An Altered Sense of Magnitude: Exploring How the Visual Presentation of Time, Space, and Numbers Can Influence Consumer Judgments and Behaviors

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An Altered Sense of Magnitude: Exploring How the Visual Presentation of Time, Space, and Numbers Can Influence Consumer Judgments and Behaviors

by

Marisabel Romero

A dissertation submitted in partial fulfillment of the requirements for the degree Doctor of Philosophy Department of Marketing College of Business University of South Florida

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ABSTRACT

Consumers are constantly evaluating quantitative information, such as the prices of different products, the time spent on an activity, or the distance covered during one day. Substantial research in psychology has demonstrated that judgments of quantity in one dimension (e.g., numbers) influence subsequent judgments on another dimension (e.g., time). The present research contributes to a growing body of work by exploring how the shared representation of time, space, and numbers affects consumer perceptions and behaviors.

My first dissertation essay explores how the organization of time on a spatial plane affects temporal judgments, product evaluations, and intertemporal discounting (i.e., time-space interaction). It has been well documented that Western consumers typically arrange temporal sequences following a past-left, future-right spatial pattern. Merging insights gained from numerical cognition and time psychology, the author develops a framework to explain how displaying temporal sequences congruently with this spatial organization of time increases subjective estimations of time and biases consumers toward present rewards.

My second dissertation essay seeks to understand how and why expressing quantitative information in symbolic code (i.e., “6”) compared to verbal code (i.e., “six”) affects magnitude judgments and product evaluations (i.e., time-number interaction). Two rival accounts to explain the symbol-verbal effect are described and tested: (1) a systematic processing account based on Arabic symbols’ perceptual and cognitive features and (2) a fluency account based on the frequency of use and facilitation of processing Arabic symbols. This research has important managerial implications related to the effective communication of quantitative information.
CHAPTER ONE

GENERAL INTRODUCTION

RESEARCH BACKGROUND

Analyzing quantitative information is an inevitable part of consumers’ daily lives. Activities, such as comparing prices, evaluating calories, and estimating driving distances, illustrate the variety of decisions where consumers rely on their ability to accurately interpret magnitude information. However, despite the vast advancement the human race has achieved in numerical knowledge, quantitative judgments are still far from perfect. An array of research has uncovered different contextual cues that bias quantitative information processing and directly impact consumer evaluations and choices. For instance, consider a price-sensitive shopper, Miguel, who is evaluating two product options at a store. Is it possible to alter his choices by using one of the two following scenarios? Scenario A: buying an option priced at $5.01 or an option priced at $4.00 vs. Scenario B: buying an option priced at $5.00 or an option priced at $3.99. It’s obvious that the objective magnitude difference between the two products remains constant across scenarios. Nevertheless, since judgments of magnitude are anchored on the number’s left digit (Thomas and Morwitz 2005), consumers perceive the price difference of the first choice set to be smaller than the price difference of the second set. Miguel could, therefore, be more likely to buy the higher priced item scenario A than in scenario B.

Imagine another purchase scenario in which a real estate agent is debating whether to set the price of a house at $395,000 or at $395,425. From an objective standpoint, the second price is
higher and, as such, could make it harder to sell the house. However, research in numerical cognition indicates that this is an erroneous assumption. The infrequent use of precise large numbers (e.g., 1001, 11,003, 1,000,067) has led consumers to believe precise numbers have smaller magnitudes than round numbers (Thomas, Simon, and Kadiyali 2010), a finding that, in this example, proves advantageous for the real estate agent.

Similar to the previous illustrations, other numerical biases exist and have been documented in the literature. Recently, Wadhwa and Zhang (2015) found that round (vs. sharp) numbers induce affect-based processing. Consequently, the use of round numbers improves the evaluations for hedonic products. Biswas et al. (2013) find a subtraction effect in which presenting discount prices to the right of original prices benefits the evaluation of the sale. Monga and Bagchi (2012) demonstrate how changes in magnitude seem larger for large compared to small units (e.g., change from one to three weeks > change from 7 to 21 days).

A common trend across the studies on quantitative biases in consumer behavior is the extensive attention given to number properties. Magnitude judgments, however, are not restricted to numbers. In fact, recent research in psychology has argued for a common magnitude system in which different types of quantitative information (e.g., time, space, numbers, light, sound, etc.) share common processing mechanisms (Walsh 2003). Interestingly, this stream of research has confirmed a behavioral monotonic mapping of quantities that allows cross-dimensional transfers to occur such that bigger, longer, further judgments in one magnitude domain correspond with bigger, longer, further judgments in another (Walsh 2003). For example, stimuli with larger numerical magnitude or larger physical size are also judged to appear for longer times (Oliveri et al. 2008; Xuan et al. 2007).
Despite the vast attention the topic of magnitude interactions has garnered in psychology, the marketing literature has yet to thoroughly examine the behavioral consequences of a common magnitude system. Some recent work alludes to this generalized magnitude system by demonstrating how physical characteristics of stimuli can increase magnitude estimations. For instance, Coulter and Coulter (2005) find that the larger size of a number leads to greater value perceptions (i.e., size - number magnitude congruence). In a follow up research project, Coulter and Norberg (2009) demonstrate that a greater horizontal separation between original price and sales price leads to higher perceived value (i.e., space - number magnitude congruence). Coulter et al. (2010) find that phonological sounds that are associated with smallness (vs. largeness) lead consumers to perceive sale prices smaller than regular prices. More recently, Kim, Zauberman, and Bettman (2012) illustrate the operation of a cross-dimension magnitude transfer. Particularly, the authors demonstrate how judging larger spatial distances (magnitude domain one) leads to higher temporal judgments (magnitude domain two) and subsequently influences intertemporal choices.

**RESEARCH OVERVIEW**

The goal of this dissertation is to further explore this dynamic relationship across magnitude domains by manipulating visual cues, such as spatial location and number notation. In particular, this dissertation intends to demonstrate how the numbers, space, time relationship influences consumer judgments in two ways. Essay 1 examines how location schemas derived from a time-space interaction have unintended consequences for consumer decision-making. Essay 2 studies a time-number magnitude interaction, demonstrating how the length of elaboration on information presented can influence magnitude judgments and, subsequently, product evaluations. The following explicate each of these objectives in detail.
Essay 1 uses the common magnitude system as the theoretical foundation for the spatial organization of time. Further, building on research from ease of processing and temporal perception, this essay, comprised of six studies, provides a conceptual framework to explain how the spatial organization of time influences judgments of future time and, more importantly, downstream consumer decisions. The first study in this essay examines the influence of spatial organization of time on temporal judgments using two different tasks. The second study seeks to demonstrate how displaying information congruently (vs. incongruently) with the spatial organization of time can negatively influence intertemporal choices. The third study seeks to provide process evidence of space-time conceptual mapping on intertemporal choices. The fourth study attempts to manipulate the active time-space mental paradigm in order to demonstrate the role of space-time congruence on intertemporal choice. Finally, Study 5 examines the influence of the time-space paradigm on product evaluation.

Essay 2 focuses on the time-number relationship by examining how symbolic (e.g., “3”) and verbal (e.g., “three”) notations influence quantitative judgments and subsequently affect product evaluations. This essay proposes two rival accounts to explain how number notation can influence judgments. First, a systematic-based processing route proposes that symbolic numbers encourage consumers to spend more time processing quantitative information. Moreover, borrowing from research on the common representation of time and numbers, this account argues that additional processing time is then associated with an overestimation of magnitude judgments, which ultimately affect product evaluations. Alternatively, an affect-based route suggests that symbolic numbers are fluently processed, improving product evaluations. The two explanations are pitted against each other empirically in a theoretical competition. Study 1a provides the effect of number notation on magnitude perception using a psychophysiological task
that does not require scaled-responses. Study 1b finds product evaluation differences that emerge after using a symbolic (verbal) number code. Study 2 rules out credibility as a potential explanation of the proposed effects. Studies 3a and 3b propose two theoretically relevant moderators that attempt to uncover the underlying mechanism behind the symbol-verbal number code effect. Study 4 explores whether mere exposure to symbolic numbers encourages consumers to engage in systematic processing. Finally, Study 5 examines whether congruent (vs. incongruent) number-units can explain the influence of number representation on magnitude judgments.

This dissertation makes five broad contributions. First, it adds to the numerical cognition literature by providing evidence as to how a generalized magnitude system not only alters quantity estimates (Lourenco and Longo 2010; Walsh 2003; Xuan et al. 2007), but also affects downstream attitudes and behaviors. While psychologists have vastly documented the interaction between time, space, and number magnitudes, to date, research exploring how magnitude interactions influence consumers has been scarce (Coulter and Coulter 2005; Coulter and Norberg 2009; Kim et al. 2012). In particular, the present research identifies how the interaction of time-space bias consumer decisions toward an immediate reward. Further, it demonstrates how the interaction of time-number affects how consumers evaluate products. Given that critical consumer judgments are based on magnitude comparisons including “Which discount is higher?” or “Which product is bigger?” it is important for marketers to understand how different magnitude cues can interact and affect product evaluations. Thus, the identification of how a shared magnitude representation can influence consumer decisions and judgments opens new questions and challenges for future research.
In addition, my dissertation contributes to the stream of literature on intertemporal choice (Kim and Zauber 2009; Kim et al. 2012; Malkoc, Zauber, and Bettman 2010; Zauber et al. 2009) by identifying the location of temporal sequences as a source of error in duration judgments and intertemporal behaviors. Previous research has found how external cues, such as order (Weber et al. 2007) or distance (Kim et al. 2012), can affect time duration and financial decision making. My dissertation, however, explores how a time-space magnitude interaction leads consumers to map time sequences on a left-to-right axis. Interestingly, exposure to a congruent (vs. incongruent) time-space map ultimately leads to increased duration judgments and preferences toward present rewards.

Moreover, I contribute to the area of visual marketing (Wedel and Pieters 2012) by exploring innovative theoretical links between novel visual cues and behavioral outcomes. While this growing area of research explores, among others, how product shapes (Greenleaf and Raghubir 2008; Raghubir and Greenleaf 2006), product location within a shelf (Chandon et al. 2009), and dynamism of a product image (Cian, Krishna, and Elder 2014; Deng and Kahn 2009) influence consumer decisions, my dissertation uniquely identifies the role of spatial arrangement and number notation cues on product evaluations and consumer decision-making.

Additionally, the proposed findings of this research are intended to help consumers avoid succumbing to numerical biases in decision-making. This is a timely topic, which requires attention given the current socio-economic environment in which obesity rates are rising (Vandegrift and Yoked 2004), savings for retirement are falling (Shwartz and Steinberg 2014), household debt is increasing (Shah 2014), and numeracy proficiency and problem-solving abilities are declining (Cassidy 2013).
Finally, the findings of this dissertation could have strong implications for companies in various industries. In particular, the findings of my first dissertation essay can have substantive applications for companies that desire to manage consumers’ temporal expectations. Also, this dissertation gains a deeper understanding as to how numerical notation can positively affect product evaluation. Hence, the insights generated in my second essay can help managers appropriately align the presentation format of numerical information with the product’s positioning strategy.
CHAPTER TWO
DOES SPATIAL REPRESENTATION OF TIME INFLUENCE INTERTEMPORAL CHOICES?

INTRODUCTION

Consumers must make daily choices regarding whether to trade immediate gratification for delayed rewards. Consider a day in the life of Julie, who wants to balance immediate versus delayed rewards. Should she avoid indulging in a delicious piece of chocolate cake today to lose five pounds by the end of the month? Should she pay $10 extra for next day delivery? Should she forego buying an attractive dress and add the money to her retirement savings instead? Each decision requires choosing between immediate and future rewards.

Consumers tend to be innately biased toward receiving immediate gains over future rewards. This desire is propelled by low construal (Malkoc et al. 2010) and “hot stimuli,” such as women in bikinis (Kim and Zauberman 2013; Van den Bergh, Dewitte, and Warlop 2008). Recently, Kim et al. (2012) established a dynamic relationship between space and time, which indicated that greater physical distance judgments lead consumers to consider prospective time periods to be longer, and, consequently, makes them act more impatiently. The identification of spatial information, distance, influencing temporal judgments raises opportunities for future research. A natural question that surfaces is: can other spatial information, such as location, influence temporal judgments and, if so, how?
Managers can benefit by understanding how spatial cues influence temporal judgments and decisions. For instance, consumers will be attracted to credit cards offering no interest for the first six months if they are persuaded to perceive six months to be a long time. In contrast, they will be attracted to savings accounts that accrue interest in six months if that seems to be a very short time. Given that the objectives of time-sensitive products differ depending upon the nature of the product, how can managers strategically use spatial cues to communicate their message in a way that best aligns with their intended positioning strategy? To address that question, I draw from cognitive linguistics, time psychology, and intertemporal choice literature.

The association of spatial location and time has been extensively made by research in magnitude perceptions and cognitive linguistics. In particular, cognitive linguists find that language is the basis for conceptual mappings of time and space. In the Western hemisphere, people generally conceptualize time as moving on a horizontal axis with the past located on the left and the future on the right (Boroditsky 2000; Fuhrman and Boroditsky 2010). This organization then affects how easily temporal information is processed. For example, Westerners categorize words associated with the past (future) more quickly when the words are positioned on the left (right) of a visual field (Ouellet et al. 2010). Although, the facilitation is universal, the spatial mapping of time changes by culture. For instance, a horizontal spatial metaphor, a black worm ahead of a white worm, facilitates time judgment questions for English speakers, such as “What month comes earlier June or August?” However, Mandarin speakers make quicker temporal judgments if they are primed with a vertical metaphor, such as a black ball above a white ball (Boroditsky 2001). These findings suggest that common metaphors in language shape thoughts about time and, more importantly, facilitate time-related knowledge.
While spatial cues facilitate processing, we know little about how these cues impact downstream judgments of time duration. Interestingly, research in the psychology of time has shown that processing requirements are strongly related to judgments about time duration. In particular, as stimuli become easier to process, more attention can be allocated to temporal information so that the passage of time seems longer. Put differently, as processing requirements decrease, duration judgments increase (Block and Zakay 1997).

Based on the knowledge accumulated by cognitive linguistics and time psychology models, I propose that displaying temporal sequences congruently (vs. incongruently) with the manner in which time is conceived spatially, known to facilitate processing, can also lead to longer duration judgments. Moreover, intertemporal research has found that longer subjective time estimations lead to steeper discounting of future outcomes (Zauberman et al. 2009). Thus, if consumers process information that is congruent with their spatial representation of time, they will be more biased toward present rather than future results.

This research reports six studies that explore how space-time congruence effect consumer choice. Studies 1a and 1b examine whether consumers estimate duration as being longer when time sequences are presented congruently with past-left, future-right representations. Study 2 explores how space-time congruence influences intertemporal choices. Study 3 examines how subjective time estimation mediates the relationship between space-time congruence and intertemporal choice. Study 4 manipulates the spatial organization of time to further substantiate that space-time congruence determines intertemporal choices. Finally, Study 5 examines congruent space-time congruence representations for their influence on consumers’ temporal expectations when they evaluate products.
This essay makes several contributions. First, it adds to the work on intertemporal choice (Berns, Laibson, and Loewenstein 2007; Weber et al. 2007; Zauberman et al. 2009) by demonstrating that space-time symbolism influences time sensitive consumer choices: consumers will sharply discount future rewards when they view intertemporal options aligned with the past-left, future-right conceptualization of time. In addition, recognizing that subjective time perception strongly determines intertemporal preferences, this dissertation integrates time perception cognitive models (Block and Zakay 1997) to show how factors, such as ease of processing, influence consumers’ time duration judgments. Moreover, although it is well documented that conceptual metaphors of time affect accessibility to temporal information (Boroditsky 2000; Casasanto and Boroditsky 2008; Casasanto, Fotakopoulou, and Boroditsky 2010), the present research demonstrates that the space-time concept also influences choices. In particular, space-time symbolism alters subjective time-length perceptions and impacts discounting. Finally, by studying how the lateral arrangement of time shapes financial decisions and product evaluations, the findings of this research adds to the extant work on how lateral organization influences consumer responses like ad evaluation (Chae and Hoegg 2013; Janiszewski 1990), motion perception (Maass, Pagani, and Berta 2007), and aesthetic judgment (Chokron and De Agostini 2000).

THEORETICAL BACKGROUND

Spatial Representation of Time

Accumulating evidence in psychology suggests that space, number, and time share a common mental representation. Two sets of explanations have emerged to explain this
interaction. One account, based on a universal magnitude code, proposes a symmetrical relationship between time, space, and numbers (Hubbard et al. 2005; Pinel et al. 2004). A second account, based on metaphorical transfer, argues for an asymmetrical relationship in which spatial extent has a greater influence on number and time estimations than vice-versa (Casasanto et al. 2010). The following section provides further details on both explanations.

**Magnitude explanation for the spatial organization of time.** A generalized system of magnitude explains that a common magnitude code processes representations of time, space, and numbers. The central proposition of this theory is that magnitude can be represented broadly in terms of “more than” vs. “less than” relationships (Lourenco and Longo 2011). Furthermore, this theory contends that magnitude judgments interact across dimensions such that larger magnitudes in one domain correspond to larger magnitudes in another (Bueti and Walsh 2009). Cross-dimensional transfers of magnitude judgments between each pairing of space and numbers, numbers and space, and time and numbers are well established in the literature (Cantlon, Platt, and Brannon 2009; Lourenco and Longo 2011; Walsh 2003). For example, Oliveri et al. (2008) asked participants to judge how long a number was presented on a screen. They found that exposure to larger numbers (e.g., 9 vs. 3) positively biases judgments of temporal duration suggesting that temporal estimations depend upon the number’s magnitude.

According to the generalized magnitude account, time and numbers also share a location representation structure in the form of left-to-right organizations (Lourenco and Longo 2010; Walsh 2003). In particular, the spatial dimension of location offers an efficient manner of organizing magnitude cues in a reliable, consistent direction (Lourenco and Longo 2010). For example, the horizontal mental number line is a phenomenon in which people organize smaller numbers on the left and larger numbers on the right. As a result of this number-space
relationship, consumers can make quicker and more accurate magnitude comparisons when the numbers are organized consistently (vs. inconsistently) with the small-left, large-right spatial organization of numbers (Dehaene, Bossini, and Giraux 1993).

