Do Good Things Come to Those Who Wait?: Investigating Temporal Discounting Rates Among Older Adults

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DO GOOD THINGS COME TO THOSE WHO WAIT?: INVESTIGATING TEMPORAL DISCOUNTING RATES AMONG OLDER ADULTS

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A DISSERTATION
Submitted in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy (in Clinical Psychology)

The Graduate School
The University of Maine

May 2023

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Dissertation Advisor: Dr. Rebecca K. MacAulay

An Abstract of the Dissertation Presented
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Decision-making is widely viewed as a higher order cognitive construct, drawing on fluid intelligence as well as intact functioning across a wide variety of cognitive domains including executive function, working memory, declarative memory, and attention. The conditions of the decision-making outcome (e.g., immediate or delayed), the framing of the outcome (e.g., loss vs. gain) and the type of outcome (e.g., money, food, social or health consequences), are consistently highlighted throughout the literature as being important influences on decision-making behavior. However, decision-making behavior among and within these contexts remains inconsistent and inconclusive in older adult populations. Considering that recent evidence suggests the emergence of decision-making decrements may serve as an effective tool for predicting future cognitive decline, or as an indication of existing impairments within subserving cognitive domains, it remains an important endeavor to understand how, and why decision-making abilities may change in older adults. This picture may be elucidated by further understanding of the underlying affective and cognitive factors that have been implicated in shaping decision-making ability.
across the lifespan. This study therefore aimed to understand whether community-dwelling older adults behave differently within an intertemporal paradigm when outcomes are framed as gains or losses and whether environmental factors such as degree of loneliness influenced decision-making. Additionally, the study introduced a novel reward system to examine whether decision making behavior in older adults differs for monetary outcomes as compared to non-monetary outcomes. Given the unclear nature of how contextual factors are associated with decision making, the current study also attempted to understand how state affect and executive control impact temporal discounting rates when choices are framed as gains or losses. Finally, the current study explored whether temporal discounting rates were associated with consequential real-life decision-making behavior.
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CHAPTER 1

INTRODUCTION

Decision-making is broadly defined as a process for choosing a preferred option among several other alternatives based upon beliefs, subjective evaluations, preferences, and values (Hastie & Dawes, 2009). This ability draws on fluid intelligence as well as intact functioning across a wide variety of cognitive domains including executive function, working memory, declarative memory, and attention (Hastie & Dawes, 2009; Hess et al., 2015; Lempert et al., 2018; Lempert et al., 2020a). In this regard, decision-making is widely viewed as a higher order cognitive construct, and recent evidence suggests the emergence of decision-making decrements may serve as an effective tool for predicting future cognitive decline, or as an indication of existing impairments within subserving cognitive domains (Gerstenecker et al., 2016; Triebel et al., 2009). For example, prior research from large cohort studies shows that measurable products of altered decision-making, such as deficits in managing finances and medications, are strongly predictive of developing dementia (Pérès et al., 2008; Sudo & Laks, 2017; Tolbert et al., 2019). Similarly, poor decision-making decisions in older adults, as evidenced by low scores on a simple and complex decision-making questionnaire, were associated with increased risk of mortality (Boyle et al., 2013). As such, decision-making ability has increasingly become an important area of interest in older adult populations, where vigilance is heightened regarding cognitive changes and decline. The benefits of understanding how and why decision-making abilities change in older adults include the potential to identify cognitive deficits at earlier stages, and therefore allow for intervention during periods in which neurodegenerative disease processes are more amenable to treatment. It may also help prevent age-associated decision-making pitfalls such as susceptibility to financial exploitation.
The associations between decision making and aging however, remain inconsistent and unclear. This picture may be elucidated by further understanding of the underlying affective and cognitive factors that have been implicated in shaping decision-making ability across the lifespan (Hess et al., 2015). For example, age-related shifts in priorities, values, and goals may alter available affective resources, whereas neuroanatomical changes associated with aging may impact available cognitive resources; both of which contribute to decision-making choices and perceptions of outcomes (Hess et al., 2015). Given the significance of decisions that are made by older adults (e.g., retirement, financial investments, healthcare options, advanced directives, etc.), it remains an important endeavor to identify mechanisms that may further our understanding of how older adults determine risk/benefit ratios for consequential lifestyle decisions, and therefore serve as potential targets for intervention.

Prospect Theory (Kahneman & Tversky, 1979; Tversky & Kahneman, 1981; Tversky & Kahneman, 1989) remains one of the most widely accepted theories of decision-making and serves as the basis for several concepts that will be presented and reviewed in forthcoming chapters. Briefly, Prospect Theory states that individuals perceive gains and losses differently and in turn behave differently in these scenarios. There are three central concepts of Prospect Theory that help explain these preferential differences: *loss aversion, certainty effect* and *isolation effect*. Loss aversion describes the greater emotional impact an individual feels from a perceived or actual loss as opposed to a perceived or actual gain (Kahneman & Tversky, 1979). In other words, the psychological pain of losing is greater than the experience of satisfaction for an equivalent gain. Certainty effect represents the tendency for individuals to undervalue probable outcomes when compared to certain outcomes (Kahneman & Tversky, 1979). Finally, isolation effect is the tendency to ignore pieces of information that are common among all
choices, leading to inconsistent decision-making choices for the same outcome presented in
different ways (Kahneman & Tversky, 1979). Collectively, these biases impact behavior in
decision-making, such that individuals tend to be risk averse in gain situations and risk seeking
in loss situations. An important consideration of this theory is that final outcome amounts are not
typically the driving factor in decision-making, but whether the outcome is framed as a gain or a
loss relative to some reference point that is reliant on the expectations and current situation of the
decision maker (Kahneman & Tversky, 1979). In other words, the decision-maker is more
sensitive to changes in value than final states of value. A decision maker’s reference point helps
to explain why contextual factors such as affective and environmental influences have the
potential to significantly impact individual choices.

A common type of decision-making behavior is known as delay discounting, or temporal
discounting. Temporal discounting is defined as the tendency to devalue a future outcome when
compared to a more immediate outcome, even when the immediate outcome is smaller in value
than the delayed outcome (Mazur, 1987). In this way, the subjective value of an outcome
decreases as a function of the time in which the outcome can be obtained (McKerchar & Renda,
2012). This is a common tactic consistently demonstrated across groups of people; however, the
rate at which an individual discounts future gains, or losses, can vary greatly from one individual
to the next (Peters & Büchel, 2011). With gain outcomes, such as monetary rewards or
emotionally desirable prizes, temporal discounting may be viewed as an estimate of impulsivity
and may explain why the overwhelming decisions in lotto winnings is to accept lump sum
payments as opposed to annuity payments. When the outcome represents a loss of some kind,
such as making an immediate payment or a later payment that accrues interest, discounting the
future results in a worse, and more costly, outcome. To this end, overreliance on delay
discounting may help explain the staggering amount of credit card debt amassed by individuals in the United States (see Estle et al., 2006). In line with impulsivity associations, steeper temporal discounting has also been consistently linked to poor health outcomes such as obesity, smoking, gambling, and addiction (Bickel & Marsch, 2001; Green & Myerson, 2004; Kirby et al., 1999; Madden et al., 1997; Odum, 2011). It is thought that the reliance on this decision-making preference and the frequency with which it is used, may be influenced by available affective and cognitive resources.

