.

The second difference between the simulated and lab results is the extent to which the multifinal means dominated choice when task references were equal and the extent to which the unifinal means for task 1 eventually dominated choice when task references were unequal. In the simulated results when task references were equal, 75% to nearly 100% of simulated individuals selected the multifinal means throughout goal pursuit. In the lab results, the percentage of participants that selected the multifinal means (the queue of International Relations majors) hovered at approximately 50%, while the percentage that selected each of the unifinal means hovered at approximately 25%. This may also speak to the assumption of the utility-maximization mechanism as the goal selection function in the HMGPM. For example, different participants in the lab study may have been engaging in different strategies to identify goal choice. The largest proportion (~50%) may have been attempting to maximize the utility of each single decision by reducing the task goal discrepancies for both Colleges simultaneously. However, and perhaps because participants were not under time pressure and therefore had a high expectation of completing their goals[2], the remaining 50% may have been alternating between the two unifinal means for the two Colleges rather than selecting the multifinal means. Explorations of the participant-level patterns of means choice suggest this may be the case. In sum, the observed results might be attributable to different participants employing a simultaneous versus a switching strategy.

When task references were unequal, the percentage of participants that eventually switched to the unifinal mean for the remaining task (the College of Business) once the alternative (the College of Arts and Languages) was accomplished was higher than the percentage of simulated individuals that took the same approach to goal pursuit. In the model, once one of the two tasks was completed, the multifinal means that was instrumental to both tasks eventually only derived utility from the

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[2] On average, participants believed they had an 84.54% (*SD* = 17.00) likelihood of completing their task goals.

remaining task, meaning its utility became equal to that of a unifinal means to the same remaining task. In the simulations, this occurred after the multifinal means' true instrumentalities were converged upon, meaning it was no longer impacted by dilution. Thus, simulated individuals were approximately equally as likely to select the multifinal means or the unifinal means to the remaining task due to their equal utilities. The results of the lab study suggest that the connection of the multifinal means to the College of Arts and Languages task goal negatively impacted participants' likelihood of selecting that means once that task had been accomplished. While this may be interpreted as a dilution effect (i.e., a reduction in the multifinal means' appeal in pursuing the focal task compared to a unifinal means) on its surface, it did not appear to impact choice via means instrumentality, as originally theorized. Participants' perceptions of the instrumentality of the multifinal means to the College of Business task (the remaining focal task) were consistent with its true instrumentality of 3 (M = 2.96, SD = 3.80). In other words, the multifinal means' instrumentality was not diluted. Further, its instrumentality was not perceived to be lower than the unifinal means' instrumentality (M = 2.77, SD = 1.59, $t(73) = -0.60$, p = 0.55, d = 0.05). Thus, in terms of instrumentality, the multifinal means was still seen as a viable route to completion of the remaining task, meaning an equal percentage of participants would be expected to select the multifinal mean as the unifinal means. However, approximately 75% to 85% of participants, depending on the goal network structure, were selecting the unifinal means by the final decisions. Thus, the multifinal means' connection to the alternative task goal may have been impacting participants' decisions through some mechanism not directly related to its perceived instrumentality.

Research Question 2. The second focal research question considered how and to what extent the certainty of means instrumentality impact means choice during multiple-goal pursuit. Figure 25 summarizes participants' means choice over time in the two goal network structures under conditions of low and high means instrumentality certainty. When means instrumentality certainty was high, the switch from a preference for the multifinal means to the unifinal means for the College of Business observed in Figure 15 was again observed. This is expected, as the results shown in Figure 18 average across task reference differences, meaning task 1 (the College of Business task) had a higher reference than task 2 (the College of Arts and Languages task) on average.

In the low means instrumentality certainty condition, however, an approximately equal percentage of participants selected the multifinal means and unifinal means for the College of Business in the later decisions of goal pursuit. While simulated individuals had a slightly lower preference for the multifinal means under conditions of low means instrumentality certainty, it was still overwhelmingly the preferred means, especially by the end of goal pursuit (cf., Figure 8). Thus, the equal preference for the multifinal means and the unifinal means to the College of Business observed under conditions of low means instrumentality certainty in the lab was inconsistent with the simulated findings.