Similarly, the cognitive representation of time has been found to interact with the spatial dimension such that earlier events are organized on the left and later events are organized on the right (Ishihara et al. 2008; Vallesi, Binns, and Shallice 2008). Furthermore, the mental timeline influences motor responses. In particular, Vallesi et al. (2008) presented participants with a fixation-cross for (1 second) or (3 seconds). After exposure, participants had to classify the duration as short or long. For half of the trials, participants pressed the letter “z” to indicate a short duration and pressed the “/” key to indicate a long duration. In the other half of the trials, the response keys were reversed (i.e., z = long, / = short). These two keys were selected because the letter “z” is located to the left of the “/” key. Participants believed the short cross duration was presented for a shorter period of time when pressing the left key compared to the right one, while the opposite was true for the long cross duration judgment. This finding suggests that time is represented through an internal spatial reference frame that increases from left to right.

*Metaphorical explanation for the spatial organization of time.* Human cognition tends to represent time as having spatial dimensions (Miles et al. 2011) as commonly reflected in daily conversation. The correspondence of space-time is a part of the human tendency to use concrete experience to better explain the abstract (Boroditsky 2001; Boroditsky 2000; Casasanto and Boroditsky 2008; Lakoff and Johnson 1980; Williams, Huang, and Bargh 2009). For example, people commonly use “ideas as food” metaphors: they use food images to represent intangible ideas through phrases, such as “this idea is half-baked” or “let me chew it over for a while” (Lakoff and Johnson 1980). Similarly, people’s understanding of time, a concept that is not
directly observable through the senses, is built through experiences in the more tangible domain of space (Boroditsky 2000; Boroditsky and Ramscar 2002; Casasanto 2008). In their research, Boroditsky and Ramscar (2002) present individuals with spatial depictions of a person moving toward an object or an object moving toward a person. Subsequently, they ask participants an ambiguous temporal question, such as “A meeting scheduled for Friday was moved two days forward. When is the meeting: Wednesday or Monday?” The authors find that if participants are primed to think of an object moving toward them, they are also more likely to conceive time as moving toward them. Consequently, they select Wednesday (vs. Monday) more frequently. When participants are primed to think of moving forward to an object, the opposite pattern is held. Similarly, Casasanto (2008) presents a spatial prime to participants and then asks them to make a temporal judgment. In particular, they present 162 horizontal lines that grow as they observe the stimuli on the screen. Participants are then asked to indicate how long the image was presented for. The authors find that the amount of spatial displacement positively biases duration judgments. These findings offer evidence that the understanding of time is shaped by spatial concepts.

These space-time schemas inherently possess an orientation (i.e., horizontal, vertical) and a direction (i.e., left-to-right, top-down), which are determined largely by linguistic and cultural factors. English speakers rarely use vertical spatial terms. Instead, they typically use horizontal spatial metaphors, such as “move ahead of time,” “look forward to meeting you,” or “falling behind schedule” to describe time movement (Boroditsky 2001). In contrast, Mandarin speakers are more likely to arrange time sequences vertically and to depict events using vertical metaphors (Boroditsky, Fuhrman, and McCormick 2011). The pervasive use of the “Time as Space” metaphor can have a direct impact on how people access temporal information. For instance,
Boroditsky (2001) provided participants with a horizontal spatial metaphor (e.g., “The black worm is ahead of the white worm”) or a vertical spatial metaphor (e.g., “The black ball is above the white ball”). The author then asked participants to make an unrelated time judgment, such as “Does June come before August” for which they had to respond TRUE or FALSE as quickly as possible. The results of this study indicated that English speakers responded to temporal questions faster after exposure to horizontal (vs. vertical) spatial primes suggesting that congruent spatial information facilitates access to time-related knowledge.

Language metaphors are only one reason why we have come to represent time spatially. Another reason is derived from the use of conventional expression systems, such as written language. For English speakers, the writing system has led to the development of a left-to-right organization of time (Chae and Hoegg 2013) in which the past is associated with the left and the future is associated with the right (Boroditsky et al. 2011; Casasanto and Bottini 2010; Santiago et al. 2012). Thus, Westerners have developed visual left-to-right horizontal cognitive representations of time. Consistent with this proposition, research has found that individuals that read from left to right are quicker at identifying targets that are moving from left to right, while the opposite is true for cultures that read from right to left (Spalek and Hammad 2005). The studies conducted focused on a Western population and, consequently, in this essay, I operationalize space-time congruence using a horizontal temporal sequence and space-time incongruence using a vertical temporal sequence.

Recently, consumer researchers have explored how space-time conceptualization affects product evaluations (Chae and Hoegg 2013). That is, attitudes toward products may be enhanced when time-related products are advertised congruently with typical mental representations of time. For instance, when advertising antiques, the most successful product placement would be
on the left side of the ad, while the right side of the ad would be more appropriate for products related to future consumption. Although consumer research has begun to explore how space-time congruence can influence advertisement evaluations, it has yet to examine how the systematic correspondence of space and time affects consumer decisions. Thus, this research contributes to the growing literature by examining how space-time congruence can bias consumers’ temporal judgment and intertemporal preferences. The following sections present the distinct processes through which space-time representations affect intertemporal discounting.

Spatial Representation of Time and Duration Judgments

Conceptual metaphors are a way of making concepts consistent with our mental schema so that information is less complex and easier to understand (Santiago, Román, and Ouellet 2011). “Time as space” metaphors facilitate information processing (Casasanto and Boroditsky 2008; Fuhrman and Boroditsky 2010; Miles et al. 2011; Santiago et al. 2007; Thibodeau and Boroditsky 2013; Ulrich and Maienborn 2010). In a study examining the effects of time as space metaphors, Boroditsky (2001) showed study participants a horizontal spatial metaphor, a black worm ahead of a white worm, or a vertical spatial metaphor, a black ball above a white ball. Participants were asked to answer true or false as quickly as possible to time-judgment questions, such as “Does June come later than August?” English speakers responded the temporal questions quicker after they saw a horizontal spatial prime. Mandarin speakers responded quicker after they saw a vertical spatial prime. These findings suggest that common metaphors in language shape thoughts about time and, more importantly, facilitate time-related knowledge. In a similar task, Miles et al. (2011) ask participants to categorize pictures of ancient or futuristic buildings as belonging to the past or the future as quickly as possible. Participants saw four types of blocks: horizontal compatible (past-left, future-right), horizontal incompatible
They found that English-speaking participants classified stimuli quicker during a horizontal compatible (vs. horizontal incompatible) block. However, given the lack of vertical time metaphors in the English language, they did not find a significant difference in response times between compatible and incompatible vertical blocks.

Other research supports the theory that when temporal sequences are displayed congruently with the internal past-left, future-right space-time mapping, viewers are better able to process temporal information (Boroditsky et al. 2011; Fuhrman and Boroditsky 2010). Fuhrman and Boroditsky (2010) provide further evidence of these associations (i.e., past-left, future-right) by exposing participants to two pictures and asking them to identify whether the second picture occurred before or after the first. Their results suggest that English speakers respond more quickly when the earlier picture is presented on the left than when it is presented on the right. Furthermore, in a different study, Boroditsky et al. (2011) employ a different mechanism to replicate this finding. Specifically, they presented participants with a picture of Woody Allen for 2s, a fixation cross, and then a second picture of Woody Allen that lasted until participants made their response. The task required respondents to indicate whether the second picture of Woody Allen, compared to the first picture, was from a previous or later time of his life. Participants made their response by pressing one of two keys labeled as “earlier” or “later.” For some of the participants, the keys were arranged in a horizontal format with the earlier key on the left and the later key on the right, while other participants had the opposite arrangement. The authors found that English-speaking participants responded to the time question quicker when the keys were arranged congruently (vs. incongruently) with the past-left, future-right conceptualization of time.
These studies demonstrate that temporal sequences must be arranged congruently with spatial schemas if viewers are to easily judge order, a phenomenon categorized as conceptual congruency (Santiago et al. 2012). In particular, when time sequences and internal conceptual metaphors are visually displayed congruently, consumers can process the information better, as shown by quicker response times (Miles et al. 2011; Ulrich and Maienborn 2010). Alternatively, incongruent placement makes the task more cognitively demanding (Hömke, Majid, and Boroditsky 2013) and increases response times (Fuhrman and Boroditsky 2010).

While space-time conceptual mapping has been shown to facilitate information processing, research has failed to explore how space-time congruence affects judgments regarding temporal duration. To fill that gap, I draw on attentional cognitive models of time perception. Specifically, attentional models of time perception argue that duration estimates are derived from a sequence of steps (Block and Zakay 2004; Block and Zakay 1997; Zakay and Block 1996). The first step of the process is an internal pacemaker, which produces a series of pulses at a constant rate. Next, a person must attend to time, instead of external events, for an attentional gate to open and allow these time pulses to move forward to the subsequent step in the process. Finally, a cognitive counter is in charge of accumulating pulse counts. Duration estimates are represented by the amount of pulses that have been recorded during a given time period.

A key premise of these models is that greater attention to time increases the inflow of pulses to the accumulator leading to higher duration judgments (Wittmann and Paulus 2008). In particular, perceived duration is conceptualized as a function of the amount of information simultaneously processed by two competing processors: a temporal information processor and a nontemporal, stimulus information processor (Zakay and Block 1996). A stimulus that makes
small processing demands allows greater attention to be allocated to the temporal dimension and leads to higher temporal estimates (Block and Zakay 2004; Block and Zakay 1997; Fraisse 1984; Thomas and Cantor 1978). Put differently, displays that facilitate information processing lead to higher duration judgments (Block and Zakay 1997), while displays that are difficult to process lead to shortening of perceived time (Allen 1980; Block, Hancock, and Zakay 2010; Harton 1942; Zakay, Nitzan, and Glicksohn 1983). For example, in their seminal work on this topic, Hicks, Miller, and Kinsbourne (1976) asked participants to sort playing cards according to a rule that varied in its processing requirements (i.e., zero bits, one bits, or two bits of information). Their work demonstrated that higher processing requirements led to lower duration judgments. Block et al. (2010) document 117 experiments that manipulate individuals’ cognitive load while making duration judgments. The results of their analysis revealed an inverse relationship between duration judgments and the amount of information processed such that duration judgments decreased when the processing task was more difficult.

While previous studies have noted how processing demands affect the perception of elapsed time (i.e., time that has already passed), this dissertation uses the attentional model of time to understand how they can influence judgments of future duration (i.e., events that have yet to be experienced). Although the two events are different, some studies have found that estimates of elapsed time and future time abide by similar rules. In particular, Kim and Zauberman (2013) confirm that increased levels of arousal lead to longer future time perceptions, which is similar to the influence of arousal on elapsed time. Additionally, researchers exploring affective forecasting, which requires duration estimations of future events, have also documented the important role of attention: consumers that are allowed to cognitively elaborate on information unrelated to the focal event tend to make shorter duration estimates of a future affective state
(Wilson et al. 2000). Even though the latter was conducted in a different topic domain, the findings of this research are also consistent with the theoretical claims of the attentional model of time. Thus, the author predicts that conceptual congruence between a visual display of a time progression and a spatial representation of time should lead to longer duration judgments: consumers will allocate greater attention to the temporal information than they will allocate to the stimulus information. Thus, temporal progressions arranged congruently with the past-left, future-right organization of time will lead to longer future time estimates.

H1: When temporal progressions are displayed congruently (vs. incongruently) with the horizontal (past-left, future-right) manner of organizing time, consumers will perceive the passage of time to be subjectively longer.

Spatial Representation of Time and Discounting

Altering time perceptions can have particularly interesting implications for decisions that involve consumer tradeoffs between benefits and costs across time (Soster, Monga, and Bearden 2010; Zauberman et al. 2009). Decisions can range from simple tasks, such as choosing between standard or expedited shipping (Malkoc et al. 2010), to more complex tasks, such as determining how much to save for retirement (Hershfield et al. 2011).

Economists and psychologists have long explored determinants that persuade people to trade immediate rewards for larger, future rewards (Read et al. 2005; Weber et al. 2007; Xu et al. 2009). Subjective temporal perception plays a critical role in determining intertemporal decisions (Kim and Zauberman 2009; Zauberman et al. 2009). That is, when individuals perceive that a long time must pass before they will receive delayed rewards, they will be more likely to select
immediate rewards (Wittmann and Paulus 2008). To illustrate, imagine a scenario in which individuals must choose between receiving $100 dollars today or $200 in a month. The longer they perceive the one-month delay, the more they will prefer the immediate reward.

More relevant for this research is understanding that contextual cues alter subjective time estimation. For instance, Malkoc et al. (2010) find that guiding consumers to focus on the details (vs. broad aspects) of an earlier decision carries over to intertemporal choices. In particular, a concrete mindset increases consumer preference for present rewards. Read et al. (2005) use numerical notation (i.e., calendar dates vs. number of months) to manipulate present bias. Since calendar dates draw attention to the moment the outcome occurs, instead of how long consumers will wait to receive the reward, the authors find that describing the availability of future rewards using calendar dates (vs. number of months) reduces the preference for present rewards.

Furthermore, Kim and Zauberman (2013) find that exposure to sexual cues (vs. a control condition) increased physiological arousal and led study participants to perceive future time to be more distant and to prefer immediate rewards. Additionally, Kim et al. (2012) confirm that participants who considered a long (vs. short) spatial distance had increased subsequent temporal judgments of time and increased discounting. Their study participants visualized the distance between Points A and B on a map. Half of the participants visualized comparatively long distances. They were then asked to evaluate the time it would take to go from one point to another. Revealing direct evidence that time and space are related, participants estimated longer time durations after they evaluated longer distances, and then they preferred immediate rewards.

While that work demonstrated that distance spatial cues can influence intertemporal preferences, my dissertation explores another spatial dimension that can alter temporal perceptions: location.
A left-to-right organization of time, common in Western cultures, can bias temporal judgments and decision-making. Because presenting options in a past-left, future-right manner increases subjective time perceptions, it should also lead to steeper discounting of future outcomes. Thus, I expect:

H2: When temporal progressions are displayed congruently (vs. incongruently) with the horizontal (past-left, future-right) manner of organizing time, consumers will have a higher preference for immediate rewards.

H3: The effect of space-time congruence on intertemporal choice is mediated by subjective time perception.

The conceptual framework proposed for understanding how spatial representation of time influences time perception and intertemporal choices is illustrated in Figure 1.

![Conceptual Model](image)
STUDY 1A: DEMONSTRATION OF SPACE-TIME CONGRUENCE ON TIME PERCEPTION

Study 1a demonstrates the influence of the spatial organization of time on temporal judgments. Space-time congruence is operationalized by manipulating the orientation of time progressions. That is, a temporal progression is displayed horizontally, congruent with the Western conceptualization of time, or vertically, an unconventional manner of organizing time spatially (Boroditsky 2000) without changing the order of presentation.

This decision was based on intertemporal discounting findings indicating that presentation order affects valuations; an effect explained by query theory. Query theory argues that time-preference construction is subject to the encoding and retrieval of memory processes. Specifically, when individuals are presented with an intertemporal choice, they fragment the decision into a series of questions. Individuals presented with the present reward first ask themselves two sequential questions: “Why should I consume now?” followed by “Why should I wait to consume later?” The order in which individuals present these questions to themselves is reversed when presented with the future option first. Furthermore, query theory argues that memory retrieval for the second question is less successful than the first, thereby making it less influential in decision-making (Loewensteins and Thaler 1989; Weber et al. 2007). When the present reward is presented first, the decision maker gathers evidence favoring the status quo (immediate consumption) tilting the scale toward immediate consumption. Presenting the future option first results in exactly the opposite process (Weber et al. 2007).

Since the order of presentation influences temporal focus and decision-making, this research manipulates the orientation of time (i.e., vertical vs. horizontal) instead of the direction of time (i.e., past-left, future-right vs. past-right, future-left). According to this dissertation’s
conceptualization, a horizontal display should lead to longer subjective time estimations than a vertical display (H1).

Method

Participants and design. Study 1a was a 2 (spatial orientation of time: horizontal vs. vertical) x 3 (delayed gift-receipt: 3 months, 12 months, 36 months) mixed-design experiment. The first factor was between-subjects and the second was within-subjects. Sixty-eight MTurk participants (44.8% were female, average age = 34.66) completed the survey in exchange for compensation. Because the organization of space-time depends upon the language and direction of the writing system, I excluded three participants for whom English was a second language.

Stimuli and procedure. A hypothetical decision scenario was used. Participants were asked to imagine that they could receive a $50 Amazon gift certificate available today, but they could wait 3, 12, or 36 months to receive a larger gift certificate. The information on the two available gift certificates was presented inside two equally distanced boxes arranged horizontally or vertically. Specifically, in the horizontal condition, the immediately available intertemporal option was placed to the left of the future option. In the vertical condition, the immediately available option was placed on top of the future option. In this study, the stimuli purposely did not specify the monetary amount available in the future to demonstrate that time perception changes occur because of the relationship between time and space, not between space and number (Dehaene et al. 1993). (Refer to Appendix A for an example of the stimuli used.)

A linear psychophysiological task assessed subjective perceptions of future time durations (adopted from Kim and Zauberman (2009). Participants were asked to think about how short or long the time would seem to them between tomorrow and 3, 12, or 36 months later. They were provided a blank text box under the stimuli and instructed to draw a line using as few
or as many dashes as necessary to represent the passage of 3, 12, or 36 months. Note that participants were free to draw horizontal or vertical lines. The presentation of time periods was randomized to keep participants from linearly increasing dashes from one time period to the other. Because the procedure of this task is not common, subjective task complexity was measured on the scale: “How easy or difficult was it to perform this task?” 1 = Very difficult/ 7 = Very easy and “How simple or complex was it to perform this task?” 1 = Very complex/ 7 = Very simple. Participants also responded to demographic questions and indicated whether English was their first language, measured to control for cultural differences that could affect space-time conceptualization (Miles et al. 2011).