Considerable heterogeneity in decision making ability exists among older adults, with some research suggesting older adults both outperform and underperform in their ability to maximize outcomes on decision-making tasks relative to younger adults. One key variable behind this inconsistency may be proposed age-related changes in affect. There is research to suggest that affective processes, such as positive affect and emotion regulation capabilities, increase and improve as we age (Carstensen et al., 1999; Carstensen, Fung, & Charles, 2003; Carstensen & Mikels, 2005; Kennedy & Mather, 2007; Mather, 2006). Socioemotional Selectivity Theory (SST) posits this is because older adults become aware of their increasingly limited time and mortality, and subsequently shift their priorities and motivations to be more in line with emotionally meaningful goals rather than future oriented goals (Carstensen et al., 1999). This concept has led to investigations that conclude older adults enjoy a “positivity effect”, in which they attend more frequently and thoroughly to “emotionally satisfying” and positive information that aligns with their newly shaped goals and priorities (Carstensen & Mikels, 2005). This tendency may also explain why older adults engage in less rumination about past decisions and are less susceptible to the sunk cost fallacy when compared to younger adults (for review, see Strough & Bruine de Bruin, 2020). However, this may come at the expense of
attending to negative but relevant information (see Löckenhoff, 2018). Further, older adults may rely more on emotional stimuli during comprehension of information (Hess et al., 2015). Collectively, these attitudes and behaviors may promote preference for immediate, concrete, “feel good” choices, as well as heightened focus on the present moment, thereby impacting the decision-making process (Cartensen et al., 2003; Kennedy & Mather, 2007).

Adding to the complexity of the relationship between affect and older age, not all research suggests that shifts in goals in the context of time constraints, occur as a function of re-assessment of priorities and values (Fung & Carstensen, 2004). Instead, older adults may have more emotionally oriented goals due to wanting more emotional meaningful connections to help them cope with difficult times (Fung & Carstensen, 2004). The shift in goals may also come at the realization that future oriented goals are no longer attainable or practical (Fung & Carstensen, 2004). It is also questionable if the positivity bias and elevations in positive affect are as universal and robust as much of the literature suggests (Fung et al., 2008; Rolison, 2019). Moreover, previous research that has investigated the positivity bias has the significant limitation of being cross-sectional in design. Therefore, it is difficult to ascertain if positive affect has in fact changed or increased with time.

As previously mentioned, decision-making is a higher order skill thought to be reliant on intact functioning within and across several cognitive domains. A substantial body of research highlights age-related decrements in cognitive abilities that are effortful and resource intensive such as cognitive flexibility, inhibition, sustained and divided attention, working memory, and processing speed (Grady, 2012; Harada, Love, & Triebel, 2013; Murman, 2015; Salthouse, 2010). Collectively, these deficits may impair decision-making strategy selection by contributing to overreliance on less cognitively demanding strategies (Hess et al., 2015). Further, age-related
decrements in declarative memory have been linked to steeper temporal discounting rates (Lempert, et al., 2018), which may be accounted for by individual variations in autobiographical memory richness (Lempert et al., 2020a). In contrast, other studies indicate no age differences in monetary decision-making paradigms of intemporal choice (Samanez-Larkin et al., 2011; Seaman et al., 2016) even when considering the magnitude of the outcome, delay period of the outcome, and whether the outcome was presented as a gain or a loss (Löckenhoff & Samanez-Larkin, 2020).

A growing body of research suggests that normal age-related declines in cognitive function are not necessarily synonymous with poor decision-making abilities (Mata et al., 2012). Careful consideration for the environment and other contextual factors may represent the difference between interpreting good vs. poor decision-making (Mata et al., 2012). For example, socioeconomic status, particularly income level, can greatly impact decision-making behavior within monetary paradigms. While steeper temporal discounting is often conceptualized as impulsive, this strategy may be advantageous for an individual living in poverty whose environment, rather than intrinsic preferences, may dictate choices (Bertrand et al., 2006; Haushofer & Fehr, 2014; Spears, 2011). Environmental changes common with the aging process may also impact decision-making skills in older adults, particularly loneliness and isolation. Additionally, some aspects of cognitive functioning remain relatively resilient to age-related neuroanatomical changes, rendering some decision-making abilities unchanged, or even enhanced when compared to younger adults (for review, see Bruine de Bruin et al., 2012; Hess et al., 2015; Samanez-Larkin & Knutson, 2015). Taken together, age-related changes likely influence how older adults interpret, remember, and act on information, thereby impacting decision making; however, these relationships have not been fully explored.
Given that many poor health behaviors such as addiction, obesity, smoking, and diabetes are modifiable and largely a product of repetitive decision-making, it is important to determine which decision-making preferences or patterns are associated with poorer health behavior choices (Loewenstein et al., 2007). It is possible that affective and cognitive changes may collectively promote greater impulsive choices by way of waning impulse-control, over-evaluating present satisfaction compared to future well-being, and overestimating risk in certain situations, while simultaneously underestimating it in others. These decision errors may translate to poor lifestyle choices, thereby increasing older adults’ risk for adverse health outcomes such as cardiovascular disease and dementia. Experts in the field of decision-making suggest a move toward linking decision-making competence derived in laboratory-based experiences with real-life health outcomes (Strough & Bruine de Bruin, 2020).

This dissertation aimed to improve our understanding of decision-making tendencies in older adults when outcomes are framed as either gains or losses and when the content of the decision is monetary or interpersonal in nature. This study further aimed to address gaps in the literature as they relate to cognitive and affective influences on decision-making, and how decisions may translate to everyday health behaviors. Toward these aims, the present study investigated differences in temporal discounting rates across four conditions (e.g., monetary gains, monetary losses, social gains, and social losses) and examined how loneliness, isolation, state positive affect, and executive control impact temporal discounting rates. This study further examined how temporal discounting rates are associated to everyday decision-making in the form of health behaviors. Findings from this study can help us gain finer grain knowledge on the relationship between decision-making preferences aging processes, namely affective and cognitive changes, as well as whether decision-making behavior changes under different
contextual situations. Providing a more nuanced understanding of decision-making behavior in older adults may shed light on why previous findings have been mixed and inconclusive. Doing so unlocks potential to elucidate and target underlying mechanisms for behavioral change with the goal of moving toward optimal decision making and reducing risk for adverse health outcomes.
CHAPTER 2
LITERATURE REVIEW

Decision-Making Overview and Prominent Theories
What defines a decision? Many decisions are theorized to contain three parts: 1) there is more than one course of action, 2) there is uncertainty about how events may impact relevant outcomes, and 3) the consequences associated with potential outcomes are evaluated based on the decision maker’s beliefs, values, and expectations (Hastie & Dawes, 2009; Oliveira, 2007). Decision making is essentially the integration of beliefs about objective events and our subjective perceptions regarding these events. Our decision-making ability is not an innately “wired-in” trait; rather it is a learned skill that can improve, or worsen, with experience and time (Hastie & Dawes, 2009). What is less clear however, are the characteristics that define a good decision. While this interpretation is largely subjective and individualistic, there are important universal parameters that should be considered together in the conceptualization of what constitutes good decision-making ability. Namely, whether the outcome is considered a gain or a loss, the magnitude of the outcome, the duration of time to pass until the outcome is obtained, and the likelihood of the outcome occurring. Seeing as how many real-life decisions involve outcomes that differ on several of these parameters, the overarching question becomes how and why individuals make trade-offs among these various dimensions (Green & Myerson, 2004).