The simulation results suggested that means instrumentality certainty tended to have a stronger influence on means choice when task references are equal. To explore this interaction, the impact of means instrumentality certainty on means choice was examined in the equal task reference condition. As observed in Figure 26, in the unifinal-multifinal goal network structure, lower means instrumentality certainty exacerbated the preference for the multifinal means: a larger percentage of participants selected the multifinal means during goal pursuit in the unifinal-multifinal goal network structure when means instrumentality certainty was low compared to the goal network structure with a single distal goal. This suggests that multifinality at the task level impacted the utility of the

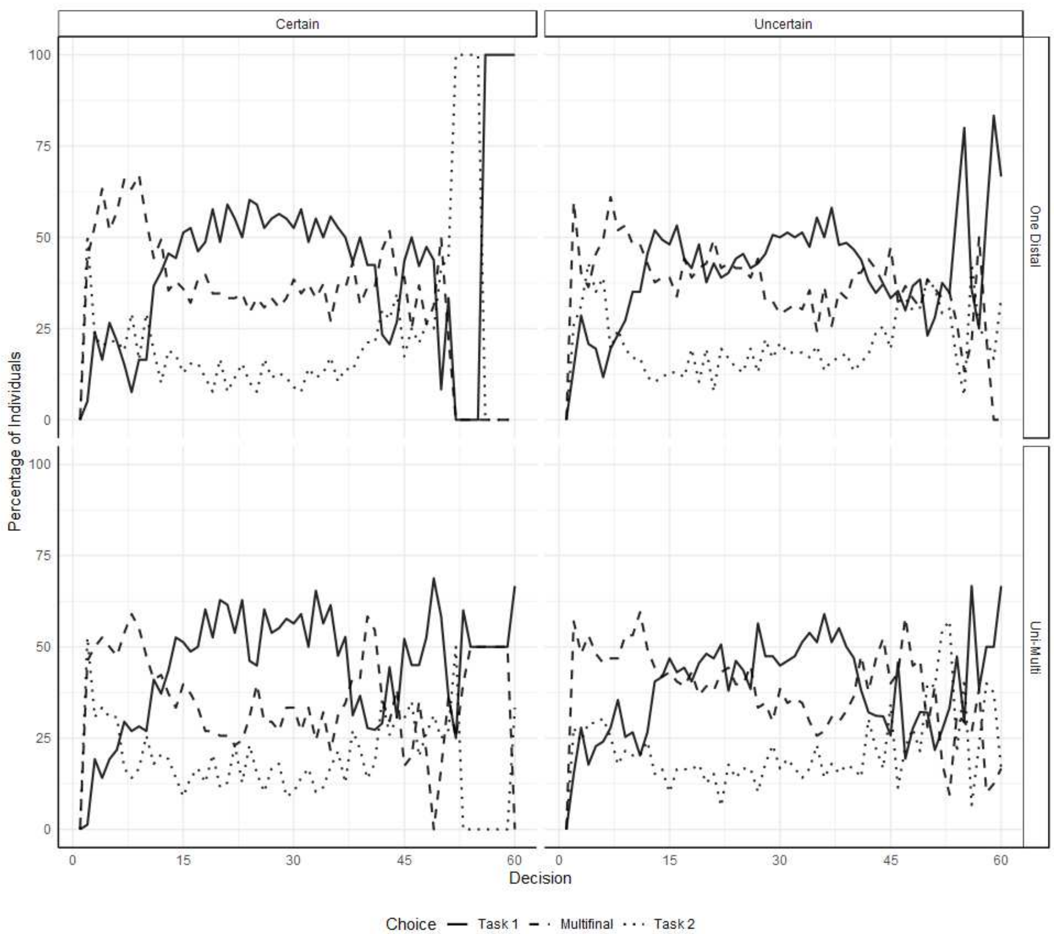


Figure 25. Study 2 Means Choice by goal network structure and means instrumentality certainty. Note that "Task 1" and "Task 2" represent the two possible unifinal means.