Results

Time estimation. The average number of dashes the participants used to represent the time passage of 3, 12, and 36 months was used as the primary dependent variable. A repeated-measures an Analysis of Variance (ANOVA) revealed no significant interaction between trials and the manipulated orientation of the options ($F (2, 60) = 2.298, p > .10$). Since the effect of time orientation did not vary across time periods, the author created an index of time perception across all trials. An ANOVA with the average perceived time duration as the dependent variable and orientation of the display as the independent variable, while controlling for subjective task complexity and handedness, revealed a marginally significant effect of subjective task complexity ($F (1, 61) = 3.58, p = .06$) and, more importantly, a significant main effect of orientation ($M_{\text{horizontal}} = 143.91$, $M_{\text{vertical}} = 87.41$, $F (1, 61) = 4.79, p < .05$) in support of H1. The model controlled for handedness, but it was not a significant covariate. See Table 1 for detailed results.
**TABLE 1: CELL MEANS AND STANDARD DEVIATIONS**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal</td>
<td>143.91</td>
<td>132.38</td>
</tr>
<tr>
<td>(n = 30)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vertical</td>
<td>87.41</td>
<td>76.54</td>
</tr>
<tr>
<td>(n = 35)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Discussion**

Study 1a suggests that displaying temporal options congruently with the way people perceive time compels them judge a prospective future time period as being farther into the future thereby supporting H1. The results also rule out several alternative explanations. First, the stimuli controlled for objective distance between options in order to eliminate the possibility that distance is influencing perceived time (Kim et al. 2012). However, it could still be argued that participants subjectively perceive the distances between options differently depending on the orientation of the display (horizontal vs. vertical). However, visual perception understandings counter that explanation. Particularly, the horizontal-vertical illusion describes a phenomenon in which vertical distances seem longer than horizontal distances (Künnapas 1957). Therefore, if subjective distance differed between conditions, the vertical stimuli should generate longer temporal judgments. The findings in this study are opposite of this prediction, rendering changes in subjective distance an unlikely explanation. In addition, the results are not related to order effects as participants were exposed to the same order: past first, future second. The next study replicates these results using a psychophysiological task.
STUDY 1B: REPLICATION WITH A PHYSIOLOGICAL TASK

Study 1a was limited in that I used a linear scale to measure the subjective perception of time. This method is potentially problematic as visual characteristics vary across conditions. In particular, the horizontal display is wider than the vertical one, so participants may have used the horizontal display as a visual anchor to determine the number of dashes to represent perceived delays. If so, then temporal duration judgments may have increased due to changes in stimuli width rather than because of changes in time perception.

To address the issue of a width anchor, I conducted Study 1b using a common psychophysical task that does not require participants to respond on a linear scale. Specifically, participants were asked to mentally simulate the duration of a future event while completing a task measuring the onset and offset points of the simulated exercise (Kim et al. 2012). If the proposed rationale holds, a congruent (vs. incongruent) display with the spatial organization of time should lead to longer latencies even in the absence of linear response scales.

Method

Participants and design. Forty-one students (70.70% female, average age = 21.82) from a large U.S. university participated in a 2 (spatial orientation of time: horizontal, vertical) x 9 (trials) mixed-design. The first factor was between-subjects and the second factor was within-subjects.

Stimuli. I created nine stimuli that displayed different temporal progressions. For robustness, I included images with monetary amounts (i.e., intertemporal choices) and without monetary amounts (i.e., before and after images). The intertemporal choices included two potential monetary rewards: one available today and the other available in the future. Other
examples included before and after images of teeth whitening or weight loss product results. (See Appendix B for an example of stimuli used.)

Procedure. Participants were told that the main purpose of the study was to simulate the passage of time between two time periods (Kim et al. 2012). In particular, before each trial, they were asked to indicate how long or short the time between the two images displayed would feel to them. Participants made appointments for completing the tasks one at a time. Similar to the previous study, participants saw a display of two time periods arranged in either horizontal or vertical format.

To simulate the passage of time, participants were told to click on a button that turned green to signal the beginning of the time period. Once they felt that sufficient time had passed to indicate the length of time passing, they clicked the button again and proceeded to the next trial. The key dependent variable was the time elapsed between the first and second button press. Finally, participants provided general demographic information.

Results

Similar to the procedure in Study 1a, I analyzed the results for those participants whose native language was English, leaving 32 participants in the final data set. One participant failed to follow instructions and was eliminated from the data set. However, keeping this participant did not alter the pattern of results. Also, in order to avoid outlier effects, I converted the duration judgments using a log transformation (Atalay, Bodur, and Rasolofoarison 2012).

The results of a mixed ANOVA model with display orientation as the between-subjects factor and trials as the within-subjects factor, while controlling for handedness, confirmed that display orientation effects did not vary across stimuli ($F(8, 21) = .69, p = .69$). However, as
expected, the results confirmed a significant main effect of display arrangement on time perception. Consistent with H1, participants considered time passage to be longer when the display was presented congruently ($M = 9.81$ equivalent to 25,691 milliseconds.) than incongruently with the mental representation of time ($M = 9.46$ equivalent to 18,679 milliseconds; $F(1, 28) = 5.06, p < .05$). Adding the participant who did not follow instructions led to the same pattern of results with a marginally significant main effect of the display arrangement ($F(1, 29) = 3.52, p = .07$). See Table 2 for detailed results.

### TABLE 2: CELL MEANS AND STANDARD DEVIATIONS

<table>
<thead>
<tr>
<th>Condition</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal</td>
<td>9.81</td>
<td>0.42</td>
</tr>
<tr>
<td>(n = 15)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vertical</td>
<td>9.46</td>
<td>0.57</td>
</tr>
<tr>
<td>(n = 16)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Discussion**

The results of Study 1b indicate that space-time conceptual mapping robustly affects duration judgment across scenarios. In particular, as predicted, compatibility between visual display and mental time representation lengthens judgments of time duration (H1). Furthermore, by measuring time perception through temporal simulation, I rule out the alternative explanation that temporal expectations increase due to variations in the width of the stimuli. Study 2 demonstrates a downstream behavioral consequence of presenting temporal progressions in a manner consistent with the past-left, future-right organization of time.
STUDY 2: INFLUENCE OF SPATIAL ORGANIZATION OF TIME ON INTERTEMPORAL CHOICE

Longer prospective time perceptions have been shown to cause consumers to steeply discount future outcomes (Kim and Zauberman 2009; Kim et al. 2012; Zauberman et al. 2009). Since viewing a temporal sequence organized congruently with the past-left, future-right organization of time increases subjective time perception, I also expect that the compatibility will increase preferences for immediate rewards (H2).

Method

Design. Seventy-one MTurk participants (45.9% female, average age = 35) participated in a single-factor design with horizontal and vertical spatial organizations of time. Four participants were excluded from the data set because English was not their first language. Three participants were eliminated because they failed an instructional manipulation check.

Procedure. Participants read the following scenario (adapted from Pyone and Isen 2011): “Imagine that a Blu-ray player that you are wishing to purchase is now available at two respectable online stores for the same price, but with different rebate promotions. The first store offers an instant rebate, while the second store offers a mail-in rebate. The mail-in rebate provides a larger amount of money than the instant rebate. However, you must wait six weeks to receive the mail-in rebate. Which of the following two promotions would you prefer?” Their two options were a $25 rebate today or a $40 rebate in six weeks. The decision context entails delayed consumption (Appelt, Hardisty, and Weber 2011; Weber et al. 2007). That is, participants were provided the present option first, and asked whether they would trade it for a larger future reward. See Appendix C for example of stimuli used in this study.
Similar to the previous manipulations, half of the participants saw the two options arranged in a horizontal format, while the other half saw the two time periods arranged in a vertical format. After making their selection, they provided general demographic information.

Results
A chi-square test revealed a main effect of spatial orientation of time on preference ($\chi^2 = 4.55, p < .05$). As expected, participants had a greater preference for the immediate reward when the promotions were presented horizontally rather than vertically ($P_{\text{horizontal}} = 80.00\%, P_{\text{vertical}} = 55.17\%$). See Table 3 for detailed results.

TABLE 3: CELL PROPORTIONS

<table>
<thead>
<tr>
<th>Condition</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal (n = 29)</td>
<td>55.17%</td>
</tr>
<tr>
<td>Vertical (n = 35)</td>
<td>80.00%</td>
</tr>
</tbody>
</table>

Discussion
The results of Study 2 demonstrate that when consumers are presented with a decision to delay consumption, they act more impatiently if the display is arranged congruently with the way they think about time (H2). These findings have important implications for consumers who want to avoid succumbing to immediate gratification. Also, managers could use these findings to design advertisements that promote long-term vs. immediate benefits. In particular, the results suggest that if managers are advertising a future reward, they should present the options vertically rather than horizontally.
The objectives of Study 3 are threefold. First, this study provides direct evidence that subjective time perception mediates intertemporal choice. Second, in addition to the typical present-left, future-right condition, this study also includes a new discounting condition in which the future reward is presented first (i.e., acceleration) (Loewenstein and Thaler 1989; Weber et al. 2007). An acceleration context anchors on the receipt of a future reward instead of an immediate one. Therefore, the first intertemporal option displayed is always the larger later reward and the second option is the smaller sooner reward.

Although it is already documented that order effects alter discounting tasks (Weber et al. 2007), this study included the condition to demonstrate that merely displaying temporal progressions horizontally versus vertically is insufficient to change temporal estimations. Instead, the horizontal display must specifically match the past-left, future-right location map to influence time perceptions and intertemporal decisions. In the acceleration task, both the horizontal and the vertical conditions are incongruent with the direction in which Westerners arrange time. The horizontal condition is organized as future-left, present-right and the vertical condition is organized as future-top, present-bottom. Thus, I expect no difference in subjective time estimations and intertemporal preferences between the vertical and horizontal conditions in the acceleration condition, only in the delay condition. Finally, I use a choice titration task to identify participants’ personal discount rates and provide further evidence that future outcomes are discounted more steeply when presented congruently with the past-left, future-right organization of time.
Method

Participants and design. One hundred and thirty-eight MTurk panelists were assigned to one of the four conditions of a 2 (spatial orientation of time: horizontal vs. vertical) x 2 (discounting direction: delay vs. acceleration of consumption) between-subjects design.

Stimuli and procedure. Respondents in the delay condition were involved in a titration task in which they made a sequence of decisions between receiving a $50 gift certificate that day and a larger gift certificate three months later. The later gift certificate increased from $50 to $100 in $5 increments (Weber et al. 2007). The two rewards were presented in equally spaced boxes arranged horizontally or vertically (see Appendix D). In accordance with established procedures in intertemporal choice (Appelt et al. 2011), a matching task followed the titration task. Specifically, participants were asked to “Indicate the dollar amount that you would need to delay redeeming the certificate by three months.” The subsequent valuation was collected to determine the indifference point for participants whose preferences lie outside the limits of the titration task and to exclude participants uninvolved in the task. That is, they never switched preferences from the fixed amount to the varying amount throughout the entire titration task, but then indicated a contradictory amount on the matching question. For example, a participant in the delay condition continuously preferred $50 today to any amount between $50 and $100 dollars, but then indicated that $50 today is equally attractive to $60 in three months.

Respondents in the acceleration condition made a choices between a $75 gift certificate available in three months and a gift certificate that day. The value of the latter certificate decreased from $75 to $25 in $5 decrements (Weber et al. 2007). After the titration task, participants answered a free response question: “Indicate the dollar amount that you would need to accelerate redeeming the certificate by three months.”
After the intertemporal task, participants self-reported measures of subjective perception of future time duration by indicating how long or short they would consider the time duration between today and a day three months from now (very short/very long, very near/very far, very proximal/very distal; adopted from Kim et al. 2012). Next, participants responded to perceived task complexity (measured similarly to Study 1a) and provided general demographic information.

**Dependent measures.** Discounting was quantified by $k = (A - V)/(V \times D)$, where $V$ is the immediate amount, $A$ is the delayed amount, and $D$ is the delay in years (Mazur 1987). Increasing values of $k$ indicate greater discounting (Appelt et al. 2011). In the delayed consumption condition, the immediate amount ($V$) is $50, while the delayed amount ($A$) is each participant’s indifference point. In the acceleration consumption condition, the immediate amount ($V$) is equal to each participant’s indifference point, while the delayed amount ($A$) is $75.

Each participant’s indifference point was obtained from the titration task using the point at which the participant switched preferences from the fixed gift certificate to the one with varying amounts. For the participant who never switched from the fixed certificate to the varying one, the free response measure was used to calculate the indifference point (Hardisty and Weber 2009).

**Results**

Ten participants were excluded because they switched preferences between present and future rewards from trial to trial or because they showed inconsistent preferences on the choice titration task and the follow-up matching task. Five participants were excluded because English was their second language. Seven participants were eliminated due to missing data.
Discounting. A regression analysis with the estimated discount rate as the dependent variable, the orientation of the options (horizontal vs. vertical), and the direction of the comparison (delay vs. acceleration) as the independent variables revealed a significant main effect of orientation of the options ($t(109) = -1.90, p = .05$), a significant main effect of the direction of the comparison ($t(109) = -2.46, p < .05$), and a marginally significant interaction between the direction of the comparison and the orientation of the options ($t(109) = 1.76, p = .08$) suggesting that the effect of space-time orientation differs depending upon the direction of the discounting task. The model included handedness, task involvement, and the average time to make a decision as controls. The last two covariates were included in the model (i.e., self-reported involvement and decision time) given the repetitive nature of the titration task.

Using ModProbe (Hayes 2013), I tested how the spatial representation of time influenced the two discounting tasks. The results revealed that orientation significantly influenced discounting when participants delayed consumption ($M_{\text{horizontal}} = 2.32, M_{\text{vertical}} = 1.39, t(109) = -1.90, p = .05$), but not when they accelerated consumption ($M_{\text{horizontal}} = 1.20, M_{\text{vertical}} = 1.48, t(109) = .55, p = .58$). These findings support the argument that space-time congruence is necessary for the effects to occur. As such, merely organizing temporal options horizontally or vertically does not change discounting. See Figure 2 and Table 4 for detailed results.
FIGURE 2. THE EFFECTS OF SPACE-TIME CONGRUENCE ON INTERTEMPORAL DISCOUNTING

TABLE 4: CELL MEANS AND STANDARD DEVIATIONS

<table>
<thead>
<tr>
<th>Condition</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal Delay (n = 33)</td>
<td>2.32</td>
<td>2.08</td>
</tr>
<tr>
<td>Vertical Delay (n = 30)</td>
<td>1.39</td>
<td>2.03</td>
</tr>
<tr>
<td>Horizontal Acceleration (n = 24)</td>
<td>1.20</td>
<td>1.12</td>
</tr>
<tr>
<td>Vertical Acceleration (n = 29)</td>
<td>1.48</td>
<td>1.62</td>
</tr>
</tbody>
</table>
Subjective time estimation. The results of a regression analysis on subjective time perception also indicated that the orientation of options had a significant main effect ($t(109) = -1.23, p < .05$) and that the direction of the comparison significantly interacted with the spatial orientation of the options ($t(109) = 1.94, p = .05$). In particular, when participants delayed consumption, the time period between today and a day three months from now felt longer when the options were presented horizontally compared to vertically ($M_{\text{horizontal}} = 4.35, M_{\text{vertical}} = 3.56, t(109) = -2.08, p < .05$). However, when the participants accelerated consumption, subjective time durations did not change ($M_{\text{horizontal}} = 3.84, M_{\text{vertical}} = 4.07, t(109) = .52, p = .52$). See Table 5.

**TABLE 5: CELL MEANS AND STANDARD DEVIATIONS**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal Delay (n = 33)</td>
<td>4.35</td>
<td>1.45</td>
</tr>
<tr>
<td>Vertical Delay (n = 30)</td>
<td>3.56</td>
<td>1.11</td>
</tr>
<tr>
<td>Horizontal Acceleration (n = 24)</td>
<td>3.84</td>
<td>1.28</td>
</tr>
<tr>
<td>Vertical Acceleration (n = 29)</td>
<td>4.07</td>
<td>1.62</td>
</tr>
</tbody>
</table>

Mediation. A mediation test was conducted to determine whether subjective time estimation explains how orientation (horizontal, vertical) influences intertemporal decisions using a nonparametric bootstrapping strategy (Hayes 2013, Model 7). The dependent variable was the discounting rate. The independent variables were orientation and the direction of the discounting task, while the mediator was the subjective time estimation. For consistency, I used
involvement, time spent on the task, and handedness as covariates; however, excluding these
covariates does not affect the results.

A mediation analysis with 5,000 bootstrapping samples revealed a significant main effect
of orientation ($b = -.79$, SE $= .38$, $t(109) = -2.07$, $p < .05$) and a significant orientation x direction
interaction ($b = 1.02$, SE $= .52$, $t(109) = 1.94$, $p = .05$) on subjective time estimation.
Furthermore, subjective time estimation had a positive effect on the discount rate ($b = .62$, SE $= .10$, $t(109) = 5.85$, $p < .001$). When subjective time estimation was included in the model, the
effect of orientation on discounting was not significant ($b = -.18$, SE $= .30$, $t(109) = -.61$, $p = .54$).

More relevant for this study are the bootstrapping results for the indirect effects.
Supporting H3, when participants delayed consumption, orientation of the options had a
significant indirect effect on the discount rate through subjective future time estimation indicated
by a confidence interval that excluded zero (95% CI = -1.08, -.05). However, for accelerated
consumption, subjective future time estimation had a nonsignificant indirect effect (95% CI = -
.34, .69).

Discussion

Study 3 provides evidence that subjective time estimation plays a mediating role in
intertemporal discounting. Displaying intertemporal options in a manner congruent with how
consumers represent time can influence time duration and intertemporal preferences.
Additionally, this study demonstrates that presenting options horizontally, but incongruently with
the spatial organization of time and presenting options vertically leads to similar discounting
outcomes. Finally, the intertemporal choice task directly demonstrates that future outcomes are
discounted more aggressively when the temporal sequences are presented congruently with the
space-time conceptual map.

**STUDY 4: MANIPULATING TIME ORGANIZATION**

Although Western consumers predominantly organize temporal progressions
horizontally, it is possible to prime them to think vertically as an alternative way of visualizing
time (Boroditsky 2001; Chae and Hoegg 2013). This study uses a timeline building task to prime
a vertical spatial representation in which time moves on a vertical axis in addition to a horizontal
axis. If my rationale is correct, activating a vertical (vs. horizontal or control) space-time
conceptualization should lead participants to prefer present rewards when the intertemporal
options are also presented vertically. The results should further demonstrate how choice displays
that are congruent with the spatial organization of time can bias intertemporal discounting
toward the present.