The roots of understanding decision-making behavior and preferences lie in the field of economics and are a central part of early economic theories which aimed to describe rational behavior (von Neumann & Morgenstern, 1947, Simon 1956). The most prominent normative theory of rational choice during this time was Expected Utility Theory, (von Neumann & Morgenstern, 1947). Rationality, defined as the “compatibility between choice and value”
(Hastie & Dawes, 2010, p. 237), is a central part of Expected Utility Theory, which explains
decision making behavior through axioms and utilities (von Neumann & Morgenstern, 1947). If
decision makers follow certain rational “rules” or axioms, they are able to arrive at real numbers,
or utilities, that serve as proxies for their values. These utilities subsequently aid them in making
rational choices (von Neumann & Morgenstern, 1947; Hastie & Dawes, 2010). However, this
theory has been heavily criticized for its constraints on choice behavior, and its inadequacy in
explaining real-life behavior that consistently violates these proposed axioms (Clemen, 1996;
Hammond et al., 1999; Kahneman & Tversky, 1979). The Theory of Bounded Rationality
represented the move toward non-expected utility theories, by describing choice behavior that
did not explicitly adhere to rational theory, but rather approximated it (Simon, 1956). Simon was
also one of the first researchers to recognize that bounds of rationality were important in
determining choice behavior, and that discrepancies existed between the decision-maker’s
subjective world and the actual world (Simon, 1956). The trajectory of these early theories paved
the way for and provided the foundation of descriptive decision theories, which sought to
account for the anomalies of the original theories.

Prospect Theory is perhaps the most influential descriptive theory for describing choices
in the context of gains and losses, and how choices are made under conditions of uncertainty
(Kahneman & Tversky, 1979). As previously described, this theory made sweeping advances in
how psychologists understand decision-making by realizing that individuals tend to view
outcomes as either gains or losses, as opposed to final states of wealth (Kahneman & Tversky,
1979). We now understand that decision-making is influenced by one’s perception of a reference
point, which in most cases is the “status quo”, and outcomes are evaluated relative to this point
(Tversky & Kahneman, 1981). This reference point differs from one individual to the next based
on contextual factors such as financial status, values, and culture, and can even differ within an individual, as reference points are not fixed and can change drastically over time (Tversky & Kahneman, 1992). While the reference point can represent an individual’s status quo, or baseline, it can also represent one’s *aspirational level* (Hastie & Dawes, 2010). The aspirational level can be conceptualized as expecting a paycheck bonus of $5,000: any less than this amount you will perceive as a loss, and any more than what you expected, you will perceive as a gain (Hastie & Dawes, 2010). Similarly, Pope and Schweitzer (2011) recognized that a score of “par” in golf, served as a real-life reference point, as “par” is considered the established baseline number of strokes expected for each hole in golf. Their analysis of millions of golf strokes revealed that professional golfers were far more likely to try harder to avoid a bogey (one stroke over par), than they were to try and achieve a birdie (one stroke under par; Pope & Schweitzer, 2011). In essence, the golfers were trying harder to avoid a deviation below their reference point, than they were to rise above the reference point. These results provide an elegant example of both a reference point and the concept of loss aversion.

The importance of reference points in decision-making are also highlighted under conditions of poverty. In the context of prospect theory, individuals who live in poverty essentially live “below their reference points.” To this end, current socioeconomic status likely has a strong influence on decision-making preferences (for review, see Haushofer & Fehér, 2014). For example, research suggests that individuals living in poverty-stricken countries or poor U.S. households display substantially steeper temporal discounting rates as compared to wealthier households (for review, see Haushofer & Fehér, 2014). However, to conclude that low-income individuals are more impulsive or have differing intrinsic time preferences when compared to wealthier individuals, is likely too simplistic of a view. Rather, poorer individuals
are likely to be more “liquidity-constrained”, meaning factors in their life dictate a need for monetary outcomes to arrive sooner rather than later (Haushofer & Feher, 2014).

Another central pillar of Prospect Theory is the concept of diminishing sensitivities. Diminishing sensitivities represent the way in which one evaluates his or her changes in wealth, such that changes in value that are closer to one’s reference point are felt more strongly, than those changes in value that are further away from the reference point (Tversky & Kahneman, 1981). Said differently, the subjective difference between $900 and $1,000 is much smaller than the difference between $100 and $200 (Tversky & Kahneman, 1981). These concepts are best represented by the S-shaped value function (Figure 1), in which gains are represented above a reference point, and losses are represented below the reference point (Kahneman & Tversky, 1979). The concave shape of the gains indicate that additional gains are felt more strongly than initial gains, while the opposite is true for the convex shape of losses in which initial losses are felt more significantly than subsequent losses (Kahneman & Tversky, 1979). Notably, the slope of the line for losses is steeper than the slope of the line for gains, which provides a striking visual representation of loss aversion (Kahneman & Tversky, 1979).

Figure 1: Kahneman and Tversky’s Prospect Theory (1979)
Biases Implicated in Decision-Making

A strength of Prospect Theory to explain and predict decision-making behavior is the consideration of the influence of cognitive bias in the decision-making process. One of the most widespread themes in decision-making research has been that humans are effectively unable to process every piece of information available to us in order to make a decision; we simply do not have the resources to do so (Peters et al., 2000). Hence, individuals rely on cognitive biases and heuristics to simplify otherwise unwieldy information quickly and efficiently (Peters et al., 2000). Briefly, cognitive biases are conceptualized as systematic distortions of human thought from some aspect of objective reality (Haselton et al., 2015). These biases greatly impact decision-making and represent the difference between normative (ideal) outcomes, and realistic outcomes. We would like to conceptualize ourselves as rational decision-makers, who appropriately weigh all the options, and select the most logical and practical choice; however, this process rarely occurs during real-life decisions. We tend to either not encode all the information to begin with or distort the information once it is processed.

Framing Effect

The wording of a decision-making problem has important consequences. The framing effect states that choice preferences are a product of variations in the wording of a problem that do not actually alter the consequences of the decision (Tversky & Kahneman, 1981). A prominent study completed by researchers at University College London investigated the neurobiological underpinnings of the framing effect and showed significant differences in choice preferences in participants based on the wording of the problem (De Martino et al., 2006). Specifically, participants were told they received a hypothetical sum of $50 and were then asked to choose between a “sure” option (e.g., keep $20, or lose $30) or a “gamble” option that was identical in both the keep and lose frames (De Martino et al., 2006). As Prospect Theory would
predict, when participants were presented with the *keep (gain)* frame, they chose the sure option; however, when they were presented with the *lose* frame, they chose the gamble option (De Martino *et al*., 2006). Considering the monetary outcomes of either choice were identical, rational theory would predict there to be no differences in behavior among the two options. On the contrary, participants overwhelmingly behaved in a risk averse manner when presented with the gain frame, and a risk seeking manner when presented with the loss frame (De Martino *et al*., 2006). Further, participants greatly differed regarding their susceptibility to the framing effect. Participants who demonstrated a decreased susceptibility to the effect, also exhibited enhanced activity in the right orbitofrontal cortex and ventromedial prefrontal cortex, while those participants who showed an increased susceptibility to the effect also demonstrated increased amygdala activity (De Martino *et al*., 2006). These results suggest important neuroanatomical differences in the degree to which individuals make decisions which will be discussed in greater depth later.