multifinal means. Specifically, participants in the unifinal-multifinal goal network structure (i.e., participants with two distal goals) had more to lose in terms of total utility realized at each decision point if an action taken was unsuccessful. If a participant in this condition selected one of the unifinal means, there was an equal likelihood that they would make no progress toward the associated task as they would make a high amount of

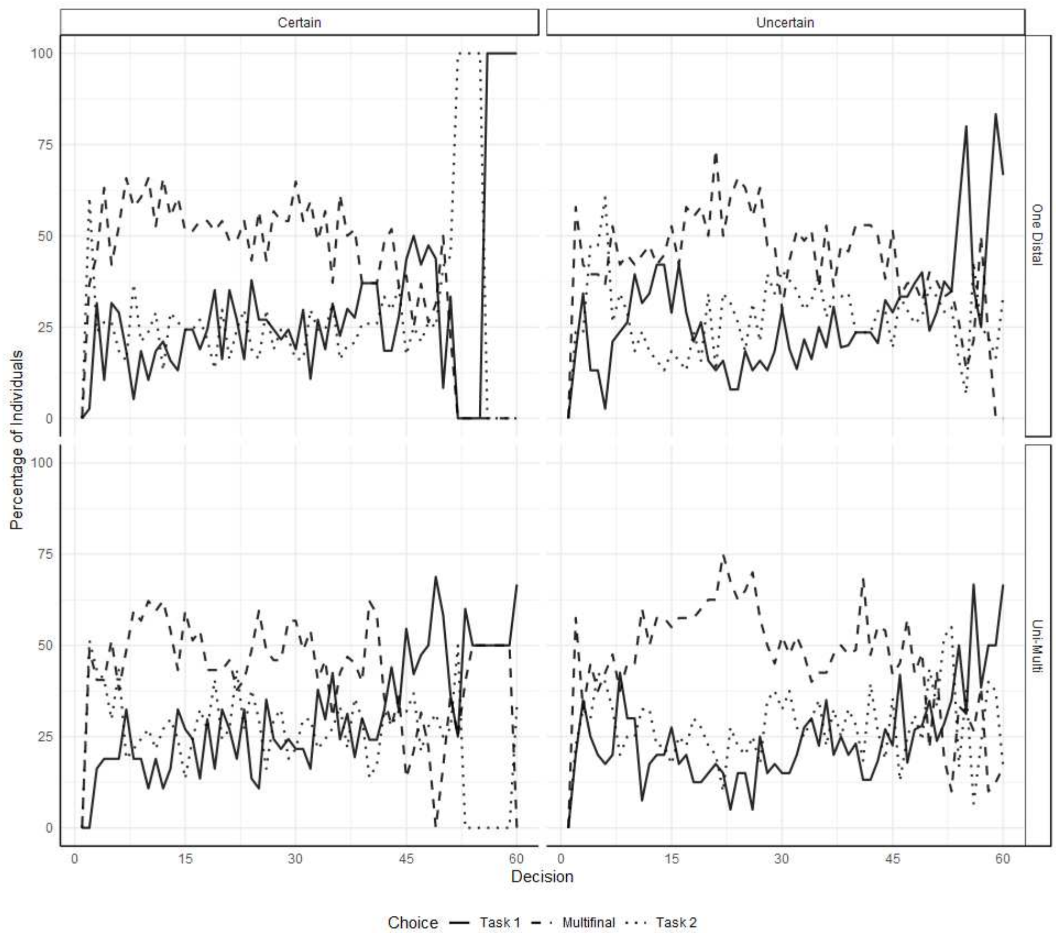


Figure 26. Means choice over goal pursuit by Goal Network Structure and Means Instrumentality Certainty (Task Reference Difference = 0)

progress toward that associated task due to the high variance in means instrumentality. While the multifinal means had the same instrumentality to both tasks as each task's unifinal means, it had a higher likelihood of making progress in general due to its multiple connected tasks. Thus, selecting the multifinal means maximized the potential amount of progress a participant could make at all levels of their goal network.