**Method**

*Participants and study design.* Participants were 380 MTurk panelists (43.7% women,
average age = 41.04) participating in a 3 (timeline construction task: control, horizontal, vertical)
x 2 (orientation of temporal progression: horizontal, vertical) between-subjects design.

*Procedure.* In the first part of the study, participants were randomly assigned to a
horizontal timeline, a vertical timeline, or a control condition. Participants in the horizontal and
vertical timeline conditions built two timelines related to the evolution of hats and the history of
telephones (adopted from Chae and Hoegg 2013). They were given six pictures for each topic
and were asked to arrange the events on a horizontal or vertical line. (Appendix E provides
examples of stimuli and instructions for this portion of the task.) Participants in the control
condition did not complete the task, but instead immediately advanced to the intertemporal
decision portion of the experiment.

Ostensibly, as part of an unrelated task, participants chose between two monetary rewards available at different times: a $50 reward today or a $70 reward in three months. The rewards were arranged horizontally or vertically in equally distant text boxes. Participants then reported perceived task ease of building the timeline and finally provided general demographic information such as age, gender, English as a first language, handedness, and task involvement.

Results

Twelve participants were eliminated from the data set because English was not their first language. The logistic regression model included two dummy variables for the timeline factor, the orientation of the temporal progression, and the interaction of each dummy variable with the orientation of the temporal progression. The model also controlled for handedness. Using indicator coding, I constructed two dummy variables for the timeline factor using the vertical condition as the reference category (treatment 1 = horizontal timeline, treatment 2 = control). The results of a logistic regression revealed a marginally significant positive interaction effect between the first treatment group (horizontal) and the orientation of the temporal progression ($Wald = 2.60, p = .10$). Notably, a significant positive interaction occurred between the second treatment group (control) and the orientation of the temporal progression ($Wald = 8.02, p < .01$). These results suggest that the orientation of temporal progression has a different effect on choice depending upon the timeline constructed.

A more in-depth analysis supported my predictions. Specifically, constructing a vertical (vs. horizontal or control) timeline altered the preference for the immediate reward when the display was also vertical ($\chi^2 = 7.42, p < .05$). When the options were presented vertically,
participants constructing the vertical (vs. horizontal) timeline had a higher preference for the immediate reward when the intertemporal options were presented vertically ($P_{\text{horizontal-timeline}} = 37.1\%$, $P_{\text{vertical-timeline}} = 54.5\%$, $\chi^2 = 3.59$, $p = .05$). The same is true for comparing the vertical timeline (vs. control) condition ($P_{\text{control-timeline}} = 30.9\%$, $P_{\text{vertical-timeline}} = 54.5\%$, $\chi^2 = 7.01$, $p < .01$). This evidence further substantiates that congruence between the active space-time conceptual mapping and visual displays of temporal sequences leads to higher preference for present rewards. See Figure 3 and Table 6 for detailed results.

![Figure 3](image_url)

**Figure 3. The Influence of Manipulating Space–Time Congruence on Preference**
To further explore the interactions, I also performed a series of post-hoc tests. First, I analyzed the choice pattern after constructing a horizontal timeline. I found that, as expected, participants exposed to the horizontal timeline had a greater preference for the immediate reward (i.e., $50) when the intertemporal options were presented horizontally as compared to vertically ($P_{\text{horizontal}} = 53.4\%, P_{\text{vertical}} = 33.9\%, \chi^2 = 4.41, p < .05$). In addition, the control condition replicated the previous findings. Consistent with H2, participants exhibited a higher preference for the immediate reward when the intertemporal options were presented horizontally rather than vertically ($P_{\text{horizontal}} = 62.5\%, P_{\text{vertical}} = 25.5\%, \chi^2 = 14.38, p < .01$). Finally, when participants were asked to construct a timeline vertically, the effect of the orientation of the display was attenuated ($P_{\text{horizontal}} = 42.9\%, P_{\text{vertical}} = 51.2\%, \chi^2 = .675, p > .40$). This attenuation might seem contradictory to the argument that congruent time-space mapping leads to an enhanced preference for the present reward. Put differently, one might expect that the vertical prime would
lead to a greater preference for the immediate reward when the options were presented vertically (vs. horizontally). However, these results can be explained by the fact that the timeline prime task is not designed to eliminate the pre-existing horizontal organization of time, but simply to highlight an alternative way of organizing time. Because the vertical timeline prime allows consumers to think about time both vertically and/or horizontally, preferences for the immediate reward did not vary across display conditions.

Discussion

Study 4 further demonstrates that congruence between the spatial representation of time and the display of intertemporal options plays a role in shaping intertemporal preferences. Specifically, by altering the space-time conceptual mapping, I directly test how space-time congruence can lead to the steeper discounting of future outcomes. As expected, priming Westerners to think about time vertically rather than horizontally caused them to prefer present rewards when the options were also presented vertically. The next study demonstrates how space-time congruence can influence the evaluations of other time sensitive products.

STUDY 5: INFLUENCE OF SPACE–TIME CONGRUENCE ON PRODUCT EVALUATION

In my previous studies, I have documented how time-space congruence can influence duration judgments and financial decisions. However, many other products in the marketplace are sensitive to time-related claims and could, therefore, be affected by changes in time expectations. The following study explores how space-time congruence can influence product evaluations in the context of a weight loss product.
Method

Participants and design. Study 5 was a one-factor (spatial organization of time: horizontal or vertical) between-subjects design. Ninety-eight participants from MTurk (33.7% female, average age = 30.76) completed the survey. All participants indicated that English was their first language so all were included in the analyses. Six participants were eliminated because they failed an instructional manipulation check and six participants were eliminated because of missing data.

Stimuli and procedure. Participants learned about a new natural dietary supplement claiming to help consumers achieve a toned, slim body. They viewed before and after pictures of users arranged horizontally or vertically (adapted from Chae and Hoegg 2013). Participants were told that the first picture was taken the first day the client started taking the product and the second picture was taken six months later.

Immediately after participants saw the pictures, they simulated the amount of waiting time required to start seeing results from using this product. Similar to Study 1a, participants indicated how much time would elapse by using as many dashes as needed to represent the passage of time. Subsequently, to study the influence of the spatial representation of time on a standardized time period, participants were informed that the manufacturer guarantees results if the user consistently takes the supplement for 12 months. Their task was to simulate the passage of the 12-month period and then indicate how willing they would be to buy the product on a 7-point scale (1 = Not at all, 7 = Extremely). At the end of the survey, participants responded to a subjective task complexity 7-point scale (similar to Study 1a; r = .82). Given the weight loss nature of the product, disposition toward healthful eating was also measured on a 7-point Likert-type scale (adopted from Chandon and Wansink 2007; r = .67): “I am not very involved with my
health,” “Eating healthily is important to me,” and “I watch how much I eat.” Finally, participants provided general demographic information.

Results

Time to start seeing results. A time index was created by counting the number of dashes that participants used to describe the passage of time between now and the moment they would start seeing results. An ANOVA using this index as a dependent variable, display orientation as the independent variable, and handedness, subjective task complexity, and disposition toward eating healthy as control variables revealed a marginally significant effect of handedness ($F(1, 81) = 3.06, p = .08$) and a significant effect of display orientation ($M_{horizontal} = 58.86, M_{vertical} = 37.78, F(1, 81) = 5.36, p < .05$). Again, supporting H1, displaying temporal progressions congruently with the natural way consumers think about time increased subjective time estimation.

Time to achieve guaranteed results. In this analysis, the dependent variable of interest was the count of dashes participants used to simulate the passage of time between now and the 12 months necessary to see the guaranteed results. An ANOVA using this dash count as a DV, display orientation as the independent variable, and handedness, subjective task ease, and disposition toward healthful eating as control variables revealed a significant effect of handedness ($F(1, 81) = 5.39, p < .02$) and display orientation ($M_{horizontal} = 101.73, M_{vertical} = 74.73, F(1, 81) = 3.75, p = .05$). Again, the results indicate that displaying options congruently with the spatial representation of time increases temporal judgments.

Willingness to buy the product. An ANOVA on willingness to buy the product as the DV, orientation of the display as the independent variable, and handedness, and disposition toward healthful eating as control variables revealed a marginally significant main effect of orientation
(\(M_{\text{horizontal}} = 2.62, M_{\text{vertical}} = 3.34, F (1, 81) = 3.62, p = .06\)). Interestingly, consumers tend to value weight loss products that act quickly, so participants were less willing to buy the product when the picture was displayed congruently with the standard spatial representation of time (i.e., horizontal). See Table 7 for detailed results.

**TABLE 7: CELL MEANS AND STANDARD DEVIATIONS**

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Condition</th>
<th>Mean</th>
<th>SD</th>
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</thead>
<tbody>
<tr>
<td>Time to Start Seeing Results</td>
<td>Horizontal (n = 45)</td>
<td>58.86</td>
<td>54.26</td>
</tr>
<tr>
<td></td>
<td>Vertical Delay (n = 41)</td>
<td>37.78</td>
<td>32.28</td>
</tr>
<tr>
<td>Time to Achieve Guaranteed Results</td>
<td>Horizontal Acceleration (n = 45)</td>
<td>101.73</td>
<td>76.39</td>
</tr>
<tr>
<td></td>
<td>Vertical Acceleration (n = 41)</td>
<td>74.73</td>
<td>62.46</td>
</tr>
<tr>
<td>Willingness to Buy the Product</td>
<td>Horizontal Acceleration (n = 45)</td>
<td>2.62</td>
<td>1.61</td>
</tr>
<tr>
<td></td>
<td>Vertical Acceleration (n = 41)</td>
<td>3.34</td>
<td>1.82</td>
</tr>
</tbody>
</table>

**Mediation.** A 5,000 bootstrapping mediation test (Hayes 2013). Model (4) demonstrated that the orientation of the display influenced willingness to purchase the product through participants’ estimated time to start seeing results (95% CI: .03, .53). This provides additional evidence that time duration judgments mediate the relationship between display orientation and consumer judgment (H3).
Discussion

Study 5 further confirms that displaying temporal progressions congruently with the way consumers conceptualize time leads to higher subjective time estimations. Interestingly, this has important repercussions on product evaluation. That is, a horizontal picture display decreases willingness to purchase a time-sensitive product, an effect mediated by temporal estimation. These findings have substantive value for marketers wishing to promote products, such as beauty products, home renovations, credit cards, and many others that need to manage consumer temporal expectations.

GENERAL DISCUSSION

Can spatial location cues alter time perception and accentuate the desire for immediate rewards? To approach this question, this dissertation merges insights from the literature on cognitive linguistics, psychology of time, and intertemporal decision-making and designed six studies revealing that when consumers view visual representations that are arranged to match with their spatial organization of time, they will judge future time as being more distant and will desire immediate rather than long-term rewards.

Studies 1a and 1b demonstrate how space-time congruence can alter temporal perceptions. In particular, the studies indicate that when consumers view a congruent rather than an incongruent display of temporal sequences, they will judge prospective time periods as being much longer. Temporal estimations are a key component of many consumer decisions about managing their finances. For example, consumers might have to choose between vacationing this year and saving for future home improvements or between buying a new car and increasing their retirement funds. Given that temporal duration judgments affect a wide array of scenarios, the
author also explored how space-time congruence can influence downstream decisions, such as intertemporal choices.

This research proposes and demonstrates that space-time congruence leads consumers to prefer present rather than delayed rewards. Study 2 indicates that when advertisers are promoting time sensitive offers, consumers will highly prefer immediate rewards of lower amounts when the available options are presented congruently with the horizontal (past-left, future-right) conceptualization of time. Study 3 replicates the results using a choice titration task to identify the rate at which individuals discount future outcomes. Specifically, I find that a temporal progression displayed congruently with the past-left, future-right manner of organizing time leads to steeply discounted future rewards. Also confirming the role of subjective time perception on intertemporal preferences, Study 3 demonstrates that changes in time perception mediate the effect of spatial organization of time on discounting. Furthermore, the results of this study show that merely displaying temporal options horizontally is not sufficient to change temporal frames or decisions.

Study 4 manipulates the active spatial organization of time to provide further support for the role of space-time congruence on intertemporal choices. In particular, consumers were primed to think of time vertically. When the options were then displayed congruently with the new alternative space-time organization, they showed increased preferences for present rewards. This indicates that the effect is not driven by the horizontal presentation of the temporal information. Instead, the difference in present reward preference between horizontal and vertical displays originates from matching the manner in which consumers conceptualize time and the arrangement of the options.
Study 5 conceptually replicated the findings of this dissertation in another managerially relevant context. When English-speaking participants viewed before and after pictures arranged horizontally, they perceived that it would take longer to see the results from using a weight loss product, and were less willing to purchase it. While these results seem to contradict Chae and Hoegg (2013), who found that consumers evaluate time sensitive products more highly when temporal sequences are displayed horizontally, this study differs from their research in that we included a temporal judgment component before evaluating the product. Thus, I used a different procedure, which first directed attention toward estimating the time it would take to see results from using the product before the evaluation took place.

The findings of this research have important conceptual implications. In particular, this dissertation enriches the literature on contextual cues that influence subjective time perceptions and, ultimately, discounting (Kim and Zauberman 2013; Kim et al. 2012). More specifically, I confirm the dynamic relationship between space and time and its influence on temporal discounting. Previous marketing work has shown that space and time judgments transfer cross-dimensionally so that longer distances are associated with longer duration times. Adding to that understanding, I study a unique dimension of spatial information, location. Unlike distance, a one-to-one relationship does not explain the effect of location on time perception. As such, I integrate knowledge regarding the psychology of time to build a cohesive framework demonstrating how space-time mappings can guide subjective time perception and ultimately influence intertemporal choices. Specifically, I propose that higher processing demands lead to longer temporal duration judgments due to higher levels of attention to the temporal judgment. This conceptualization adds to the existing literature seeking to understand different factors that can influence time perception (May and Monga 2014; Siddiqui, May, and Monga 2014).
This research contributes to the growing psychological literature exploring how language metaphors shape how we think about time. In particular, this stream of research has demonstrated that consumers can process information more quickly when temporal displays are congruent with their patterns of conceptualizing time. This dissertation examines how space-time interactions affect downstream consumer behavior, such as duration judgments, intertemporal decisions, and product evaluations.

This research also expands prior marketing studies that examine how spatial location affects consumer perceptions by primarily focusing on the location of images or text as they influence product evaluations (Chae and Hoegg 2013; Deng and Kahn 2009; Janiszewski 1990; Peracchio and Meyers-Levy 1997). Recently, Cian et al. (2015) examine how vertical positions influence judgment. In particular, they confirm that up is associated with rational and down is associated with emotions. This mapping can influence how consumers evaluate messages, such as political slogans, that vary on logical vs. emotional appeal. My studies, however, indicate how location cues can influence not only product attitudes, but also consumer decisions, such as intertemporal choices.

The findings of this research have strong implications for advertisement designers. In particular, this research indicates that displaying temporal progressions congruently with the spatial organization of time can affect consumer reactions, particularly regarding advertisements for products that promise future satisfaction, such as beauty enhancement, new home construction, and products requiring assembly.

From a consumer advocacy perspective, this research could increase awareness as to how innocuous location cues can influence intertemporal choices. The findings of this research could be used to promote positive approaches to retirement plans or college advertisements. Finally,
other intertemporal researchers can utilize the findings to design choice tasks that control for location factors to avoid biasing temporal preferences.

*Future Research and Limitations*

The present work has several limitations. First, the manipulations are visual in nature, so it is difficult to establish a true control condition. Therefore, the results cannot indisputably reveal whether a display congruent with the spatial representation increases intertemporal discounting when compared to the baseline or whether the incongruent condition attenuates discounting when compared to the baseline. Second, this research is limited to Western consumers and may fail to generalize to non-English speaking cultures. For example, Chinese individuals typically arrange time vertically (Boroditsky 2001), so the findings might reverse with a Chinese population. Third, I have not identified individual factors, such as impatience, impulsiveness, or the need for structure, that could accentuate or attenuate the effect of the spatial representation of time on intertemporal decision-making. Finally this research examined how ease of processing can influence future time duration judgment and intertemporal choices using space-time congruence. This finding is in line with numerous studies in time psychology, which link fluency experiences with increased temporal estimations during experienced time judgments (Warm and McCray 1969; Witherspoon and Allan 1985). That is, fluency allows consumers to process information more quickly, yet also leads to longer time duration judgments. For instance, familiar stimuli (vs. unfamiliar) are perceived to be presented longer (Avant, Lyman, and Antes 1975). Future research should further explore this counterintuitive relationship between fluency and future time duration judgments by using different manipulations of fluency (e.g., manipulating ease of reading a font style).
Future research could pursue other promising avenues. The present dissertation contributes to the understanding as to how consumers use temporal information to make financial decisions (Nenkov, Inman, and Hulland 2008; Soster et al. 2010). However, the findings of this study also have interesting implications for consumer health. Can temporal arrangements be used to help consumers quit risky health behaviors? For instance, can depicting the consequences of smoking vertically, rather than horizontally, influence intentions to give up smoking? Additionally, is it possible that presenting weight loss achievement vertically, rather than horizontally, makes other consumers feel more willing to start a weight loss program?

From a financial standpoint, there are also plenty of topics to explore. In particular, the current studies have focused on a limited number of scenarios trading money and time in a very controlled task. However, what is yet to be studied, is how these spatial arrangements can influence consumer decisions in an applied marketing context. For example, would consumers be more willing to invest in retirement if an advertisement presents a temporal progression of a person’s life vertically (vs. horizontally)? Moreover, the findings of this research could have interesting implications for the promotion of financial products. For example, would a bank be better off promoting a loan with a six month grace period on a horizontal (vs. vertical) layout? Should this layout be reversed if it was promoting a savings account? It would also be interesting to explore how the spatial representation of time influences choices in the context of monetary losses. That is, how would consumers use space–time congruence to make decisions related to payments rather than receipts? Furthermore, future research could explore how consumers incorporate time and space relationships into decision making when more than two choices are arranged congruently with the spatial organization of time (e.g., an investment payout in one year, five years, or ten years). In the presence of an intermediate alternative, would consumers
continue to demonstrate a present-bias when options are presented horizontally (vs. vertically) or would preferences shift toward the future?