Another important study corroborated these findings with non-monetary outcomes in a group of university medical doctors (McNeil *et al*., 1982). Doctors were presented with statements regarding the efficacy of a cancer treatment. Half of the doctors were presented with the statement: “The one-month survival rate is 90%”, while the other half of the participants were shown the statement: “There is a 10% chance of mortality in the first month” (McNeil *et al*., 1982). As would be expected, doctors showed an overwhelming preference for the treatment when presented with the first option (84%), and less of a preference when shown the second option (McNeil *et al*., 1982).
Affect Heuristic

As shown with the framing effect, emotional arousal plays a prominent role in the outcome of a decision, and differential outcomes are influenced by neuroanatomical underpinnings. Another source of variation may be the affect heuristic. Briefly, this heuristic is thought to influence an individual’s risk/benefit assessment of a decision based on the positive or negative emotions the participant feels toward the decision content (Finucane et al., 2000; Slovic et al., 2007). If individuals have positive feelings toward the content, they are more likely to judge the benefits as greater and the risks as less; whereas the opposite risk/benefit analysis is made if the individuals have negative feelings toward the event (Finucane et al., 2000; Slovic et al., 2007). This concept has been largely supported by seminal work showing that affect toward choice content is a significant influencer of decision making. More specifically, these decisions are largely resistant to probabilities of the outcome, indicating that for emotionally or affect laden content, the mere suggestion or possibility of an outcome is enough to sway one’s decision (Loewenstein et al., 2001; Rottenstreich & Hsee, 2001; Zajonc, 1968).

Negativity Bias

As it turns out, not all emotions are created equal when considering their associations with decision making. There is research to suggest that humans are hard-wired to observe and interpret negative stimuli more quickly than positive stimuli (Rozin & Royzman, 2001; Vaish et al., 2008). From an evolutionary perspective, this function serves us well as it allows us to detect threats and promptly take action if needed (Rozin & Royzman, 2001; Vaish et al., 2008). This same pattern is observed even when considering hypothetical or symbolic threats (Rozin & Royzman, 2001; Vaish et al., 2008). As a result of this bias, we are more likely to be affected by negative stimuli or outcomes than we are positive stimuli or outcomes, a concept analogous to
loss aversion (Baumeister et al., 2001). As Rozin and Royzman quote in their seminal paper: “a spoonful of tar can spoil a barrel of honey, but a spoonful of honey does nothing for a barrel of tar” (Rozin & Royzman, 2001, p. 296). Particularly, some research suggests that negative emotions or negative affect impart a greater effect on choices than do positive emotions or affect (for reviews, see Baumeister et al., 2001; Carstensen & DeLimea, 2018; Rozin & Royzman, 2001). In addition, while this phenomenon is not always observed, some research suggests a reversal of these tendencies and biases within the decision-making choices of older adults (Carstensen & DeLiema, 2018; Sparks & Ledgerwood, 2019; Strough & Bruine de Bruin, 2020).

Taken together, it is apparent that cognitive heuristics and biases have an important influence on choice preferences. Further, emotional responses and affect appear to also impact the degree to which individuals rely on or are affected by the aforementioned biases. It may be that emotional responses “weaken” cognitive factors associated with decision making (Rottenstreich & Hsee, 2001).

**Temporal Discounting**

The aforementioned sections have described tenets of a prominent decision-making theory, and also illustrated selected reasons why individuals make certain decisions. The following sections will discuss how individuals behave in decision-making paradigms, as well as review individual specific characteristics that further influence these behaviors (e.g., age, affect, cognition, contextual factors). The phenomenon known as discounting describes the process by which an outcome is “discounted” or devalued relative to the odds of or time passed until receiving the specified outcome (Green & Myerson, 2004).

As previously discussed, temporal discounting refers to the tendency to prefer a more immediate reward as compared to a delayed reward (Rachlin et al., 1991). This preference exists
more robustly when the difference in magnitude between the immediate and delayed reward is small, or when the difference in duration of time between both options is vast (McKerchar & Renda, 2012). Said another way, it is a tendency to discount outcomes more strongly the further into the future they exist. The indifference point is defined as the point in which the subjective magnitude of the immediate and delayed reward is equal, and the participant is indifferent to either outcome (Odum, 2011). The rate of discounting is assessed by plotting various indifference points for different reward magnitudes and deriving a slope (Rachlin et al., 1991). Thus, if an individual exhibits a “steep” discounting rate, they more often choose the immediate reward over the delayed reward regardless of magnitude (Rachlin et al., 1991).

In a study investigating the discounting rates of 38 opioid-dependent individuals when compared to 18 demographically matched control participants, results indicated that the addicted participants discounted future monetary rewards at a rate seven times that of the controls (Madden et al., 1997). A recent meta-analysis supported these findings, revealing that discounting rates were significantly associated with both engagement in addictive behaviors and addiction severity (Amlung et al., 2017). In addition, some research suggests that temporal discounting may be considered a personality trait (Odum, 2011). Beyond the temporal discounting rate, one study found that intertemporal choice inconsistency was predictive of nicotine relapse in former smokers (Grosskopf et al., 2020). Together, these results suggest that steeper discounting rates are likely associated with impulsivity and that both discounting rates and trajectories may be predictive of particular health behaviors.

In addition to being a proxy for impulsivity, steeper temporal discounting rates have also been linked to cognitive decline (Halfmann et al., 2013; Thoma et al., 2016). Specifically, individuals with cognitive impairment exhibited greater preference for smaller more immediate
rewards as compared to cognitively healthy individuals who generally preferred greater delayed rewards (Halfmann et al., 2013). These results supported those of Lindbergh and colleagues (2014) who found steeper temporal discounting rates in participants diagnosed with mild cognitive impairment (MCI) as opposed to healthy controls. Additionally, they observed more variable decision-making patterns in those with MCI. In a longitudinal study of decision-making in older adults without dementia, faster rates of cognitive decline were predictive of steeper temporal discounting rates for monetary outcomes of larger magnitudes (James et al., 2015).

Similar to findings from the Lindbergh (2014) and James (2015) studies, a separate longitudinal study on decision-making preferences in older adults revealed that participants with mild Alzheimer’s disease (AD) demonstrated steeper temporal discounting rates when compared to participants with MCI and healthy controls (Thoma et al., 2016). Moreover, those participants whose cognitive decline worsened with time, showed increasingly steep temporal discounting rates (Thoma et al., 2016). Consistent with the above findings, steeper temporal discounting rates were also associated with decreases in autobiographical memory and general cognitive decline in patients with AD (El Haj et al., 2020). In contrast, improvements to cognitive functioning, namely working memory, may attenuate temporal discounting rates (Bickel et al., 2011). In a prominent study investigating temporal discounting rates among stimulant-dependent individuals, it was found that those individuals assigned to the working memory training group displayed lower temporal discounting rates for monetary rewards when compared to the control group (Bickel et al., 2011). Taken together, steeper temporal discounting rates appear to be linked to undesirable outcomes but may be modifiable.

However, temporal discounting is not always observed, particularly with non-monetary outcomes. For example, undergraduate participants placed more value on delayed outcomes
when they included meeting their favorite celebrity (Rottenstreich & Hsee, 2001). Relatedly, unfavorable outcomes (conceptualized as emotional “losses”) may also be chosen more immediately, such as choosing to experience a painful electric shock sooner rather than later (Rottenstreich & Hsee, 2001). In both of these examples, the anticipation of the outcome is arguably more important than the outcome itself. Relatedly, it is thought that higher levels of self-regulation lessen the tendency to devalue future outcomes and instead allow for individuals to be more willing to accept delayed gratification (Göllner et al., 2018).