Discussion

The pattern of results from the empirical study shared a number of consistencies with the results predicted by the simulations in Study 1. As in the simulated data, goal network structure did not exert a considerable influence on means choice independent of other factors. Task reference difference, on the other hand, impacted participants' multiple-goal pursuit strategies. When task references were equal, the majority of participants selected and persisted with the multifinal means throughout task goal completion. However, when task references were unequal, a majority of participants initially selected the multifinal means until the task with the smaller reference was completed. With only a single task goal remaining, many participants then switched towards utilizing a unifinal means to satisfy task goal completion. Overall, these results are similar to those predicted by the HMGPM.

Despite this general consistency between the simulated and lab results, important differences were observed. With respect to task reference differences, the empirical data suggest that a large proportion of participants may have been engaging in an alternative strategy to goal pursuit when task references were equal. Rather than simultaneously making progress on both task goals at each decision point by selecting the multifinal means, the data appeared consistent with a strategy in which many participants may have been switching between the two unifinal means. Participants may have made a longer-term calculation that they could complete both task goals through the less efficient switching strategy. This potential long-term calculation was not incorporated into the model. How and what predicts when participants may make decide to pursue this switching strategy versus pursuing goals simultaneously utilizing a multifinal means remains to be researched. For example, under conditions of time pressure, a larger percentage of participants may be influenced to take the multifinal strategy, as the long-term expectancy of completing both task goals using a switching strategy would be lower given the reduced efficiency of each action taken.

Another key difference emerged under conditions of unequal task references. Participants in the lab preferred the unifinal means for completing their College of Business (i.e., task 1) goal once their College of Arts and Languages (i.e., task 2) goal was complete to a greater extent than simulated individuals. These results may offer important insights into the dilution effect. Specifically, dilution may be impacting the appeal of the multifinal means via an alternative route than through instrumentality given that participants' direct perceptions of the multifinal mean's instrumentality were consistent with its true instrumentality, as reported in the results of Study 2. This suggests the dilution effect may operate differently than it is typically theorized and as incorporated into the HMGPM. However, the greater preference for the unifinal means for a single task goal observed in the empirical data is consistent with the pattern of means choice predicted by prior researchers (Orehek et al., 2013).

Thus, while dilution does not appear to be directly reducing the instrumentality of the multifinal means, as would be predicted by prior researchers as the cause of the preference for a unifinal means, it may impart influence through some other mechanism, explored further in the General Discussion. That is, the connection of the multifinal means to a task that the participants no longer had to complete appeared to impact their decisions and this impact was not part of the mechanisms incorporated into the HMGPM. Thus, more precisely identifying and describing the dilution effect may be a fruitful goal of future research.

Chapter 6: General Discussion

The current project aimed to extend and explore initial validation evidence for a model of multiple-goal pursuit in a hierarchical goal network (HMGPM; Samuelson, 2017). The primary aim and contributions of this work centered on two important research foci: how variations in (1) task goal finality (i.e., the number of higher-level, distal goals more proximal tasks are instrumental in achieving) and (2) means instrumentality certainty (i.e., the variability in the effectiveness of actions taken toward goals) impact the manner by which individuals pursue multiple hierarchical goals. Simulations with the HMGPM and an experimental lab study designed to evaluate the model predictions in real data provided several insights into behavior in a multiple-goal pursuit context. Insights with respect to the research questions initially posed and with respect to validation of the HMGPM are discussed below. The paper then concludes with a discussion of the limitations of the current studies and suggestions for future research.