Although I have focused on how temporal spatial arrangements can influence present reward bias, future research could explore when and how numerical spatial arrangement can affect time-money tradeoffs. This spatial organization of numbers would likely be important in intertemporal acceleration conditions. That is, would the mental number line affect intertemporal decisions when the consumer is primarily focused on potential money losses compared to time losses? The exploration of how number magnitude can also influence consumer decisions can also have substantive implications on how consumers make risky decisions, such as gambling. Would a consumer be more likely to take a gamble if the monetary amounts are arranged congruently with the mental number line (i.e., small left, large right)?

The findings documented in this essay can also open the discussion to psychological explanations of why consumers are present-biased. Previous research (i.e., Weber and colleagues) has proposed that when delaying consumption, consumers prefer a present reward because of memory processes (i.e., query theory; (Weber et al. 2007). Specifically, consumers first think about why they would like to receive a present reward and subsequently think about why to receive a future reward. Due to how retrieval processes work, consumers can gather more arguments supporting the first query (i.e., present-reward) compared to the second one (i.e., future-reward), leading them to prefer present rewards. However, my findings demonstrate that even when keeping order constant, a vertical (vs. horizontal) display leads to lower present-bias because of differences in temporal duration. Therefore, future research should seek to reconcile both accounts (query theory and subjective-time) to provide a cohesive framework of when and why consumers innately prefer immediate rewards. That is, do my findings suggest that spatial
cues interfere with retrieval methods? Or is it possible that consumers’ present-bias can be explained through a temporal-duration explanation rather than memory retrieval?

My first dissertation essay demonstrated how the spatial representation of time can affect duration judgments (i.e., magnitude of time), which then influences important time sensitive consumer decisions. In my next dissertation essay, I examine how the visual representation of numbers can affect quantity judgments (i.e., magnitude of number) and how this has downstream consequences related to product evaluations.
CHAPTER THREE
THE SYMBOL-VERBAL NUMBER EFFECT: HOW DOES THE VISUAL REPRESENTATION OF NUMBERS INFLUENCE CONSUMER JUDGMENTS?

INTRODUCTION

As a consumer, would you evaluate the cost of purchasing a gym membership any differently if its price was expressed as “50 dollars a month” rather than “Fifty dollars a month”? Commonly, symbolic, and verbal number notations are thought to be alternative ways of presenting the same magnitude information and used interchangeably in the marketplace. Nevertheless, the central thesis of this work is that consumers process symbolic representations of numbers (e.g., 5) differently than word representations (e.g., five), which ultimately leads to changes in quantity estimations and product evaluations. The present research explores this possibility and its consequences for marketing communication and decision-making.

Extensive research in marketing has examined how subtle differences in the way quantitative information is presented can influence judgments and decisions. For instance, consumers perceive larger attribute differences on scales with large units (Monga and Bagchi 2012), increase judgments of precision if information is presented in fine-grained versus coarse units (Zhang and Schwarz 2012), overemphasize the magnitude of the numerical amount compared to the unit (Pacini and Epstein 1999), and incorrectly evaluate precise numbers to be of lower value than round numbers of similar magnitude (Thomas et al. 2010). Similarly, Coulter
and Roggeveen (2014) find that when deal numbers constitute multiples of each other, fluency is increased and the promotion evaluation is improved.

While previous work has looked at changes in unit presentation (e.g., 3 weeks vs. 21 days) or precision (e.g., 115 vs. 120), the present research uniquely studies whether the visual notation of quantitative information can influence consumer judgment even when keeping magnitude and unit constant. In particular, it investigates the differential impact of using symbolic number notations, compared to verbal, on consumer judgment and evaluations. Two alternative explanations for differences between notations are explored and tested in this essay.

Arabic symbols have long been associated with precision and accuracy (Windschitl and Wells 1996). Moreover, due to their ideographic notation (Besner and Coltheart 1979), Arabic numbers (when compared to verbal numbers) are more visually salient (Treisman and Gormican 1988) in any marketing communication. Centered on these cognitive and perceptual characteristics, it is proposed that symbolic numbers (vs. verbal numbers) activate systematic forms of processing, increasing the amount of time consumers spend elaborating on quantitative information. Drawing on cognitive neuroscience findings, which demonstrate a positive link between time duration and numbers (Walsh 2003), this account predicts that longer elaboration time will be associated with judgments of higher quantities of a given attribute. These magnitude judgments will then affect product evaluation depending upon whether the attribute is positive or negative for the product evaluation.

As an alternative explanation, it is possible that Arabic digits and number words influence product evaluation through fluency. Specifically, the visual nature of symbolic numbers allows them to be processed like objects, which allows consumers to retrieve magnitude information more rapidly from memory (Ferrand 1999). Furthermore, due to their convenience,
Arabic symbols (vs. number words) are more frequently used to represent quantitative information. Grounded on these two characteristics, it is possible that Arabic numbers (vs. number words) are more fluently processed. Given that highly fluent processing tends to lead to favorable attitudes toward the target (Labroo and Lee 2006; Lee and Aaker 2004), symbolic numbers could lead to improved product evaluations.

The following dissertation explores the effect of number notation on judgment with the help of seven studies. Study 1a seeks to demonstrate that the presentation of quantities using symbolic numbers, as compared to verbal numbers, leads to higher magnitude judgments. Furthermore, Study 1b provides evidence of the downstream effects number format can have on product evaluation. Study 2 demonstrates how presenting a product ingredient using symbolic numbers, as compared to number words, differentially influences perceptions of quantity of an advertised ingredient, anticipated taste of the product, and brand evaluations. Additionally, this study rules out credibility as an alternative explanation to the proposed effects.

Study 3 uses two theoretically relevant moderators to explore the underlying mechanism of the symbol-verbal effect. Study 3a manipulates the availability of cognitive resources to separate the two possible process explanations. A systematic processing account predicts that a high cognitive load will attenuate the symbol-verbal number effect as there are insufficient resources for symbols (vs. verbal numbers) to increase elaboration. In contrast, a fluency account predicts that a state of high cognitive busyness will accentuate the influence of number notation on judgment as constraining mental resources leads to an overreliance on feeling inputs (Wadwha and Zhang 2015). Study 3b manipulates consumption goals as consumers are evaluating a symbolic (vs. verbal) number in order to disentangle a cognitive vs. affective-based explanation as they predict opposite results. That is, if symbolic numbers influence systematic
processing, then a utilitarian (vs. hedonic) goal would create a better fit between number notation and the decision context (Wadhwa and Zhang 2015) thereby accentuating the symbol-verbal difference. However, if symbolic numbers increase reliance on affective processing, then a hedonic (vs. utilitarian) goal would create a better fit, thus accentuating the effect.

Study 4 examines whether mere exposure to Arabic symbols (vs. number words) affects the type of processing consumers engage in subsequent decisions. This study also attempts to provide evidence of increased elaboration even when the symbolic number is not accompanied by a verbal unit. Finally, Study 5 examines the source of increased elaboration by testing whether congruent (vs. incongruent) “number-unit” representations alter magnitude representations.

THEORETICAL BACKGROUND

Number Notation

According to numerical cognition models, numbers can be presented in three notations: an Arabic symbolic code (“3”), a verbal code (“three”), and an analogue code (“III”) (Dehaene 1992). The analogue code represents quantities approximately and nonverbally, mapping quantities to an internal number line in order to make relative judgments of size (Dehaene, Dehaene-Lambertz, and Cohen 1998). Further, the analogue code is an innate semantic system of magnitude that is present in animals and in humans since infancy (Dehaene and Cohen 1995). Given its characteristics, enumeration of quantities in an analogue format involves a concrete form comprised of a set of similar visual objects (e.g., thirty dots) that individuals then count or approximate (Piazza et al. 2007). In a marketing context, space constraints in advertising or retail space limit the use of visual representations of the analogue code. For instance, it would be
difficult to display a price of $50 through the use of 50 one-dollar bills. Because of these constraints, the discussion of this dissertation will primarily focus on understanding the differences between Arabic and verbal codes.

Researchers in numerical cognition have extensively debated whether one or multiple mental representation systems of number magnitude exist (Kadosh and Walsh 2009). That is, when and how does the visual notation of a number influence the processing of magnitude information? Although this is an ongoing and unresolved debate in numerical cognition, there is some evidence to attest that each number notation is processed through different mechanisms. The following sections explicate these differences and how they can influence consumer judgment.

*The Influence of Number Notation on Systematic Processing*

The influence of Arabic (verbal) numbers on magnitude judgment could be explained through cognitive and perceptual routes. Research in the uncertainty literature has found that numerical scales elicit deliberate and rule-based reasoning when compared to verbal scales (Windschitl and Wells 1996). The authors base their arguments on the way people commonly interact with both number codes. For example, from an early age, symbolic numbers (vs. number words) are more commonly used to express arithmetic, algebra, and geometry problems, and are generally associated with accuracy, precision, objectivity, and formal rules of logic. Other research has demonstrated that people are much faster and more accurate at solving addition problems when the numbers are presented in digits rather than words (Campbell 1994). Given that symbolic numbers are related to more deliberate and accurate processing than verbal...
numbers, this dissertation argues that symbolic number cues (as compared to a number word) motivate a systematic reasoning process.

Additionally, from a perceptual saliency perspective (Treisman and Gormican 1988), symbolic numbers are also more likely to stand out in a product package or advertisement thus drawing more visual attention and generating greater elaboration (Paivio 1969). Salient attributes, such as symbolic numbers, can also influence information processing as they can recruit greater information from memory (McGill and Anand 1989) and are also more heavily weighted in judgments (Monga and Bagchi 2012; Towal, Mormann, and Koch 2013).

Given the cognitive and perceptual characteristics of symbolic numbers (vs. number words), this account proposes that symbolic numbers (as compared to number words) increase reliance on systematic processing and, as such, increase the amount of time consumers spend elaborating on quantitative information. But how does this lead to changes in magnitude perception?

A large body of work with various animals and humans has found similarities in representing number and time information (Meck and Church 1983). Behavioral interactions between time and numerosity estimates are evident even at early stages in life. For example, infants’ temporal and numerical ability increases in precision at the same rate between six and ten months of age (Xuan et al. 2007). More importantly, changes in number magnitude have been known to influence perceptions of time. Oliveri et al. (2008) found that merely looking at a larger number symbol positively biases judgments of temporal duration suggesting that temporal estimations depend upon a number’s magnitude. Chang et al. (2011) replicated this finding by asking participants to reproduce the duration time that a given number was presented on a screen.
They found that duration reproductions were shorter for smaller numbers as compared to larger numbers demonstrating a number-time link.

Given the evidence for a shared magnitude code, it could be argued that longer elaboration times can have downstream consequences on number magnitude judgments. Because bigger/faster/brighter magnitudes in one domain correlate with bigger/faster/brighter judgments in another (Bueti and Walsh 2009; Coulter et al. 2010), it is expected that longer elaboration time will be associated with higher estimates of quantity for a given attribute and subsequently incorporated into product evaluations. Thus, I expect:

H1: When consumers are presented with information in symbolic Arabic code, compared to verbal code, their magnitude estimates are larger.

Influence of Number Notations on Product Evaluations

Magnitude judgments have important consequential effects on product evaluations. For example, the literature has found that higher prices indicate higher quality (Dodds, Monroe, and Grewal 1991), higher caloric intake relates to unhealthy meals (Chandon and Wansink 2007), and higher discounts lead to greater willingness to purchase (Biswas et al. 2013). From these examples, it is evident that high, compared to low, magnitudes do not always improve consumer evaluations. Instead, the influence of magnitude on product evaluations depends upon the valence of the attribute for the particular evaluation being considered. A positive valence refers to an attribute for which as magnitude increases, product evaluation improves.

As an illustration, imagine a consumer evaluating the nutritional value of a food product. Perceptions of high caloric intake would negatively influence the nutritional value of the product.
Alternatively, the product would benefit from perceptions of high protein content. Formally stated, I predict:

H2: Attribute information in symbolic Arabic code, compared to verbal code, will positively influence product evaluations when the valence of attribute is positive.

The conceptual model as to how number representations influence magnitude judgments and product evaluations is depicted in Figure 4.

![Conceptual Model](image)

**Figure 4: Conceptual Model Chapter Three**

**Study 1a: Symbol-Verbal Number Effect on Magnitude Perception**

In this study, I use a common psychophysiological task to determine whether number notation has an influence on magnitude judgments. The reason for using this type of procedure is that scaled measurement instruments typically require the use of verbal or numerical
information. Therefore, it could be argued that changes between symbolic and verbal conditions are due to the perceptual contrast between the numerical stimulus and the scales used to measure perceptions (e.g., symbolic notation and a verbal scale).

To account for this perceptual difference, this study asks participants to mentally simulate a time passage between tomorrow and a day X months in the future (Kim et al. 2012). Because elaborating longer on symbolic numbers (vs. number words) leads to larger magnitude estimations, it should also lead to overestimation of the perceived duration (Oliveri et al., 2008). That is, consumers will take longer to mentally simulate time passage when months are expressed in symbolic format rather than words.

Method

Participants and design. Thirty-five students from a national University (57% female, average age = 25) participated in this study. The design of the study was 2 (number format: symbolic vs. verbal) x 13 (trials: one, two, four, five, six, eight, nine, ten, twelve, fourteen, twenty, twenty four, and thirty months). The first factor was manipulated between-subjects and the second factor was measured within-subjects.

Procedure. This study instructed participants to simulate the passage of time between “tomorrow and a day X months from now” (Kim et al., 2012). They started with two practice trials to familiarize themselves with the task. Next, they completed 13 trials in which “X” represented 1, 2, 4, 5, 6, 8, 9, 10, 12, 14, 20, 24, and 30 months listed either in symbolic or verbal format. The order of presentation of the trials was randomized. The task required participants to click on the START button to simulate the beginning of the time period and once they felt that sufficient time had passed to complete the time passage, they had to click on the END button to
proceed to the next trial. After completing the 13 trials, participants provided their gender and age.

Results

Because number size can influence magnitude judgments (Verguts, Fias, and Stevens 2005), I examined whether the symbol-verbal effect varied across this factor. The results of a repeated measure ANOVA revealed a nonsignificant interaction effect between number size and number representation ($F(1, 22) = 1.10, p = .40$). The same analysis revealed a marginally significant main effect of number format ($F(1, 33) = 2.96, p = .09$). Confirming H1, participants considered time passage to be longer when the months were expressed in symbolic numbers ($M = 22,975$ milliseconds) as compared to verbal numbers ($M = 14,753$ milliseconds). See Table 8 for detailed results.

**TABLE 8: CELL MEANS AND STANDARD DEVIATIONS**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symbolic</td>
<td>22,975</td>
<td>16,000</td>
</tr>
<tr>
<td>(n = 19)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Verbal</td>
<td>14,753</td>
<td>11,330</td>
</tr>
<tr>
<td>(n = 16)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Discussion

This study demonstrates that number format affects perceived magnitude judgments. Consistent with my expectations, a symbolic (vs. verbal) number format increases magnitude perception. More importantly, this study demonstrates changes in magnitudes without using...
scaled-responses thereby eliminating the possibility that the effects are due to perceptual differences between the number notation on the stimulus and the number notation on the scale.

These results are also inconsistent with a concrete-abstract mindset explanation. Specifically, since precision and vividness have been known to give rise to a concrete mental construal (Maglio and Trope 2011), it could be argued that symbolic numbers lead consumers to concrete (vs. abstract) mental construal. However, if this were the case, then a stimulus that is psychologically close (i.e., concrete) should also be associated with shorter temporal distances (Trope and Liberman 2003), which is in contrast to the findings in this study.

Additionally, these results demonstrate that more characters do not bias magnitude estimations upwards. That is, verbal numbers with higher number of characters were perceived as being of lower magnitude than symbolic numbers. Study 1b explores a downstream effect of number notation.

STUDY 1B: SYMBOL-VERBAL NUMBER EFFECT ON PRODUCT EVALUATION

Study 1b demonstrates the differences that emerge from presenting quantitative information in symbolic or verbal number codes in the context of a product claim. In particular, the study uses a fitness tracker product that allows users to lose weight. Given that losing weight is desirable for consumers, I expect the product evaluation to improve when the advertised amount of weight loss achieved is presented in symbolic (vs. verbal) numbers.

Method

Participants and design. One hundred and five online panelists (53.90% female, average age = 37.77) evaluated an ad for a new fitness trainer. The design used a one-factor between-subjects design (number format: symbolic vs. verbal). Specifically, I created two identical ads
featuring a new fitness tracker: Moov. The ad claimed that Moov enables users to maximize their workout and lose 15 (fifteen) pounds in less than a month. The only difference between the two ads was the number notation used to represent the weight. See Appendix F for an illustration of the stimuli.

Procedure. Participants were asked to look at the ad and then answer questions measuring their attitudes toward the brand. Attitude toward the brand was measured on a three-item semantic differential scale (Very Bad, Very Good; Very Negative, Very Positive; Very Unfavorable, Very Favorable; r = .97). Finally, participants provided general demographic information.

Results

A one-way Analysis of Variance (ANOVA) with attitude toward the brand as the dependent variable and number representation as the independent variable revealed a significant main effect of number representation ($F(1, 103) = 5.29, p < .05$). Confirming H2, participants had a more positive evaluation of Moov when the weight information was presented in symbolic numbers ($M = 4.56$) than when it was presented in words ($M = 3.79$). See Table 9 for detailed results.

**TABLE 9: CELL MEANS AND STANDARD DEVIATIONS**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symbolic (n = 52)</td>
<td>4.56</td>
<td>1.36</td>
</tr>
<tr>
<td>Verbal (n = 53)</td>
<td>3.79</td>
<td>2.02</td>
</tr>
</tbody>
</table>
Discussion

The results of this first study reveal that symbolic numbers, when compared to verbal numbers, improved brand evaluation. These findings have important managerial implications. Specifically, since the attribute that marketers would like to showcase for this product is losing weight, these results suggest that it would be in the product’s best interest to present the weight information in symbols rather than words. In the next study, I demonstrate the robustness of the symbol-verbal effect on product evaluation by testing it in a hedonic context, food evaluation.