**Future Time Perspective**

One hypothesized mechanism underlying the degree to which an individual may engage in temporal discounting is the individual’s concept of their time: specifically, their future time perspective. Future time perspective was originally defined as “the totality of the individual’s views of his psychological future and psychological past existing at a given time” (Lewin, 1951, p. 75). More recently, it has been conceptualized as a general consideration for one’s future (Kooij et al., 2018). A recent meta-analysis suggested that future time perspective is negatively associated with risk-taking behavior, while positively associated with well-being, desirable health behaviors, and retirement planning (Kooij et al., 2018). Future oriented behavior has also been associated with lower temporal discounting rates (Göllner et al., 2018), as has purposefully imagining positive and negative future outcomes (Bulley et al., 2019). As such, it may be that future time perspective enhances one’s ability to plan for and anticipate future outcomes thereby influencing preferences for larger delayed rewards as opposed to smaller immediate rewards.

A related concept, known as event sequencing, describes the individual preference for ordering both positive and negative events of differing magnitudes as a function of time (Löckenhoff & Samanez-Larkin, 2020). In other words, planning how to schedule the order of
bigger events in relation to smaller events when these events are either positive or negative. For example, event sequencing choices may represent the difference between putting off an adverse event such as a blood draw or a loan payment vs. deciding to get the event over and done with (Löckenhoff & Samanez-Larkin, 2020). Similarly, one may decide to pay off a smaller loan before a bigger loan or accept a larger lump sum payment up front rather than spread smaller amounts out over time (Löckenhoff & Samanez-Larkin, 2020). In this regard, individual future time perspectives appear to impact multiple temporal decision-making behaviors. In contrast, a recent large adult-life span cohort study found that older age was associated with a preference for experiencing the “bigger” events sooner rather than later, whether these events were positive (enjoyable weekend or receiving money) or negative (painful dental procedure or paying money), and that future time perspective did not explain these preferences, but rather the employment of reasoning and experience (Strough et al., 2019).

**Decision-Making Across the Lifespan**

Decision-making abilities wax and wane throughout the lifespan. Building on concepts previously discussed, the review of decision-making across the lifespan will focus on the use of biases and heuristics, as well as behavior observed under time delayed situations involving gains and losses.

**Childhood and Adolescence**

In early life, there tends to be more of a reliance on intuitive, fast, and automatic decisions which are heavily influenced by biases (Strough et al., 2011). As the transition is made from childhood to adolescence, along with more capacity for functions like metacognition, there is a shift to a more deliberate, thoughtful and effortful decision-making process (Strough et al., 2011). However, there is also evidence to suggest that biases, such as the framing effect do not
show consistent linear changes. For example, preschool children tend to show no differences in choice preference between gain and loss situations treating outcomes relatively the same, whereas adolescents demonstrate standard framing behavior when compared to adults when reward magnitudes are smaller but show an increased preference for risk in gain situations as compared to adults when the monetary outcome is larger (e.g., reverse framing; for review, see Strough et al., 2011).

Not surprisingly, children also show preferences in line with those previously discussed for immediate vs. delayed outcomes (Mischel & Grusec, 1967). A famous study investigated decision-making attitudes in 48 boys and 48 girls in fourth and fifth grades by presenting them with choices between smaller immediate rewards and larger delayed rewards, as well as smaller immediate punishments and larger delayed punishments (Mischel & Grusec, 1967). The study design included four conditions in which 12 boys and 12 girls were assigned to each condition. In conditions I and III, reward outcomes were presented first followed by punishment outcomes, and in conditions II and IV, the reverse was true (Mischel & Grusec, 1967). Additionally, in conditions I and II, the probability for receiving the delayed outcome was stated as certain, and the amount of delay time for both rewards and punishments varied (Mischel & Grusec, 1967). The opposite was true for conditions III and IV, in which the delay period was kept constant, and the probability of receiving either the reward or punishment varied. Results revealed that larger delayed rewards were chosen more frequently when the probability of these rewards increased; however, greater preference was made for immediate punishments when the probability of the delayed punishments increased (Mischel & Grusec, 1967). This finding is interestingly consistent with the findings from the Rottenstreich and Hsee (2001) study regarding affective-
rich outcomes among college-aged students. Given these similarities, it may be that children rely more on their affective and intuitive “gut” instincts when making decisions.

Contrary to the above findings, some research has shown that children are more risk-taking than adults in gain situations, but not in loss situations (Levin et al., 2007), suggesting that loss aversion may be a prominent force even in individuals as young as five. Interestingly, young children (5-7 years) showed diminished sensitivity to the expected value of the outcome on both gain and loss trials than adults; however, this discrepancy was less pronounced for older children (8-11 years; Levin et al., 2007). Increased risk-taking behavior in children and adolescence as compared to adults is a well-established phenomenon (for review, see Reyna & Farley, 2006) and typically reaches its peak during adolescence during which time significant associations exist between risk-taking behavior and poor outcomes such as substance and unsafe sexual behaviors. The increased risk-taking attitude displayed during childhood and adolescence is likely influenced by premature functional and anatomical formation of the prefrontal cortex, a structure heavily implicated in making advantageous choices (for review, see Weller et al., 2011). However, younger adolescents showed steeper temporal discounting rates as compared to older adolescents (Olson et al., 2007). The authors concluded these results may suggest that perception of time, and time as a fraction of one’s current lifespan, may explain why temporal discounting rates differed (Olson et al., 2007).

Taken together, decision-making appears to be characterized by more quantitative decision-making in youth, with a noted transition to more qualitative “gist-based” decision-making with age (for review, see Strough et al., 2011). Risk-taking behavior appears to reach a peak during adolescence, and then stabilize into adulthood, which is thought to be partially due to neuronal maturation (for review, see Weller et al., 2011).
Early Adulthood

Broadly, the evidence on decision-making behavior in early adulthood is varied. Beyond evidence for a strong negativity bias characterized decision making in early adulthood (Baumeister et al., 2001; Rozin & Royzman, 2011), there appears to be inconsistencies in early adult abilities when comparing to adolescence and to older adults. A 2011 meta-analysis investigating age differences in risky choices, suggested that differences between early adult and older adult decision-making abilities are a function of task characteristics (Mata et al., 2011). Differences were most prominent for tasks in which there was a learning component associated with understanding the level of risk, particularly if reversal learning was required for advantageous decision-making (Mata et al., 2011). To this end, older adults performed worse on these measures than younger adults. In contrast, when risk probability was explicitly stated, there were no notable differences in choice behavior between younger and older adults (Mata et al., 2011).

Another meta-analysis investigating age differences in everyday problem-solving/decision-making effectiveness (EPSE) compared groups of young, middle-aged, and older adults (Thornton & Dumke, 2005). Results indicated that EPSE ability remains relatively consistent throughout life, with only noticeable reductions in ability seen during later life (Thornton & Dumke, 2005). Further, ratings regarding abilities between experimenters and younger adults were more consistent than ratings were between experimenters and older adults, with older adults rating their decision-making skills significantly better than experimenters determined (Thornton & Dumke, 2005). These findings suggest older adults may lack insight into their abilities or may distort their memories to be in line with a view in which they perceive their choices as more positive (Mather & Johnson, 2000).
With regard to comparisons between adolescents and young adults, some evidence suggests greater levels of loss aversion in younger adults (Cauffman et al., 2010). A study investigating performance on a prominent risk-taking decision paradigm (Iowa Gambling Task), revealed that younger adults demonstrated more avoidance of disadvantage card decks than did adolescents (Cauffman et al., 2010), which is consistent with the increased levels of risk-taking behavior commonly observed in adolescents.