Impact of Goal Network and Certainty on Multiple-Goal Pursuit

There are two main takeaways with respect to the research questions. One, the relative difference in importance of an individual's task goals (i.e., their reference values) appears to impacts goal pursuit choices to a greater extent than the number of distal goals salient to that individual. Both simulated individuals and lab participants tended to take the same strategy to multiple-goal pursuit whether they had one or two salient distal goals. However, if they had a more demanding task goal (i.e., a task with a higher reference), both simulated individuals and lab participants typically attempted to make simultaneous progress on both goals by using a multifinal means. Once the less demanding task was completed, they tended to switch to using a unifinal means to the remaining task, despite the multifinal means still being equally as effective. In contrast, if both tasks were equally important, individuals prioritized the multifinal means for the entirety of their goal pursuit. These results suggest that individuals do consider their goal pursuit actions in a multiple-goal context—if a data scientist needs to develop a dashboard for her company and develop a workshop for young coders and has an available means for completing those tasks simultaneously, she will take that means. However, once one of those tasks is complete, the current studies suggest that she will opt for a means that only helps her make progress toward the remaining task, even if the multifinal means remains equally as effective. This switching behavior is discussed in the context of the dilution effect in more detail below.

Despite this general lack of influence from goal network structure, there was one specific condition examined in the current studies where the number of salient distal goals did appear to matter. Participants who had multiple salient distal goals (their work role as advisor and their affiliation with the College of Arts and Languages) were particularly impacted by uncertainty in the effectiveness of their means to goal completion when their two tasks were equally important. These participants prioritized the multifinal means for task completion to a much greater extent than others.

Thus, a second main takeaway related to the research questions is that the presence of multiple goals throughout an individual's goal hierarchy may motivate them to maximize each action they take during goal pursuit by opting for a means that has the highest likelihood of moving them towards completing at least one of their goals. This uncertainty-driven maximization may generally be an effective strategy to multiple-goal pursuit in terms of a single individual's goal achievement. However, when other factors are taken into consideration, uncertainty may have an overall negative impact on goal pursuit. For example, research suggests that individuals under conditions of uncertainty may be unable to reap the self-enhancement benefits of high-quality, specific feedback (Whitaker & Levy, 2012). With the addition of other relevant factors, different patterns of multifinal versus unifinal means choice may be observed under uncertainty.

Validity of the HMGPM

Broadly, the HMGPM generated patterns of means choice during multiple-goal pursuit that matched those of participants in a lab setting. These patterns have been discussed in detail above and can be summarized as a preference for multifinality in contexts with multiple tasks and a preference for unifinality when a single task remains. However, discrepancies between the simulated and empirical data raise questions about specific processes represented in the HMGPM. One process of interest is the utility-maximization rule incorporated into the model at the means-choice stage. In the current simulation, the HMGPM represented three independent means choices—a unifinal means for each of two tasks and a multifinal means that satisfied both tasks. The HMGPM indirectly represents an individual's "memory" for previous means chosen in the form of updates to a means' perceived instrumentality. Further, it did not take future information into account beyond the final deadline. Thus, when making a choice about which means to select, the HMGPM selects the means that has the highest value at that specific decision point without taking the broader picture into account. That is, it selects a single action for a single decision point, rather than a *strategy* toward goal completion.

In conditions of equal task references, this resulted in a nearly 100% preference for the multifinal means at each decision point. The data collected in the lab suggests this may only be one of many strategies an individual could take to goal pursuit, particularly when not under time pressure. Approximately half of the participants opted to take a switching strategy toward multiple-task completion, where they switched between the two unifinal means and still completed both tasks. The HMGPM did not account for the possibility of pairing different means across time and still maximizing long-term utility. In the development of an HMGPM that most accurately represents human behavior in multiple-goal pursuit, this discrepancy highlights an area for future consideration.

The second process of interest with respect to observed discrepancies between the simulated and empirical data is the dilution effect. The HMGPM incorporates dilution into perceived instrumentality. Consistent with previous discussion of this topic (Zhang et al., 2007), when an element in a goal system has multiple vertical connections, its instrumentality to any of those higher-level elements is perceived to be weaker, or “diluted.” The simulations examined a range of strengths of that dilution, from a perceived instrumentality that was half as large as its non-diluted magnitude to one that was a tenth as large.