STUDY 2: RULING OUT CREDIBILITY

The goals of Study 2 were threefold. First, it replicates the symbol-verbal code effect in a real product evaluation context by manipulating the cheese content description of a cracker (“4” vs. “four” cheese). In addition, this study explores how changes in the numerical representation of attributes can influence downstream product evaluations, such as taste and brand attitude. Because increasing the amount of cheese content is beneficial to taste evaluations, it is expected that higher magnitude judgments will positively influence taste evaluations and attitudes toward the brand.

Moreover, this study seeks to rule out a potential alternative explanation based on the differential use of each notation in everyday communication. Consumers are exposed to symbolic numbers more often than number words when evaluating quantities. Furthermore, symbolic numerical expressions, as compared to number words, constitute a simpler way of communicating quantitative information. Consumers may expect to see numerical expressions in symbols (Grice 1970) and may judge products more favorably when they comply with these pre-established rules of conversational logic. To rule out this alternative explanation, the following
study manipulates communicator trustworthiness. In particular, previous research has shown that consumers only make use of the rules of conversation when they believe that the communicator is not deliberately trying to mislead them. Thus, if conversational logic explains the proposed effects, then the symbol-number effect should only occur when consumers trust the source of information. However, if the company is not trustworthy, then consumers should no longer rely on notation-based inferences (Zhang and Schwarz 2012) and the symbol-verbal effects should be attenuated or eliminated. In contrast, the proposed explanation based on systematic processing does not depend upon the communicator’s intentions. Therefore, the author would expect that the symbol-verbal effect will hold regardless as to the communicator’s level of trustworthiness.

Method

Participants and design. One hundred seventy-nine MTurk participants (45.3% female, average age = 37.32 years old) were assigned to one of the six conditions based on a 2 (number format: symbolic, verbal) × 3 (source credibility: high vs. low vs. control) design.

Procedure. Participants were informed that a company was planning to launch a new product soon. In the high trustworthiness condition, participants learned that the company has been on Forbes’ list of the “100 Most Trustworthy Companies” for the last few years, while in the low trustworthiness condition, participants read that the company had been found to “falsify financial records” for the past few years (Zhang and Schwarz 2012). In the control condition, participants were not given any background information on the company.

Immediately after reading the credibility statement, participants saw a mock-up of the company’s new 4 (four)-cheese cracker product (see Appendix G). They then rated the product’s cheese content on a three-item scale (1=Very low/7=Very high, 1 = Minimal/7=Substantial, 1= Negligible/7= Significant; r = .97). Following, anticipated taste of the product was assessed with
the following two items (adapted from Raghunathan, Naylor, and Hoyer 2006): (1) “How tasty do you think the product would be?” and “How much do you think you would enjoy eating the product that you just evaluated?” on a 10-point scale (1 = Not at all, 10 = Very Much; r = .79). Attitude toward the brand was evaluated with three items (1 = Very Bad/ 7= Very good; 1= Very negative/ 7= Very positive; 1= Very unfavorable/ 7 =Very favorable; r = .97). Subsequently, to evaluate whether participants were paying attention to the task, they completed an instructional manipulation check (Oppenheimer, Meyvis, and Davidenko 2009). Finally, I measured task difficulty with a two-item, seven-point scale (“How easy or difficult was it to perform this task?” measured on 1 = Very difficult/ 7 = Very Easy” and “How simple or complex was it to perform this task? measured on 1 = Very complex/ 7= Very simple”) and general demographic information.

Results

Twenty-two participants were eliminated from the data set because they failed the instructional manipulation check. Therefore, a total of 157 participants were left in the final data set.

Cheese content. A 2 × 3 ANOVA on cheese content revealed a marginally significant main effect on number representation (F(1,151) = 3.48, p = .07), a non-significant main effect on source credibility (F(1,151) = .00, p = 1.00), and a nonsignificant interaction effect (F(2,151) = .77, p = .46). Consistent with H1, when the product attribute was expressed in symbolic (vs. verbal) code, consumers evaluated it as having higher cheese content (M_{symbolic} = 4.93 vs. M_{verbal} = 4.52). More importantly, number notation influenced magnitude judgment irrespective of the credibility of the source, effectively ruling out conversational logic as an alternative explanation.
Taste evaluations. A 2 × 3 ANOVA on taste revealed a significant main effect on number notation ($F(1,151) = 9.35, p < .01$), a marginally significant main effect on credibility ($F(1,151) = 2.45, p = .08$), and a nonsignificant number × credibility interaction ($F(2,151) = 1.49, p = .23$). Given that cheese content is a positive attribute to possess for a cheese cracker, the taste evaluation of the product was improved when the attribute was presented in symbols ($M = 7.59$) rather than verbal numbers ($M = 6.63$). The lack of a number x credibility interaction suggests that the influence of number notation on product evaluation is not due to pre-established rules of conversation.

Brand attitude. A 2 x 3 ANOVA on brand attitude revealed a marginally significant effect of number notation on brand attitude ($F(1,151) = 3.13, p = .07$), a nonsignificant effect on credibility ($F(1,151) = 1.11, p = .33$), and a nonsignificant number × credibility interaction ($F(1,151) = .41, p = .66$). In particular, participants felt marginally more favorable toward the brand when the attribute was expressed in symbols compared to number words ($M_{\text{symbolic}} = 4.74$, vs. $M_{\text{verbal}} = 4.38$). See Table 10 for detailed results.


**TABLE 10: CELL MEANS AND STANDARD DEVIATIONS**

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Condition</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cheese Content</td>
<td>Symbolic (n = 79)</td>
<td>4.93</td>
<td>1.37</td>
</tr>
<tr>
<td></td>
<td>Verbal (n = 78)</td>
<td>4.52</td>
<td>1.50</td>
</tr>
<tr>
<td>Taste Perception</td>
<td>Symbolic (n = 79)</td>
<td>7.59</td>
<td>1.89</td>
</tr>
<tr>
<td></td>
<td>Verbal (n = 78)</td>
<td>6.63</td>
<td>2.29</td>
</tr>
<tr>
<td>Brand Attitude</td>
<td>Symbolic (n = 79)</td>
<td>4.74</td>
<td>1.35</td>
</tr>
<tr>
<td></td>
<td>Verbal (n = 78)</td>
<td>4.38</td>
<td>1.25</td>
</tr>
</tbody>
</table>

**Mediation.** A mediation test was conducted to determine whether the magnitude judgment (i.e., cheese content) explains how number notation (horizontal, vertical) influences taste evaluation using a nonparametric bootstrapping strategy (Hayes 2013), Model 4). The dependent variable was taste. The independent variable was number notation and the mediator was estimated cheese content of the cracker.

A mediation analysis with 5,000 bootstrapping samples revealed a marginally significant main effect of number notation on cheese content (b = -.41, SE = .23, t(155) = -1.80, p = .07). Furthermore, the cheese content estimation had a positive effect on the taste evaluation (b = .82, SE = .10, t(154) = 8.44, p < .001). When the cheese content estimation was included in the model, the effect of the number notation on taste evaluation was weakened (b = -.61, SE = .28, t(154) = -2.18, p < .05). More relevant for this study are the bootstrapping results for the indirect effects. Number notation had a significant indirect effect on taste evaluation through cheese content estimation indicated by a confidence interval that excluded zero (95% CI = -.77, -.0007).
**Task ease.** The results of a $2 \times 3$ ANOVA revealed a significant main effect of number notation ($F(1, 151) = 6.36, p < .05$). Specifically, participants concluded that it was easier to evaluate the product when it was presented in symbols ($M = 5.71$) than in verbal format ($M = 5.24$). However, the results of the number notation on cheese magnitude, taste, or brand attitude remain unaltered after controlling for task ease.

**Discussion**

The findings of this study suggest that number notation can influence magnitude judgments. In particular, the direction of the results support H1, whereby attribute information presented in symbolic numbers is perceived as having larger magnitude than when it is presented in words. Furthermore, the results confirm that number notation influences other managerially relevant outcomes, such as taste perceptions and brand attitude. In addition, the data also indicate that the proposed effects are not driven by conversation rules developed over the years by the frequent use of symbolic numbers.

Interestingly, the results of this study also suggest that task ease is enhanced when using a symbolic (vs. verbal) number notation. Although I argue that symbolic (vs. verbal) numbers lead to higher elaboration of information and subsequently affect product evaluation, the change in task ease evidenced in Study 2 suggests that symbolic numbers could improve evaluations through an affect-based route (i.e., fluency). The following section explicates processing differences between symbolic and verbal numbers that could be the basis of a fluency explanation.
Symbolic and verbal numbers inherently differ in the type of notation they use to communicate numerical magnitude. Arabic numbers’ notation is ideographic as the visual form of the digit represents an idea or concept and is only arbitrarily assigned a phonological form (Besner and Coltheart 1979). Furthermore, Arabic symbols are processed in a manner similar to objects, whereas verbal numbers are processed like any other word. It is well established that the processing of words and objects vary extensively. In particular, objects, compared to words, have faster and direct access to conceptual information (Ferrand, Grainger, and Segui 1994). Following this logic, symbols also have faster access to semantic information than verbal numbers (Ferrand 1999). In contrast, number words are notated alphabetically. As such, the specific letters of the word specify its pronunciation, but do not specify its meaning. An alphabetical notation allows direct access to phonological forms, but only indirect access to meaning (Damian 2004). In fact, it has been argued that individuals can process number words without having to access magnitude information (i.e., nonsemantic route; Campbell 2004).

Fias, Reynvoet, and Brysbaert (2001) show evidence of the processing asymmetry between symbolic and verbal numbers in their experiments. In their experiments, participants are exposed to a verbal numeral and an Arabic numerical simultaneously in a display and are instructed to name the verbal numeral while ignoring the Arabic number information. The authors demonstrate that participants were capable of ignoring the irrelevant Arabic information during the naming task, evidenced by the fact that participants’ latencies did not change regardless as to whether the trial was congruent (i.e., Arabic numeral matched the verbal one) or incongruent (i.e., the Arabic numeral was different from the verbal one). However, when participants were required to access semantic information to respond, for example indicate
whether the number was odd or even, they showed faster responses when both numbers were the same magnitude than when they differed. This finding suggests that verbal numbers access semantic information only if the task requires it.

Other evidence that number words can be processed through a nonsemantic route comes from the fact that researchers are not able to replicate well-established automatic numerical effects when using number words. For example, the size congruity effect is a Stroop-like phenomenon in which participants are asked to process a stimulus that differs in magnitude and size. However, they are asked to only consider one dimension while responding to a question. In one condition one of the numbers is larger in magnitude size and in physical size (3, 4). In contrast, the incongruent condition includes one digit, which is larger in magnitude but smaller in physical size (3, 4). When participants are performing this task using Arabic symbols, they are unable to discount the irrelevant physical size information. Therefore, their responses to the incongruent trials are slower than to neutral trials. However, this effect is not replicated when the numbers are presented in verbal notation (i.e., Three-Four is equivalent to Three-Four) suggesting that the numerical value is not processed automatically for verbal notation (Ito and Hatta 2004; Kadosh et al. 2011). Processing differences between number words and Arabic symbols has also been evident in the neuropsychological literature. For instance, patients that can no longer read words can accurately recognize and compute Arabic numerals (Dehaene and Cohen 1997).

Along with having easier access to magnitude information, Arabic numbers, compared to verbal numbers, are also more regularly used to express quantities as they provide a quicker and more space-efficient manner to communicate quantities. For instance, the verbal number “one
hundred and fifty-seven” uses nine times as many characters than the symbolic equivalent “157.” Increased frequency of use has been known to make stimuli easier to process (Wadhwa and Zhang 2015). For example, round numbers are more fluently processed than sharp numbers due to the frequency in which they appear in written language (Kettle and Häubl 2010).

Given the asymmetries in magnitude accessibility and frequency of use between symbolic and verbal numbers, Arabic (vs. verbal) numbers should be processed more fluently. Furthermore, since processing fluency is hedonically marked, evaluations toward the target should improve when the information is presented in symbols (vs. words) (i.e., fluent processing) (Labroo and Lee 2006; Reber, Schwarz, and Winkielman 2004).

Both the fluency and elaboration explanations described seem plausible. Thus, this dissertation will pit the two against each other to determine which one best explains how Arabic symbols influence judgments. Specifically, the next two studies use theoretically relevant moderators to disentangle the two possible mechanisms of the symbol-verbal effect. Cognitive load and consumption goals are theoretically relevant moderators because a systematic processing explanation, when compared to fluency, predicts opposite results for each level of the moderator.

**STUDY 3A: COGNITIVE LOAD**

This study intends to explore the underlying mechanism of the proposed effects by manipulating the cognitive capacity available to consumers as they are evaluating a product. If a fluency account was valid, then constraining mental resources, which leads to an overreliance on feeling inputs (Wadhwa and Zhang 2015), will accentuate the proposed effects. However, if a systematic processing account was valid, then constraining mental resources, which does not
allow consumers to elaborate on the information (Barrett, Tugade, and Engle 2004), will attenuate or eliminate the symbol-verbal effect.

**Method**

*Study design.* One hundred and eight students (27.80% female, average age = 20.81) participated in a 2 (number representation: symbolic, verbal) x 2 (cognitive load: present vs. absent) between-subjects design.

*Procedure.* Cognitive load is typically manipulated by providing participants a long (vs. short) string of digits or letters to memorize (Shiv and Fedorikhin 1999). However, given that the purpose of this dissertation is to demonstrate how symbolic numbers (vs. number words) lead to deliberate processing, it could be a potential confound to expose participants to merely one of these codes prior to the evaluation task. Therefore, this study constrained cognitive resources by exposing participants to a string of letters and numbers. At the start of the study, participants were told that the purpose of the study was to understand how memory affects advertising information. For this purpose, they were asked to memorize a string of letters and digits as they simultaneously evaluated an advertisement. In the low cognitive load condition, participants were asked to memorize a two-digit string comprised of one letter and one word (C3), while in the high cognitive load condition participants memorized an 11-item string (4ZQ6B2G87U). Once participants saw the target advertisement, they were asked to report the string of letters and digits they memorized.

The target product of this study was a whole grain cookie. The wheat content in the front façade of the product was presented as “100% wholegrain content” or “One hundred percent wholegrain content.” (See Appendix H). Note that the unit was also presented in either a symbol or verbal format, matching the numerical representation. After exposure to the product,
participants rated the perceived nutritional value of the product on three-item scale (adapted from (Kozup, Creyer, and Burton 2003). “Based on the information provided, how important would this product be as a part of a healthy diet?” anchored on 1 = Not at all, 7= Very Important. “I think the nutrition level of this product is…” anchored on 1 = Very Poor, 7= Very Good. “Overall, how would you rate the level of nutritiousness suggested by the information provided?” anchored on 1= Not Nutritious at all, 7 = Very Nutritious (r = .87). To further assess whether symbolic numbers changed elaboration patterns, participants were asked to recognize the amount of wholegrain content that the advertised product had. If a systematic processing account holds, then participants should have better recall of the symbolic numbers than the verbal numbers. Participants also rated how easy it was to evaluate the product on two seven-point scale items (1 = Very difficult/7 = Very easy; 1 = Very complex/7 = Very simple; r = .93). Finally, participants provided some general demographic information, such as gender and age.

Results

Manipulation check. A 2 x 2 ANOVA on task difficulty revealed only a significant main effect of cognitive load. As expected, a low cognitive load allowed participants to evaluate the product easily (M = 5.52) compared to a high cognitive load (M = 4.69; F(1,104) = 8.90, p < .01).

Nutritional value of the product. A 2 x 2 ANOVA on the nutritional value of the product revealed a significant interaction (F(1,104) = 6.06, p < .05). As predicted by a systematic processing account, when participants had high cognitive load, the effect of number formatting on evaluation was attenuated (M_{symbol} = 4.52, M_{verbal} = 4.70; t(104) = .68, p = .50). However, the effect was replicated when participants had a low cognitive load (M_{symbol} = 5.29, M_{verbal} = 4.54; t(104) = -2.74, p < .01). See Figure 5 and Table 11 for detailed results.
Recall. Additional evidence of increased elaboration would be provided if participants seeing symbols (vs. verbal numbers) had better memory for the numerical attribute. In particular, participants were asked to identify the percentage of wholegrain the product contained. They were given a set of four options (50, 100, 20, or 80). The format of the numbers in the
recognition question matched the format presented in the ad. A correct response on this question was coded as one and an incorrect response was coded as zero. The results of a 2 x 2 logistic regression on recognition found a nonsignificant main effects or interaction (p’s >.80). See Table 12.

**TABLE 12. RECALL CELL PROPORTIONS**

<table>
<thead>
<tr>
<th>Cognitive Load</th>
<th>Number Notation</th>
<th>Symbols</th>
<th>Verbal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Cognitive Load</td>
<td>76.00%</td>
<td>76.92%</td>
<td></td>
</tr>
<tr>
<td>High Cognitive Load</td>
<td>72.00%</td>
<td>72.41%</td>
<td></td>
</tr>
</tbody>
</table>

Although, this might seem contradictory to an elaboration explanation, the nonsignificant results might be due to the low amount of additional information in the ad. It is also possible that the effect was not significant given that the question was framed as recognition and not recall. Further research can identify whether recognition and recall differences emerge after exposure to symbolic or verbal numbers.

*Discussion*

Study 3a provides some insight as to how symbols influence evaluation. In particular, the results provide support for a systematic processing account, which predicts that a high cognitive load diminishes the capacity to elaborate on the quantitative information regardless as to whether it is presented in symbols or verbally, thereby attenuating the number format effect. Given that a fluency explanation predicts that a high load condition should accentuate or at least not attenuate the symbol-verbal effect, the results deem fluency as an unlikely mechanism through which number representation affects evaluations. Next, Study 3b examines how utilitarian (vs. hedonic) consumption goals moderate the symbol-verbal effect.
This study intends to provide additional evidence to determine whether symbolic numbers influence magnitude judgments through a feeling-based (vs. cognition) route. In particular, (Wadhwa and Zhang 2015) demonstrate the importance of fit between the type of reaction that the number elicits (affective vs. cognitive) and the decision-context to improve consumer evaluations. Specifically, the authors argue that fluently processed rounded (non-rounded) numbers increase the likelihood of relying on affect (cognition) leading to more favorable evaluations when the decision-context is driven by feelings (e.g., a hedonic consumption goal). That is, a fit between the nature of the number and the context of the purchase decision improves the evaluative judgments related to the target product.