**Older Adulthood**

Decision making ability often changes as we age, likely as a function of available cognitive resources, as well as shifts in goals and priorities as a function of time and longevity (Hess et al., 2015; Mather, 2006). It has been suggested that older adults differ from their younger counterparts regarding decision-making, such as engaging in less monetary temporal discounting (Eppinger et al., 2012; Green et al., 1994; Löckenhoff et al., 2011), and experiencing anticipation of losses less profoundly during risky situations (Halfmann et al., 2013; Pachur et al., 2017; Samanez-Larkin et al., 2007). However, it has also been suggested that older adults have a greater tendency to devalue future outcomes (Boyle et al., 2012; Huffman et al., 2019) and that temporal discounting rates may show a curvilinear relationship with age (Göllner et al., 2018). One explanation raised for these inconsistent patterns has been differing task characteristics across studies (Mata et al., 2011). For example, age-related differences in risky decision-making are apparent when task associated learning demands are present; however, these age differences dissipate once learning demands are removed (Mata et al., 2011). Similarly, older adults may have more difficulty with cognitively demanding decision-making tasks, yet also exhibit optimal decision-making abilities when decisions involve
the integration of experiential and affective processes (for review, see Strough & Bruine de Bruin, 2020).

Commonly the first step in any decision-making process is to be aware that a decision needs to be made. In this regard, older adults may engage in more avoidance of decision-making in general (Löckenhoff, 2018). For example, in health-care related contexts, older adults report they would rather not make medical decisions and instead prefer for their physician to do so for them (for review, see Mather, 2006). However, it is unclear if this represents a general avoidant tendency towards decisions, or the notion that older adults face greater health care complexities as the result of multiple ailments, and decisions regarding the best course of medical action may be too advanced and complex. During the information gathering phase, in attempts to limit cognitive demand, older adults may not consider all relevant data points relative to younger adults and thus exhibit a less exhaustive search strategy (for review, see Strough & Bruine de Bruin, 2020). Relatedly, they may also be more likely to utilize heuristics, rely on personally relevant information, and draw more heavily on personal experience and emotional states when compared to other age groups (for review, see Peters et al., 2007; Strough & Bruine de Bruin, 2020). Notably, the context of the decision has a large influence in whether these aforementioned behaviors are viewed as advantageous or hindering.

Increased reliance on more personal experience is consistent with the notion that older adults may be more apt to utilize schematic information, and also may employ the representativeness heuristic more often (for review, see Peters et al., 2000). In this regard, relying on pre-existing knowledge or learned prototypes, may cause older adults to make inaccurate decisions by neglecting base rates or make risky financial investments by assuming current positive returns are indicative of continuous future returns (for review, see Peters et al.,
Overdrawing from experience is also seen in studies that suggest older adults use the availability heuristic more often than younger adults, through greater ease at recalling examples and therefore overestimating likelihood (for review, see Peters et al., 2000).

Evaluation of decisions is thought to be more positively viewed in older adults, who may show less regret for previous decisions (for reviews, see Löckenhoff, 2018; Hess et al., 2015; and Mather 2006). Supporting this view, older adults tend to endorse fewer negative emotions and more positive emotions, even after experiencing losses, which appears to be driven by avoiding preoccupation with negative thoughts and shifts toward limited time perspectives (Bruine de Bruin et al., 2018). These tendencies may explain why older adults have been shown to more readily avoid the sunk cost fallacy, and not continue to “throw good money after bad.” Similarly, it has been suggested that older adults maintain intact affective forecasting skills (e.g., the prediction of emotional state), and may therefore have higher congruence between post-decision emotions and outcomes.

There is evidence to suggest that older adults may not as readily engage in the more deliberative, thoughtful and effortful decision-making processes (for reviews, see Strough et al., 2011 and Peters et al., 2000). This may be due to preference construction, or the tendency to come up with one’s preferences “on the spot” based on in-the-moment availability of resources (Peters et al., 2011). It is thought that preferences are more likely to be constructed when the following factors exist in a decision: unfamiliarity, complexity, familiarity that is not personal, emotionally difficult trade-offs, or difficulty engendering or translating affective responses (Peters et al., 2011). Another posited reason is that older adults may have greater difficulty applying decision rules and discerning between multiple options that differ on a variety of attributes (Bruine de Bruin et al., 2012; Rosi et al., 2019).
In contrast to the previously mentioned findings, there is also mounting evidence to suggest that older adults and younger adults do not differ in the degree to which they discount future monetary rewards (Löckenhoff & Samanez-Larkin, 2020; Read & Read, 2004; Samanez-Larkin et al., 2011; Seaman et al., 2016). Relatedly, some studies show equal tendencies for loss aversion across age groups. Recent evidence has also suggested that temporal event sequencing preferences also do not differ by age (Löckenhoff et al., 2019).

In attempts to provide clarity to the inconsistent literature on decision-making across the lifespan, some researchers speculate that when we view decision-making ability as the merging of affective, experiential and deliberative processes, that a different picture may emerge regarding conceptualizations of older adults’ decision-making abilities (for review, see Strough et al., 2011). More specifically and recently, a conceptual framework proposed by Löckenhoff (2018) identifies decision-making as a recursive and evaluative process that informs future decision-making. This framework distinguishes affective, cognitive and motivational factors as distinct yet interacting age-related mechanisms involved with this process. These factors need to be considered in conjunction with situation context and task characteristics in order to aid researchers in determining the quality of decision-making (Löckenhoff, 2018).

It is also important to consider that a large proportion of decision-making research is cross-sectional, and it is posited that previously conceptualized age-associated declines in decision-making may be due in part to cohort effects (DelMissier et al., 2020). A recent longitudinal study investigating aspects of decision-making competency over a period of five years revealed no significant decrements in decision-making abilities among older adults, with the exception of the oldest old group (DelMissier et al., 2020). Further, there is relatively little focus on decision-making behavior in regard to loss frames across the lifespan, with the vast
majority of studies focused on gains or rewards. Understanding whether behavior dissociates as a function of condition is an area in need of further investigation.

In sum, research suggests notable differences in decision-making preferences between older and younger adults; however, recent findings have called these conclusions into question. Our conceptualization of young vs. old tendencies in decision-making competencies may be too simplistic, narrow, and dichotomous of a view. It is important to highlight the multiple factors that lead to decision-making being a reiterative and integrated process. Further, previous conclusions have been drawn based on studies that have been limited by cross sectional designs. In this regard, future decision-making research using longitudinal designs is also warranted.

**Dual-Process Model**

One of the most well-known theories to describe the influence of affect and cognitive control in decision making is the dual-process theory (Epstein, 1994). This theory posits that individuals make choices based on two separate modes of thinking: 1) affective/experiential and 2) deliberative (Epstein, 1994). The characteristics of the affective/experiential system, or “System 1” (Kahneman, 2003), are automatic, fast, intuitive, and implicit. Further, this system is thought to be largely guided by emotions and initial judgments regarding if something is “good or bad” (Epstein, 1994; Kahneman, 2003; Peters et al., 2007). The deliberative system, or “System 2” (Kahneman, 2003), is slower, effortful, thoughtful, and reason-based (Epstein, 1994; Kahneman, 2003; Peters et al., 2007). It has been suggested that System 2 exerts an effortful control over the processes of System 2, and that the partnership of these two systems is important in making good decisions.

This model may account for some of the patterns observed in discounting. Intemporal choices are thought to be a product of either the competition or confluence of these systems
(McClure & Bickel, 2014). However, there are also arguments to be made that while affective and cognitive systems may have distinguishable anatomical differences, there are not well-defined boundaries between emotional and cognitive processes (Hastie & Dawes, 2010). As such, the influences of affective and cognitive processes on rates of temporal discounting are areas in need of further investigation.