This dilution was expected to decrease the preference for a multifinal means, particularly in contexts where the two tasks had different references. However, in all cases, this dilution effect only had a minor impact on means choice, even when only one task remained. Participants' patterns of means choice, however, were somewhat in line with predictions driven by the dilution effect. When they had a single task to complete, they opted for a unifinal means despite the equal viability of the multifinal means in terms of its perceived instrumentality. Thus, the multifinal means' multiple connections did appear to impact participants' behavioral choices, but it did not change their perceptions of that means' instrumentality as was expected. With respect to model validation, these results suggest that dilution should be a point of development in the HMGPM in order to improve its fit with human behavior.

Future Research

The current project is novel in its emphasis on multifinality in self-regulation and multiple-goal pursuit. Research within this domain has tended to either focus on multifinality in goal choice at a single time point (Chun et al., 2011; Kopetz et al., 2011; Kruglanski et al., 2002) or on switching behavior in non-hierarchical multiple-goal pursuit (Vancouver et al., 2010; Ballard et al., 2016). Thus far, the potential for an individual to pursue their goals using a strategy of simultaneous goal progress had not been incorporated into recent investigations into this phenomenon. By integrating the concept of multifinality from the goal hierarchy and choice literature with the dynamics of the self-regulation literature, the current studies raise new questions for future research in both domains.

With respect to goal choice, the current study suggests that individuals' choices may be different in action and over time than what has been observed in static, cross-sectional investigations. With respect to the self-regulation literature, the current studies suggest that varying the type of actions an individual may take toward their goals and the number of goals that are salient impacts how they behave. Currently, the self-regulation and multiple-goal pursuit research has only examined individuals' choices when pursuing two task goals each with a single unifinal mean (e.g., Vancouver et al., 2010). However, the present research indicates that the addition of a multifinal means and higher-level, distal goals that impart subjective value on tasks changes those decisions. The results of the current studies suggest goal network structure, including the means, task, and distal levels, is an important factor to consider in future research on self-regulation. Many goal network structures that were not feasible to include in this project, such as limiting means choice to one unifinal and one multifinal means, remain to be examined.

Developing a computational model of a psychological phenomenon involves the translation of informal, narrative theory into a formal, precise representation. The comparison of that formal representation with empirical data highlights areas for future research into the original theory. That exercise in the current project illuminated a need for further research on the nature of the dilution effect. Thus far, research on the dilution effect has concluded that multiple vertical connections originating from one element in a goal system reduces the instrumentality, or association strength, at any one of those connections (Zhang et al., 2007). However, this research has not investigated qualitative differences in elements at different levels in that hierarchical goal system. That is, as theorized and examined here, means are qualitatively different than tasks, which are qualitatively different than distal goals. The translation of the dilution effect into the HMGPM at the vertical connections between both means and tasks and tasks and distal goals in the present work generated data that is inconsistent with previously observed effects of dilution (Kopetz et al., 2011; Zhang et al., 2007). The empirical data collected in the lab study were also inconsistent with previously theorized effects of dilution (Orehek et al., 2013).

This suggests that one potential area for future research on dilution is how it functions at different levels in a goal system. Instrumentality at the vertical connections in a goal system that are more proximal, such as the impact of a means on a task, may be less susceptible to perceptual effects such as dilution because they have tangible, observable consequences. However, multifinality may still negatively impact a means' appeal through routes other than its instrumentality. For example, participants preferred a unifinal means when they had a single task left to complete. Had they continued using the multifinal means, they would have continued making progress on the remaining task, though doing so also would have affected the already completed task. It may be that making progress toward something that has already been completed, even if that progress is not costly in terms of time or effort, is unappealing and imparts negative value on a means. This suggests that a *negative* discrepancy at the task level (i.e., making progress after task completion) may flow down to the means level and impart it with a negative motivational force. Future research on this topic can leverage the transparency and precision of the HMGPM by incorporating new findings or newly theorized processes into the model and assessing their validity through simulations and comparisons with empirical data.