The present study uses the concept of “fit” between the type of number and the decision context to determine which of the two proposed accounts best explains the influence of number notation on magnitude judgment. In particular, if symbols enhance evaluations through fluency, then a hedonic (vs. utilitarian) purchase context should create a better fit between number notation and decision context thereby accentuating differences between the symbols and verbal numbers. In contrast, if symbols improve evaluations through elaboration, then a utilitarian (vs. hedonic) purchase context should create a better fit between number notation and decision context leading to an enhanced symbol-verbal difference. Thus, I expect:

H3a: Based on a fluency account, a hedonic (vs. utilitarian) goal will accentuate the difference between symbolic numbers (vs. number words).
H3b: Based on a systematic processing account, a utilitarian (vs. hedonic) goal will accentuate the difference between symbolic numbers (vs. number words).

To test the two rival hypotheses, this study will manipulate participants’ consumption goals to be either a hedonic goal promoting the use of feelings or a utilitarian goal promoting the use of cognition. This study will also demonstrate the robustness of the effect by manipulating the numerical notation of a different type of information: pricing.

Method

Study design. One hundred and eighty-six students (45.2% female, average age = 20.88) were assigned to one of four possible conditions in a 2 (number representation: symbolic, verbal) x 2 (consumption goal: hedonic, utilitarian) between-subject design.

Stimuli. In this study, I presented participants with information about a car rental. Given that the study manipulated the consumption goal, I selected a product category that has been known to possess hedonic and utilitarian value (Voss, Spangenberg, and Grohmann 2003). (See Appendix I for an example.)

Procedure. Similar to Wadhwa and Zhang (2015), participants first read a statement indicating the goal of the car rental. Half of the participants read that they were looking to rent a car to use during a vacation (hedonic consumption goal). The other half of the participants read that they were renting a car to take to school while their car is in the shop (utilitarian consumption goal). Participants then saw a picture of a car, priced at 35 dollars/day or Thirty-five dollars/day. Immediately after, they were asked to evaluate their attitude toward the car on a four-item, seven-point scale (Good, Favorable, Reliable, Effective; r = .92) and to indicate how
likely they would be to rent the car on a nine-point scale (1 = Not at all Likely/9 = Very Likely). As part of an attention check, participants were asked to recognize what the goal was for the car rental according to the survey. They selected one of four possible options (1 = vacation, 2 = go to school, 3 = go to a conference, 4 = for fun). Finally, they provided general demographic information.

Results

Sixty-one participants were eliminated from the data set as they failed the attention check. In the utilitarian goal condition, they read that the purpose of renting the car was to use it to go to school, yet they selected any of the other three options (i.e., vacation, go to a conference, or for fun). In the hedonic goal condition, participants read the purpose of renting the car was to use it to go on a vacation, yet they selected one of two options (i.e., go to school or go to a conference). Given that a vacation can be considered “fun,” I did not eliminate participants in the hedonic goal condition that selected “for fun” as their response.

It is important to exclude participants on the basis of failing the attention check as it indicates that they did not use the goal of the car rental to evaluate the rental car information. Therefore, the goal manipulation could not be successful for these participants. The distribution of attention check failures across goal conditions is the following: 1) 23 participants from the hedonic goal condition failed the attention check, and 2) 38 participants from the utilitarian goal condition failed the attention check. Equivalent amounts of participants failed the attention check across number notation conditions (30 participants from the symbol condition and 31 participants from the verbal condition).
Likelihood of renting the car. A regression analysis with consumption goal and number notation as the independent variables and the likelihood of renting the car as the dependent variable revealed a significant main effect of goal ($b = 1.34$, $t(1,121) = 2.22$, $p < .05$) and a significant number notation × goal interaction ($b = -1.84$, $t(1,121) = -2.17$, $p < .05$). Specifically, a hedonic goal attenuated the number notation effect ($M_{\text{symbol}} = 4.69$ vs. $M_{\text{verbal}} = 5.00$; $t(1,121) = .54, p = .59$). However, consistent with H3b, a utilitarian goal led participants to prefer renting the car when the price was presented in symbols rather than words ($M_{\text{symbol}} = 6.03$ vs. $M_{\text{verbal}} = 4.50$; $t(1,121) = -2.44, p < .05$).

Attitude toward the product. A regression analysis with consumption goal and number notation as the independent variables and attitude toward the car as the dependent variable only revealed a significant main effect of goal ($b = .77$, $t(1,121) = 2.03$, $p < .05$). Although the number notation × goal interaction was not significant ($b = .54$, $t(1,121) = -1.38$, $p = .16$), a more detailed analysis reveals the same pattern as participants’ likelihood to rent the car. Specifically, a hedonic goal attenuated the number notation effect ($M_{\text{symbol}} = 4.43$ vs. $M_{\text{verbal}} = 4.36$; $t(1,121) = .36, p = .84$). However, when using a utilitarian goal, participants had a better attitude toward the product when the price was presented in symbols rather than words ($M_{\text{symbol}} = 5.21$ vs. $M_{\text{verbal}} = 4.40$; $t(1,121) = -2.04, p < .05$). See Table 13 for detailed results.
### TABLE 13: CELL MEANS AND STANDARD DEVIATIONS

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Consumption Goal</th>
<th>Number Notation</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hedonic</td>
<td>Symbolic (n =36)</td>
<td>4.69</td>
<td>2.20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Verbal (n = 33)</td>
<td>5.00</td>
<td>2.76</td>
</tr>
<tr>
<td>Likelihood of Renting the Car</td>
<td>Utilitarian</td>
<td>Symbolic (n = 26)</td>
<td>6.03</td>
<td>1.90</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Verbal (n = 30)</td>
<td>4.50</td>
<td>2.31</td>
</tr>
<tr>
<td>Attitude Toward the Car</td>
<td>Hedonic</td>
<td>Symbolic (n =36)</td>
<td>4.43</td>
<td>1.38</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Verbal (n = 33)</td>
<td>4.36</td>
<td>1.50</td>
</tr>
<tr>
<td></td>
<td>Utilitarian</td>
<td>Symbolic (n = 26)</td>
<td>5.21</td>
<td>.97</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Verbal (n = 30)</td>
<td>4.40</td>
<td>1.38</td>
</tr>
</tbody>
</table>

**Discussion**

The results of this study provide further evidence that numerical symbols influence product evaluations through systematic processing. Because a utilitarian goal has a high fit with an elaboration mindset, this study finds that a utilitarian (vs. hedonic) consumption goal magnifies the difference between a symbol and verbal numbers. The results of Studies 3a and 3b suggest that the influence of symbolic numbers on evaluations is based on an increase in systematic processing. However, the previous studies have not directly measured systematic processing. Study 4 addresses this limitation.
The current study seeks to provide further distinction between the fluency and systematic processing explanations. In particular, this study uses a priming task to explore whether mere exposure to symbolic numbers activates deliberate processing. Results confirming a systematic processing account should reveal that participants exposed to symbolic (vs. verbal) numbers in an isolated task will engage in systematic processing to solve problems in a subsequent task. However, a fluency account would predict that the presence of symbolic (vs. verbal) numbers would not influence performance on a subsequent deliberation task. The two rival theories provide opposite predictions for this study:

H4a: Based on a fluency account, there will be no difference in systematic processing after exposure to symbolic numbers (vs. number words).

H4b: Based on a systematic processing account, consumers will adopt a systematic approach to reasoning when they encounter symbolic numbers (vs. number words).

The presentation of numbers in the form of a priming task also intends to separate the influence of number notation from unit notation regarding information processing. In particular, my previous studies have presented quantitative information in symbolic or verbal number notation followed by a verbal unit. This type of manipulation is externally valid as nearly all interpretation of quantitative information requires the use of units. However, it might be argued that the symbol-verbal influence documented is based on a disruption caused by a notation-unit
incongruence (i.e., symbolic number, verbal unit). Study 4 makes a preliminary attempt to confirm that symbolic number properties can influence information processing by presenting numbers that do not include any units.

Method

Study design. One hundred and twenty-six students (48% female, average age = 24.42) were assigned to one of three possible conditions in a 3 (number representation: symbolic, verbal, control) between-subject design.

Procedure. The first task was a search assignment. Participants in the symbolic or verbal conditions were instructed to find a total of nine numbers in a scrambled puzzle. The numbers were displayed in symbolic or verbal form depending upon the participant’s condition. To avoid confounds, the number magnitudes remained constant across conditions. (See Appendix J.) However, the disadvantage of keeping the numbers’ magnitudes constant is that the symbolic number search task could be perceived as being easier than the verbal number search task. In order to control for this effort difference, perceived task difficulty was assessed after completion of the task using a seven-point scale: “How easy or difficult was this task? 1 = Very difficult, 7 = Very easy. Participants in the control condition were given an initial task and completed only the second task.

In a second ostensibly unrelated task, participants completed the Cognitive Reflective Test (Read et al. 2005), which serves as a measure of cognitive deliberation. This test consists of three items for which the easy default answer (System 1) is incorrect. However, deliberation makes it possible to overcome intuition and correctly answer the questions (System 2). The CRT consists of the following questions: (1) A bat and a ball cost $1.10 in total. The bat costs $1.00 more than the ball. How much does the ball cost? ___ cents. (2) If it takes 5 machines 5 minutes to
make 5 widgets, how long would it take 100 machines to make 100 widgets? __ minutes. (3) In a lake there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake? __ days. Participants then provided general demographic information.

Results

A correct response to each CRT question was coded as “1” and an incorrect response was coded as “0”. An index was then created by adding all three coded responses. Therefore, higher numbers indicated higher systematic processing.

One participant did not complete the CRT task and one participant was eliminated from the sample because he completed the CRT task before the word puzzle. The results of a one-way ANOVA revealed a main effect of number representation ($F(1,121) = 7.31, p < .01$). Supporting H4b, a Bonferroni post-hoc test indicated that completing the symbolic number puzzle led to higher systematic processing than completing the verbal number puzzle ($M_{symbol} = .92$ vs. $M_{verbal} = .23; p < .01$). More importantly, completing the symbolic number puzzle increased systematic processing as compared to the control condition ($M_{symbol} = .92$ vs. $M_{control} = .46; p < .05$). In contrast, the verbal number puzzle did not change the propensity to engage in systematic processing when compared to the control condition ($M_{verbal} = .23$, vs. $M_{control} = .46; p = .68$).

The symbolic search task was considered easier to complete than the verbal search task ($M_{symbol} = 6.13$ vs. $M_{verbal} = 3.34, F(1,84) = 71.42, p < .001$). However, the effect of number representation on cognitive elaboration remained even after controlling for task ease ($M_{symbol} = .92$ vs. $M_{verbal} = .46; F (1,81) = 5.18, p < .05$). See Table 14.
TABLE 14: CELL MEANS AND STANDARD DEVIATIONS

<table>
<thead>
<tr>
<th>Condition</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symbolic</td>
<td>.92</td>
<td>1.11</td>
</tr>
<tr>
<td>(n = 42)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Verbal</td>
<td>.23</td>
<td>.61</td>
</tr>
<tr>
<td>(n = 43)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>.46</td>
<td>.75</td>
</tr>
<tr>
<td>(n = 39)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Discussion

The present study demonstrates that mere exposure to symbolic numbers, compared to the word numbers and compared to the control condition, motivates consumers to engage in deliberate processing. Hence, the findings of this study provide additional support for the argument that Arabic numbers influence evaluations by increasing systematic processing.

Furthermore, this study finds an increase in elaboration even when using a priming task in which number notations were presented in the absence of units. This is an important finding given that one limitation of my previous studies is that numerical information has always been accompanied by a verbal unit. While the verbal condition utilizes the same notation for both pieces of information (e.g., one hundred calories), the symbolic condition combines the two different types of notations: a symbolic number and a verbal unit (e.g., “100 calories”). Therefore, it is possible that the discrepancy between the number and unit in the symbolic condition could interrupt the natural flow of reading. That is, it could create a disfluent experience, which, in itself, has been known to trigger deliberate reasoning (Alter et al. 2007). If this were the case, then Arabic numbers could increase the likelihood of relying on systematic processing due to experienced disfluency and not due to the Arabic symbols’ properties as argued previously.
Although the results of Study 4 are not aligned with a disruption explanation, the next study will further explore this incongruence explanation. In particular, Study 5 will present the unit in the same format as the numerical quantity in the context of pricing where the unit can naturally be presented in a symbol ($) or a word (dollar). If the mismatch between the number and the unit increases elaboration, then the symbol-verbal effect on magnitude will be attenuated when the number and unit match.

**STUDY 5: NUMBER — UNIT CONGRUENCE**

*Method*

*Design.* The study used a 2 (number representation: symbolic, verbal) x 2 (unit: symbolic, verbal) between-subjects design. Two hundred and twenty online panelists (47.7% female, average age = 37.05) were randomly assigned to one of four condition.

*Procedure.* Participants were asked to imagine that they were going to purchase a watch. A salesperson shows them a product listed at the price of $120. The price of the watch was displayed in Arabic or verbal code. Furthermore, the dollar unit was also presented in symbolic ($) or verbal (dollars) format, for a total of four possible conditions: 1) One hundred and twenty dollars, 2) $ One hundred and twenty, 3) $120, or 4) 120 dollars. Participants were then asked to evaluate the price of the watch on an 11-point bipolar scale: (1 = Very Small, 11 = Very Large; (Thomas et al. 2010). No other product information, aside from the price, was presented at the time of the evaluation. Finally, general demographic information was collected.
Results

A 2(number notation) x 2(unit notation) ANOVA on price magnitude revealed a significant number x unit interaction ($F(1, 216) = 5.63, p < .05$). This interaction is explored in a series of post-hoc tests. See Table 15.

**Table 15. Cell Means and Standard Deviation**

<table>
<thead>
<tr>
<th>Unit Notation</th>
<th>Number Notation</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symbolic</td>
<td>Symbolic (n=56)</td>
<td>6.73</td>
<td>1.89</td>
</tr>
<tr>
<td></td>
<td>Verbal (n=54)</td>
<td>7.18</td>
<td>1.72</td>
</tr>
<tr>
<td>Verbal</td>
<td>Symbolic (n=54)</td>
<td>7.14</td>
<td>1.97</td>
</tr>
<tr>
<td></td>
<td>Verbal (n=56)</td>
<td>6.35</td>
<td>2.15</td>
</tr>
</tbody>
</table>

*Shaded area represents congruent number and unit notations.

Symbol-verbal effect. Consistent with the results reported in this dissertation, the symbolic number with a verbal unit (i.e., incongruent) was perceived as having higher magnitude than the verbal number with a verbal unit (i.e., congruent; $M_{\text{symbol-unit verbal}} = 7.14, M_{\text{verbal-unit verbal}} = 6.35$; $t(108) = 2.00, p < .05$). Interestingly, the results of a post-hoc test revealed that the difference between symbols and verbal numbers is weakened when the number notation matches the unit format ($M_{\text{symbol-unit symbol}} = 6.73, M_{\text{verbal-unit verbal}} = 6.35$; $t(110) = .98, p = .33$).

Although this finding suggests that the incongruence between the symbol and unit creates an interruption that affects magnitude perception, the incongruence in itself is not sufficient to reveal a symbol-verbal effect. This is evidenced by the fact that a verbal number with a symbolic
unit (i.e., incongruent) is not perceived as having a higher magnitude than a symbolic number with a symbolic unit (i.e., congruent; $M_{\text{number symbol-unit symbol}} = 6.73$, $M_{\text{number verbal-unit symbol}} = 7.18$; $t(108) = -1.31, p = .19$). The following analyses seek to gain a better understanding of when the number-unit congruence (vs. incongruence) changes magnitude perceptions for symbolic and verbal notations.

**Congruent (vs. incongruent) unit for symbolic numbers.** Post-hoc tests confirmed that magnitude perception for the symbolic number did not change regardless as to whether the units were presented in symbolic or verbal format ($M_{\text{congruent}} = 6.73$, $M_{\text{incongruent}} = 7.14$; $t(108) = 1.13, p = .26$). If disruption was a primary driver of the proposed effects, then the use of a verbal unit (i.e., incongruent) should have significantly increased magnitude perceptions when compared to the symbolic unit (i.e., congruent). In light of this result, however, disruption of the reading flow is not the only mechanism at play. Instead, it seems that the properties of symbols can increase elaboration and, as such, magnitude perceptions.

**Congruent (vs. incongruent) unit for verbal numbers.** For the verbal number, presenting the dollar sign as a symbol increased magnitude perception ($M_{\text{congruent}} = 6.35$, $M_{\text{incongruent}} = 7.18$; $t(108) = 2.22, p < .05$). While, in this case, incongruence seems to be increasing magnitude perception, this effect is also in line with the properties described for numerical symbols. In particular, it is possible that using the dollar symbol ($) enhanced saliency for the verbal number, also leading to higher cognitive elaboration and subsequently magnitude perception.

**Discussion**

This study provides insight regarding the source of changes in magnitude perception between symbols and verbal numbers. This dissertation argues that symbolic numbers possess visual and cognitive properties that lead to increased cognitive elaboration and magnitude perception.
perceptions. An additional explanation regarding why elaboration could take place is based on the incongruence between number and unit representations used in previous studies.

Study 5 manipulates the symbolic representation of prices and units to identify whether the source of changes in magnitude judgments is based on the properties of the symbolic numbers or on the unit-number incongruence. The results indicate that incongruent (vs. congruent) number-unit combinations lead to larger symbol-verbal number magnitude differences. However, the findings also indicate that the incongruence between number notation and unit is sufficient to change magnitude perceptions. For instance, a deep dive analysis on unit congruence for each type of number notation revealed that incongruent (vs. congruent) unit representations do not enhance magnitude perceptions for symbolic numbers. Therefore, it seems that the properties of the symbolic numbers are sufficient to increase elaboration and, consequently, magnitude perception. In contrast, adding a symbolic unit to a verbal number (i.e., incongruent) increases magnitude perceptions. This is aligned with the arguments presented regarding the salience of symbols. A dollar sign could draw attention to the number leading to increased elaboration and magnitude judgments.