**Affect and Decision-Making**

**Overview of Affect**

A challenge of understanding how affect impacts decision-making, is the difficulty in identifying common themes in the literature. At the basis of this difficulty, is the ubiquitous and all-encompassing use of the word *affect* to describe certain processes. Some studies use affect to be synonymous with emotion, while others delineate the two terms. The literature investigating the associations between affect and decision making vary widely and may include mood induction paradigms, investigation of neural processes, or self-reported trait affect, all while describing the phenomenon as “affect”. Thus, for the purposes of this review, affect will be broadly referred to as experts in the field of affective science have defined it: “the evaluation at any level and in any modality, including affective feelings, thoughts, expressions” (Barrett et al., 2016, p. 533).

**Affective Influences**

Affect has increasingly gained attention as being an important influence in the decision-making process. Early work in this area was conducted by Zajonc (1968, 1980), who speculated that the temporal ordering of our affective reactions to the environment play a role in the decision-making process by orienting our attention to a stimulus and allowing us to make quick and efficient assessments of the situation.
The impact of affect upon decision-making can be broken down in several important ways. Loewenstein and Lerner (2003) proposed a theoretical model that postulates decision-making is impacted by two influences at the broadest level: expected emotions and immediate emotions. Expected emotions represent the decision-maker’s attempt to predict how he or she will feel if certain outcomes happen, thus they are not “experienced” emotions, but rather hypothesized predictions (Loewenstein & Lerner, 2003). Immediate emotions occur at the time of the decision-making and can exert influence in both direct and indirect ways (Loewenstein & Lerner, 2003). Direct influences might include anxiety at the time the individual needs to make the decision. Indirect influences impact the decision-making process by causing the decision-maker to think about the probability or utility of the outcomes as well as post-decision emotions he or she may face (Loewenstein & Lerner, 2003). While this may sound similar to expected emotions, these two processes differ in ways regarding factors that independently influence each, as well as the intensity and severity that each is felt by the decision-maker (Loewenstein & Lerner, 2003).

Incidental influences are factors that occur tangentially or outside of the decision-making process (e.g., dispositional affect, the weather, your mood when you woke up, etc.; Loewenstein & Lerner, 2003). This is also sometimes referred to as incidental affect (Blanchette & Richards, 2010; Västfjall et al., 2016). The general take-away from this model is that direct and indirect routes of affective information can impact a decision at various stages of the decision-making process.

The relationship between affect and decision-making suggests a dissociation between negative and positive affect. Some researchers suggest that higher levels of positive affect, specifically gratitude, are associated with reduced temporal discounting (Dickens & DeSteno, 2016; Patalano et al., 2018). It is posited those greater levels of gratitude impart effects on
temporal decision-making by strengthening self-control and attenuating impulsivity.

Additionally, positive affect has also been associated with more rapid decision-making by way of utilizing less information and engaging in less rechecking of information (for review see Isen, 1984). Interpretation of these results suggested that those higher in positive affect were not more impulsive, but rather more efficient in their decision-making process (Isen, 1984). At the other end of the spectrum, negative affect has been linked to more impulsive decision-making. In particular, one study experimentally manipulated participants’ mood through film clips designed to induce sad mood and found that these participants displayed steeper temporal discounting rates (e.g., were less likely to choose larger delayed awards; Lerner et al., 2012). This effect appeared to be mediated by impatience, but not disgust, suggesting not all negative moods produce a preference for more immediate rewards (Lerner et al., 2012). Collectively, these findings suggest that isolating particular emotions may yield differing conclusions related to discounting behavior.

Affective processes also allow individuals to consider the degree of ‘want’ for an outcome, or the perceived utility of the outcome. Blanchette and Richards (2010) provide an example of how mismatches in outcomes and perceived utility can occur: your odds of winning a bicycle might be in your advantage; however, if you have just recently purchased a bicycle, this reward becomes less enticing. In essence, perceived utility is the value that the individual places on an outcome (Blanchette & Richards, 2010). What makes this concept challenging however, is the realization that many individuals are unaware of the specific value they would place on an outcome (for review, see Peters et al., 2000). This raises the question of how affect impacts our perceptions and thus alters our perceived utility of outcomes, and how affective resources interact with biases, and risk attitudes for perceived losses and gains.
It is also unclear how individual perception is impacted by positive and negative outcomes. Some research suggests individuals who endorse positive affect perceive losses even more negatively than those who report a more neutral affect (for review, see Blanchette & Richards, 2010). Further, anxiety has been shown to impact the perceived utility of negative but not positive outcomes and is also associated with both anxious and positive affective states (for review, see Blanchette & Richards, 2010). In these ways, affect may influence the level of risk or loss aversion that an individual exhibits during decision-making. It may be that anxious affect exerts an influence via attentional and memory bias; while positive mood may exert an effect via alterations in perceived utilities of negative outcomes (e.g., an exaggerated loss aversion; for review, see Blanchette & Richards, 2010).

There is substantial literature to suggest that affect impacts cognitive processes. For example, higher levels of positive affect have been shown to promote cognitive flexibility, facilitate working memory, and improve decision-making in complex situations (Ashby & Valentin, 2002; Isen, 2008; Yang, Yang & Isen, 2013).

Affective Theories of Aging

One of the most prominent theories of affective aging is known as the socioemotional selectivity theory (SST; Carstensen et al., 1999; Carstensen & Mikels, 2005). SST posits that due to perceptions of time horizons shortening, shifts towards emotional goals that optimize the emotional experience become more important to older adults, thereby increasing monitoring of affective information. As a result of these changes in motivation towards achieving more meaningful lives and developing richer social connections, it is thought that older adults are better able to regulate emotions (Carstensen & Mikels, 2005), and research suggests that older
adults tend to engage in more favorable antecedent-focused strategies as opposed to response-focused strategies (for review, see Löckenhoff, 2018).

Consistent with this notion, older adults may also show advantageous strategy selection when making decisions. For example, in a longitudinal design, Bruine de Bruin and colleagues (2016) investigated the associations between decision-making strategies and emotional well-being two years after baseline. Their findings suggested that older adults are less likely than younger adults to engage in ‘maximizing’ strategies (e.g., spending considerable time searching for the best option), and instead are satisfied with choosing an option that is “good enough” (Bruine de Bruin, et al., 2016). Given prior associations between maximizing and unhappiness and regret, the authors speculated that older adults may choose decision-making strategies that allow them to maintain positive affect (Bruine de Bruin et al., 2016). Relatedly, there is also evidence to suggest that emotionally salient information may be relatively spared from normal aging decrements in memory (for review, see Carstensen & Mikels, 2005), with some research suggesting older adults show improved performance in decision-making when instructions are emotionally-focused, as opposed to information-focused instructions (Mikels et al., 2010). Similarly, induced positive feelings contributed to better decision-making (e.g., choosing more advantageous choices from both winning and losing decks) among older adults resulting in more money earned (Carpenter et al., 2013).

The heightened emphasis on emotional goals and better emotion regulation abilities, may collectively lead to a “positivity effect” in which older adults either increase focus on positive information and/or decreases focus on negative information (for review, see Mather, 2004). A seminal study reported that older adults report more positive affect and recover from negative affective states more quickly than younger adults (Carstensen et al., 2000). Results from a meta-
analysis of over 100 studies revealed a robust positivity effect regarding an attentional and memory bias for positive information in older adults (Reed et al., 2014). In one of few longitudinal studies on positive affect, older adults reported higher levels of positive affect and lower levels of negative affect after two years when compared to younger adults, even after adjusting for negative life events and relevant demographic variables (Bruin de Baine et al., 2016). Moreover, the positivity effect appears to be relevant even within the current COVID-19 pandemic, as older adults reported higher levels of emotional well-being when compared to younger adults (Carstensen et al., 2020).