Model comparison may also be leveraged in future research in order to examine different mechanisms of utility maximization and/or the impact of individual differences on strategy choice in multiple-goal pursuit in contexts of no time pressure. The multiple-goal pursuit data collected in the lab in the current project suggests that a simultaneous strategy and a unifinal, switching strategy are both viable options that individuals take toward multiple-goal achievement. The HGMPM currently only captures the former in the form of a momentary utility-maximization mechanism. Future model development could involve efforts to incorporate past and future perspectives into present means choice. Taking both these perspectives into account more explicitly may afford the HMGPM with the capacity to better reflect long-term strategy in goal pursuit, rather than only short-term action choice. Incorporating individual differences into the HMGPM may also aid in explaining strategy choice. For example, an individual with a higher need for closure, or a preference for predictability, order, and structure (Webster & Kruglanski, 1994), may be more motivated to make as much progress as possible at each decision point, increasing their preference for a multifinal simultaneous strategy.

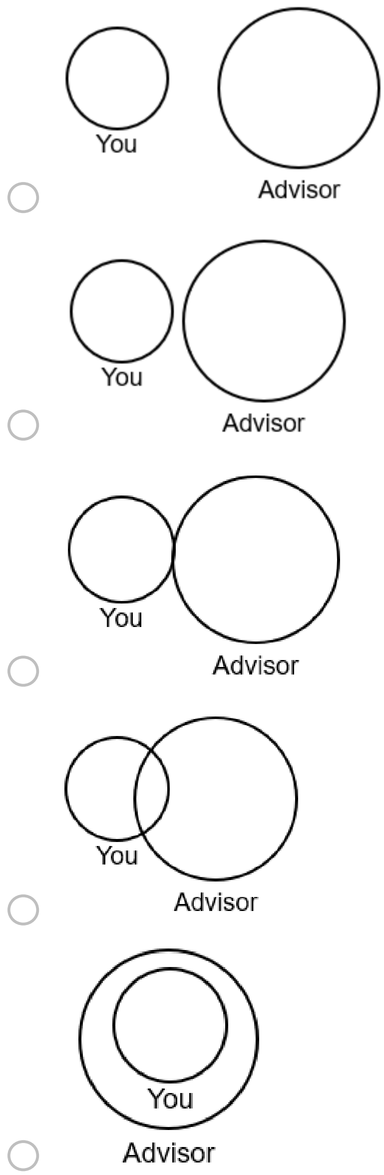
Conclusion

The current project furthers our understanding of individual multiple-goal pursuit in a hierarchical goal context. Using computational modeling and simulation, the original HMGPM (Samuelson, 2017) was extended to capture how individuals choose to complete multiple tasks simultaneously, how their higher-level, distal goals impact that choice, and how uncertainty in their goal-pursuit environment influence their patterns of choice. By pairing this modeling and simulation with behavioral data collected in the lab, the current project revealed new insights into individual's multiple-goal pursuit strategies. Specifically, individuals are motivated to complete multiple tasks simultaneously when possible and to maximize their value gained from goal pursuit under conditions of uncertainty. Future research can leverage the model developed and knowledge gained in this project to better understand how perceptual biases, such as the dilution effect (Zhang et al., 2007), impact individuals' choices in goal pursuit and how different individuals might engage in different strategies to completion of their tasks. In practice, these findings suggest that understanding the goals an individual has, which goal(s) they value over others, and how instrumental they believe their available actions will be toward those goals will shed light on how that individual may complete their tasks.

Appendix A

An example of the affiliation measure used to assess the salience of distal goals to participants in Study 2.

How affiliated do you feel with the role of advisor at the Northeast Institute? In the following images, the smaller circle represents you and the larger circle represents the advisor role. Select the response that best represents how affiliated you feel with the role of advisor.



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