Nevertheless, the results of this study present an important boundary condition for the proposed symbol-verbal number effect. Further research is required to fully understand how number-unit congruence influences magnitude perceptions and downstream product evaluations.

GENERAL DISCUSSION

The current research indicates that the mere notation of a number can shape magnitude judgments and product perceptions. Two rival explanations as to how number notation affects consumer judgments are proposed and tested. First, a systematic-processing account proposes that due to cognitive and perceptual differences between symbolic and verbal numbers,
consumers elaborate longer on quantitative information when it is presented as symbols (vs. words). Further, this account argues that due to the parallels between number and time magnitude, longer time elaboration leads to overestimation of quantity, which later influences product evaluation. Alternatively, this dissertation explores whether the increased frequency of the use of symbolic numbers and the ease with which they access magnitude information can lead to improved product evaluation through a fluency route.

Seven studies were designed to test the symbol-verbal effect in several ways. In particular, Study 1a provides evidence that presenting information in symbolic (vs. verbal) code increases magnitude judgments. This effect was present even in the absence of scaled responses. Therefore, it is unlikely that the symbol-number effect is due to perceptual mapping between the number format on the scale and the number format used on the stimuli. Study 1b demonstrates the downstream implications of altering number representation. A weight-loss product was better evaluated after using symbolic (vs. verbal) numbers to describe a positive benefit of the product.

Study 2 examines how number format influences magnitude perception and, more importantly, affects taste and improves attitudes toward the brand. This study also rules out the possibility that symbolic numbers serve to comply with conversational logic rules. Specifically, the study demonstrates that the symbol-verbal effect exists regardless as to the level of communicator trustworthiness.

Studies 3a and 3b use two theoretically relevant moderators, cognitive load and consumption goal, to disentangle two competing theoretical explanations (systematic processing vs. fluency) for the symbol-verbal effect. The results of both studies support a systematic processing account. As such, the difference in product evaluations after seeing an attribute
presented in symbols, instead of words, is accentuated when consumers have lower mental constraints or when they hold a utilitarian consumption goal.

Study 4 demonstrates that mere exposure to symbolic number notations in an unrelated task is sufficient to activate deliberate processing. Hence, it directly provides evidence for the argument that seeing symbolic numbers leads to systematic processing. Additionally, the numbers in this study do not use units, and therefore, provides initial evidence that the properties associated with symbolic numbers are sufficient to activate a deliberate mindsets.

Study 5 attempts to further disentangle whether the source of increased elaboration stems from a number-unit representation incongruence. The results of this study confirm that the symbol-verbal effect is attenuated when both the number and the unit use congruent notations. At the same time, the results indicate that number-unit incongruence is not sufficient to increase magnitude perception. More research is necessary to explore whether the cognitive and visual properties of symbolic numbers, as argued herein, are the primary driver of an increase in elaboration.

This research makes several contributions. First, while prior literature on numerical cognition in psychology has focused on whether or not different number representations are processed under a common neural system, the current dissertation examines how number notation affects processing components that occur after magnitude representation takes place, such as working memory and response selection (Cohen Kadosh and Walsh 2009). In addition, the current research also contributes to the growing literature on numerosity and consumer behavior. Unlike previous studies, the author finds a unique effect of number representation on consumer judgments in which magnitude and unit remain unchanged. Specifically, the results of the studies intend to demonstrate that consumers attribute different quantities to attributes
presented in symbolic as compared to number words even while the objective magnitude and unit are kept constant.

Moreover, this dissertation offers evidence to determine the underlying mechanism for the effect of number notation on magnitude judgment and product evaluation. By pitting two potential explanations against each other, the current research contributes to the literature in numerical cognition by clarifying how number representations are processed and affect downstream behavior. The findings of this dissertation support a systematic processing route. As such, I contribute to the generalized magnitude system literature by demonstrating how time-number magnitude interactions not only affect magnitude judgments, but also downstream consumer evaluations. It also contributes to the literature in numerical cognition by establishing how mere exposure to Arabic symbols (verbal) motivates consumers to engage in systematic processing.

Given the essential role numbers play in forming consumer judgments, the findings of this research have important managerial implications. For instance, imagine the manager of a new gym in town that would like to advertise the gym as an affordable option that offers many aerobics classes. Should he present the membership cost in numbers or words? What about the number of classes the gym offers? The ubiquitous use of numbers has led us to believe that we can use the two systems interchangeably. However, this research proposes and provides evidence that managers should use these different representations selectively depending upon the message they would like to emphasize or underscore. Furthermore, from a consumer policy perspective, the symbol-verbal number effect could also have important implications for consumer decisions that involve quantitative information processing, such as food consumption and spending.
Limitations and Future Research

This research also presents several limitations. First, the current dissertation uses moderators, such as cognitive load and consumption goal, to evidence how increases in the amount of elaboration positively influence number magnitude. Future research could make use of physiological measures, such as eye-tracking, to accurately determine the amount of time spent on Arabic (vs. verbal) numbers and the relationship of this time to magnitude estimates. Additionally, this research purposely uses noncomplex numbers (e.g., 4, 15, 100, 35) to explore the process through which number notation influences judgment to avoid additional confounds that can surface from the complexity of the number (e.g., length, time to read the number, etc.). Once the mechanism has been established, the findings of this research should be extended to more complex number scenarios (e.g., 1003, .75, 268).

Moreover, this dissertation has explored the influence of symbolic numbers on product evaluations using attributes for which higher amounts are positive for the evaluation of the product. Future research should evaluate if the results reverse when the attribute has a negative relationship to the product evaluation (e.g., calorie perceptions and nutritional value). Finally, this research is restricted to exploring differences between symbolic and verbal number codes because of their predominant use in marketing communication. This restriction, however, limits the theoretical understanding of how consumers use all three number notations (i.e., analogue, symbolic, and verbal notations) to make magnitude judgments. To address this limitation, future research can use contexts in which analogue code is a feasible option (e.g., dollars) to compare evaluations for all three codes. Given that analogue and symbolic codes have equal access to magnitude information and are also equally salient (Dehaene 1992), I expect a difference in evaluations only between the analogue and verbal codes.
There are also other promising areas for future research. Additional research is necessary to rule out alternative mechanisms as to how number notation influences product evaluations. Thus far, the results presented in this dissertation favor a systematic processing explanation as to how symbolic (vs. verbal) numbers affect evaluations. However, it is also possible that the influence of number notation on evaluations is driven by uncertainty related to judgments with verbal numbers. The lack of use of verbal numbers to represent quantity could make them more difficult to process than symbolic numbers. In the context of numerical judgments, processing difficulty has been known to evoke beliefs related to magnitude. For instance, previous research has found that precise (vs. round) numbers are more difficult to process. Therefore, consumers use the belief that precision is related to smaller magnitudes to make evaluations, leading to lower magnitude judgments when quantities are presented in precise instead of rounded numbers (Thomas et al. 2010). In line with this reasoning, verbal numbers (vs. symbols), which are harder to process, would likely evoke magnitude beliefs. What beliefs are related to verbal numbers? Convention dictates that verbal numbers should be used to represent small quantities (i.e., numbers below ten), while symbolic numbers should represent large quantities. Therefore, it is possible that when performing magnitude judgments of verbal numbers, which are more cognitively difficult to process, the verbal equals small association comes to mind and taints judgment.

The processing asymmetries of symbolic (vs. verbal) numbers described in this essay can also be studied in terms of individual differences in information processing style (Wyer, Jiang, and Hung 2008). This body of work suggests that consumers are naturally inclined to process information in a verbal or image-based format. As such verbalizers (i.e., verbally inclined) tend to prefer information presented in a verbal format, whereas visualizers prefer information
presented in images, a preference that subsequently affects evaluations. Given that symbolic information is processed as objects and number words are processed as verbal content, it is necessary to explore how information processing style moderates the symbol-verbal effect proposed herein. My contribution to this literature lies in extending the knowledge of processing verbal and image-based information into the realm of magnitude perceptions. Specifically, while previous work in this domain has studied how congruence between an individual’s processing style and marketing information improves evaluations (e.g., product evaluation), my dissertation focuses on how two numerical formats can influence the magnitude of an attribute (i.e., how big it is perceived). Nevertheless, it is necessary in the future to explore when and how the individual disposition toward verbal or visual information moderates the symbol-verbal effect.

Future research studies should also explore the role of number representation in different mathematical contexts. For example, multiplication has been known to rely heavily on a verbal code, while subtraction knowledge relies on a symbolic code. Therefore, it could be possible that promotions such as “Half off” would benefit from verbal representations, while “$10 less” would benefit from symbolic representation. Further, it would also be interesting to explore whether the difference between verbal and symbolic codes extends across modalities. For instance, how does processing numerical information through auditory vs. visual modalities affect consumer judgments? This could be particularly interesting for marketers that often have to use a combination of radio and television advertisement. Moreover, it is necessary to gain a deeper understanding as to how other individual characteristics (e.g., visualizer-verbalizer propensity) change the direction of number notation influences on product evaluations. Finally, future investigation could explore how number notation influences consumer decision-making. For example, are attributes presented in symbolic (vs. verbal) codes weighted more heavily in
choices? Are consumers more likely to engage in risky or impulsive behavior when percentages are presented in symbolic (vs. verbal) code? Are they more likely to exert self-control when caloric information is presented in symbolic (vs. verbal) format? These are certainly interesting questions for future research endeavors.
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### APPENDIX B: STIMULI CHAPTER TWO, STUDY 1B

<table>
<thead>
<tr>
<th>TODAY</th>
<th>1 month</th>
<th>TODAY</th>
<th>24 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receive $3,400 today</td>
<td>Receive $3,800 in one month</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tooth pulled today</td>
<td>Tooth pulled in 2 weeks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Receive a $25 rebate today</td>
<td>Receive a $30 mail-in rebate in six weeks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Receive a $50 gift-certificate today</td>
<td>Receive $75 gift-certificate in 3 months</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Receive a $50 gift-certificate today</td>
<td>Receive $X gift-certificate in 36 months</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX C: STIMULI CHAPTER TWO, STUDY 2

Receive a $25 rebate today

Receive a $40 mail-in rebate in six weeks

Receive a the $25 rebate today

Receive a $40 mail-in rebate in six weeks
Delay Condition

Horizontal

Receive a $50 gift-certificate today
Receive a $55 gift-certificate in 3 months

Vertical

Receive a $50 gift-certificate today
Receive a $55 gift-certificate in 3 months

Acceleration Condition

Receive a $75 gift-certificate in 3 months
Receive a $70 gift-certificate today

Receive a $75 gift-certificate in 3 months
Receive a $70 gift-certificate today
APPENDIX E: CHAPTER TWO, TIMELINE TASK STUDY 4

Instructions: In this first part of the research project, we would like you to imagine that you were building a short timeline for a school project. The professor would like you to build a timeline of the history of hats. There are six events that you must arrange in the timeline, which are provided below. The professor provides you with a picture of the timeline (depicted below) so that you can complete it. Please indicate how you would organize your timeline by matching the numbers on the timeline to the picture you think belongs in that position.

Horizontal Timeline

Vertical Timeline
Moov enables users to maximize their workout and lose up to 15 pounds in less than a month.
APPENDIX G: STIMULI CHAPTER THREE, STUDY 2

![COSTA Cheese Snack Crackers](image1)

![COSTA Four Cheese Snack Crackers](image2)
APPENDIX H: STIMULI CHAPTER THREE, STUDY 3A

![Weetabix Box](image1)

![Weetabix Box](image2)
APPENDIX I: STIMULI CHAPTER THREE, STUDY 3B

Compact

Transmission Automatic
Air Conditioning
Radio, DVD player

25 dollars a day

Compact

Transmission Automatic
Air Conditioning
Radio, DVD player

Twenty-five dollars a day
APPENDIX J: CHAPTER THREE, STUDY 4

Find the Numbers

Y A L T U E Y E D G G R W Y P
Q T K E I S N B I F Y E S T W
Y I R G X S M A H I N R S X G
N G H I Q C L H F F F Q B I B
R T R G H Z U W T T C I L S K
Y M M B J T I X W E H K D Y U
F B J C Q X W B O E V M V E R
M N O O B I U G F N K F E A L
P T M V Q G C V H Q H I S V R
P Z C S G X V O W U K J F Y Y
M K I E M Y M I B C Q Q J T U
T O R C K Z Y T E N I N R C V
G K N I A L P M S G B O U U E
F I V E E B L W D J F B U L E
T Q I N Z L R O V I C J Q M D

Find the numbers below:

Eighty
Forty
Sixty
Fifteen
Nineteen
Thirty
Five
One
Two

80
180
20
58
60
2000
97
35
13

128
# APPENDIX K: SUMMARY TABLE OF STUDY OBJECTIVES

<table>
<thead>
<tr>
<th>Essay 1</th>
<th>Study Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study 1A</td>
<td>Demonstrate the influence of the spatial organization of time on temporal judgments (H1).</td>
</tr>
<tr>
<td>Study 1B</td>
<td>Demonstrate the influence of the spatial organization of time on temporal judgments using a common psychophysiological task that does not require scaled responses (H1).</td>
</tr>
<tr>
<td>Study 2</td>
<td>Demonstrate that when consumers are presented with a decision to delay consumption, they act more impatiently if the display is arranged congruently with the way they think about time (H2).</td>
</tr>
<tr>
<td>Study 3</td>
<td>This study provides direct evidence that subjective time perception mediates intertemporal choice. It also includes the acceleration condition to demonstrate that merely displaying temporal progressions horizontally versus vertically is insufficient to change temporal estimations. Finally, it uses a choice titration task to identify participants’ personal discount rates and provide further evidence that future outcomes are discounted more steeply when presented congruently with the past-left, future-right organization of time.</td>
</tr>
<tr>
<td>Study 4</td>
<td>Manipulate time-space congruence to demonstrate how choice displays that are congruent with the spatial organization of time can bias intertemporal discounting toward the present.</td>
</tr>
<tr>
<td>Study 5</td>
<td>The following study explores how space-time congruence can influence product evaluations in the context of a weight loss product.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Essay 2</th>
<th>Study Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study 1A</td>
<td>Determine whether number notation influences numerical magnitude judgments (H1).</td>
</tr>
<tr>
<td>Study 1B</td>
<td>Demonstrates the differences that emerge from presenting quantitative information in symbolic or verbal number codes in the context of a product claim (H2).</td>
</tr>
<tr>
<td>Study 2</td>
<td>Replicates the symbol-verbal code effect in a real product evaluation context. This study also explores how changes in the numerical representation of attributes can influence downstream product evaluations, such as taste and brand attitude. Moreover, this study seeks to rule out a potential alternative explanation based on the differential use of each notation in everyday communication.</td>
</tr>
<tr>
<td>Study 3A</td>
<td>This study intends to explore the underlying mechanism of the symbol-verbal effect by manipulating the cognitive capacity available to consumers as they are evaluating a product.</td>
</tr>
<tr>
<td>Study 3B</td>
<td>Provide additional evidence to determine whether symbolic numbers influence magnitude judgments through a feeling-based (vs. cognition) route (H3a and H3b).</td>
</tr>
<tr>
<td>Study 4</td>
<td>This study uses a priming task to explore whether mere exposure to symbolic numbers activates deliberate processing (H4a and H4b).</td>
</tr>
<tr>
<td>Study 5</td>
<td>This study identifies the source of systematic processing by manipulating the notation congruence between number and unit.</td>
</tr>
</tbody>
</table>
APPENDIX L: IRB APPROVAL LETTER ESSAY I

1/12/2016

Marisabel Romero, M.B.A.
USF College of Business
4202 East Fowler Avenue, BSN 3403
Tampa, FL 33620

RE: Expedited Approval for Continuing Review
IRB#: CR3_Pro00011164
Title: How visual cues affect asymmetric discounting

Study Approval Period: 1/17/2016 to 1/17/2017

Dear Ms. Romero:

On 1/9/2016, the Institutional Review Board (IRB) reviewed and APPROVED the above application and all documents contained within including those outlined below.

Approved Item(s):
Protocol Document(s):
IRB-study-protocol_intertemporal_choice_Dec_18th.docx

The waiver of informed consent documentation has been renewed.

The IRB determined that your study qualified for expedited review based on federal expedited category number(s):

(7) Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

As the principal investigator of this study, it is your responsibility to conduct this study in accordance with USF HRPP policies and procedures and as approved by the USF IRB. Any changes to the approved research must be submitted to the IRB for review and approval by an amendment. Additionally, all unanticipated problems must be reported to the USF IRB within five (5) calendar days.
We appreciate your dedication to the ethical conduct of human subject research at the University of South Florida and your continued commitment to human research protections. If you have any questions regarding this matter, please call 813-974-5638.

Sincerely,

\[\text{Signature}\]

John Schinka, Ph.D., Chairperson
USF Institutional Review Board
February 18, 2016

Marisabel Romero, M.B.A.
Marketing
4202 East Fowler Avenue, BSN 3403
Tampa, FL 33620

RE: Exempt Certification
IRB#: Pro00025423
Title: Visual Cues and Consumer Behavior

Dear Ms. Romero:

On 2/18/2016, the Institutional Review Board (IRB) determined that your research meets criteria for exemption from the federal regulations as outlined by 45CFR46.101(b):

(2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless:
(i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects’ responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects’ financial standing, employability, or reputation.

Approved Items:

Visual Cues Protocol 10.02.2016.docx

Studies 1, 2, 3, 4, 5 Online Consent Form.docx

Study 5 Lab Consent Form.docx

As the principal investigator for this study, it is your responsibility to ensure that this research is conducted as outlined in your application and consistent with the ethical principles outlined in the Belmont Report and with USF HRPP policies and procedures.

Please note, as per USF HRPP Policy, once the Exempt determination is made, the application is closed in ARC. Any proposed or anticipated changes to the study design that was previously
declared exempt from IRB review must be submitted to the IRB as a new study prior to initiation of the change. However, administrative changes, including changes in research personnel, do not warrant an amendment or new application.

Given the determination of exemption, this application is being closed in ARC. This does not limit your ability to conduct your research project.

We appreciate your dedication to the ethical conduct of human subject research at the University of South Florida and your continued commitment to human research protections. If you have any questions regarding this matter, please call 813-974-5638.

Sincerely,

John Schinka, Ph.D., Chairperson
USF Institutional Review Board