While this “positivity effect” may be advantageous for mood and affect, it could also limit older adults’ decision making by way of not fully considering negatively valenced characteristics that are important for making decisions or lead them to evaluate past choices as overly positive, thereby impeding future learning (Hess et al., 2015; Löckenhoff, 2018). In other words, they may be more apt to employ heuristics during decision-making that are in line with maintaining positive mood. Further, there are competing ideas about the basis of SST, and whether the positivity effect is a universally demonstrated effect. An alternative viewpoint is that shifts toward emotionally meaningful goals may come at the realization that future oriented goals become increasingly impractical with age (Fung & Carstensen, 2004). Additionally, the impetus for social connections may be to find comfort during emotionally stressful and difficult times as opposed to efforts to achieve an emotionally meaningful life (Fung & Carstensen, 2004). It has also been demonstrated that the positivity effect does not appear to be a culturally universal concept. Fung and colleagues (2008) found that the attentional biases of Chinese participants were not oriented towards positive information. Relatedly, in older adults who viewed stimuli
associated with real life consequences, there was no indication of a positivity effect (Rolison, 2019).

**Affect, Aging and Decision-Making**

Given the suspected age-related shifts in affect and connections between affect and decision-making, it has been shown that this process also changes with age. For example, considering the theme of perceptions of waning time horizons central to SST, it may be that older adults engage in steeper levels of temporal discounting, particularly when the delay for the reward is particularly large, as there may be concern time will run out before the prize is obtained (Löckenhoff & Rutt, 2015). In other words, older adults may show a preference for the “here and now.”

On the other hand, the speculated increases in affective processes such as emotion regulation and affective forecasting, (Scheibe & Carstensen, 2010) may prompt older adults to engage in less temporal discounting, as they may be able to vividly imagine emotional outcomes resulting from their decision. Indeed, this is in line with a study that demonstrated decreased temporal discounting for delayed gains in older adults as compared to younger adults (Löckenhoff et al., 2011). This difference was only found for delayed gains, and not delayed losses, suggesting that older adults may wish to avoid immediate monetary negative outcomes with the same intensity as other age groups. However, experience-based knowledge may mitigate the tendency to avoid more immediate negative outcomes. For example, older adults demonstrated better performance on financial decision-making measures, particularly those that assessed sunk cost decisions and credit card repayment options (Eberhardt et al., 2019). Performance on financial measures was positively associated with experience-based knowledge, motivation level and lower reports of negative emotions (Eberhardt et al., 2019).
Interestingly, monetary findings were in contrast to the results revealed in the electric shock study by Rottenstreich and Hsee (2001), which suggested there may be preferences for more immediate and smaller pains, as opposed to larger delayed pains. It may be that negative monetary outcomes are weighted and valued differently than negative emotional outcomes; however, the latter study was conducted entirely in an undergraduate sample. Toward this end, a recent study by Seaman and colleagues (2016) was one of the first studies to investigate socially salient reward types in both temporal and probability discounting tasks among older adults. Older adults demonstrated steeper temporal and probability discounting rates as compared to younger adults for both social (spending time with a close friend) and health (receiving the benefits from a hypothetical drug) rewards (Seaman et al., 2016). However, when considering adverse outcomes, such as anticipation of a physically adverse electric shock, no age differences were observed in the sensitivity to delay (Löckenhoff et al., 2016). Overall, these results suggest the outcome type is of critical importance in determining potential age differences in decision-making behavior.

**Cognition and Decision-Making**

**Neuroanatomical Substrates of Decision-Making**

One of the most widely studied aspects of neural circuitry regarding decision-making is the frontostriatal circuit (Hess et al., 2015). Broadly, this brain network is composed of the striatum (collectively the caudate, putamen and nucleus accumbens), anterior cingulate (ACC), and frontal regions including the dorsolateral prefrontal cortex (DLPFC) and orbitofrontal cortex (OFC; Hess et al., 2015). Circuits within these structures are important for performing executive functions such as problem solving and planning, as well as displaying appropriate social behavior and motivation (Hess et al., 2015). The medial orbitofrontal cortex (mOFC) and
posterior cingulate cortex (PCC) have been associated with reward valuation, whereas the DLPFC and posterior parietal cortex (PPC) have been linked to cognitive control processes (Peters & Büchel, 2011). Relevantly, connections between the prefrontal cortex and striatum are important for cognitive control and incorporating feedback from reward-based signals with other information sources to inform decision making (Hess et al., 2015). The frontostriatal circuits gained attention in decision-making literature as the result of lesion studies, in which patients failed to consider future consequences, exhibited risk-seeking behavior, did not use corrective actions, and exhibited poor working memory (for review, see Mather, 2006). Since then, these circuits continue to be an explanatory focus of decision-making behavior. Studies of conditions historically characterized by decision-making difficulty such as obsessive-compulsive disorder (OCD), attention deficit hyperactivity disorder (ADHD), Parkinson’s disease, and addiction have revealed deficits in these brain regions (Frank et al., 2007; Jentsch et al., 1999; Norman et al., 2016; Sonuga-Barke & Fairchild, 2012). Pertinent to this review, neural mechanisms of decision-making have also become a focus of aging research given the growing aging population and relative importance of decisions that are made in later life (Lighthall, 2020).

In temporal discounting paradigms, it is thought that immediate and delayed outcomes are processed differently from a neuroanatomical perspective. For example, preferences for immediate rewards are thought to be governed largely by limbic and paralimbic structures, whereas preferences for delayed rewards appear to be a function of lateral and prefrontal areas as well as parietal areas (McClure et al., 2004). Further work in this area proposes that three networks have been implicated in contributing to temporal discounting behavior. First, the ventromedial PFC (vmPFC), mOFC, and ventral striatum are associated with determining a subjective value for the choices in question (Peters & Büchel, 2011). As has been previously
discussed, subjective values often differ from the objective values by way of perceived utility and reference points. Next, the lateral PFC and ACC contribute to cognitive control and conflict monitoring (Peters & Büchel, 2011). Finally, medial temporal lobe regions likely have a role in imagery-based predictions of future outcomes from decisions (Peters & Büchel, 2011). Relatedly, Han and colleagues (2013) found that frontostriatal connectivity patterns were largely responsible for temporal discounting behavior.

Building on this research, specific brain areas have been implicated based on whether decisions are framed as gains or losses (Zhang et al., 2016). These results are in line with commonly observed temporal discounting behaviors, in which individuals tend to discount future gains more so than future losses; a concept known as gain-loss asymmetry (Hardisty et al., 2013; Loewenstein & Prelec, 1992; McKerchar et al., 2013). Specifically, neuroimaging results indicated avoidance motivation is negatively associated with connections between the mOFC and the PPC for gains; and positively associated with connectivity between the mPFC and the PCC as well as the insula in the loss domain (Zhang et al., 2016). While the generalizability of these results is speculative based on the sample demographics and size, it raises the idea that gains, and losses, may be differentially processed at the neuroanatomical level.

**Neurocognitive Changes in Normal Aging**

There is a substantial body of literature discussing the neuroanatomical changes implicated in healthy aging. For purposes of brevity, clarity, and relevance, only age-associated brain changes that closely and significantly impact decision-making will be discussed. Relatedly, emphasis will be given to discussing changes seen in normal aging, as this group is the population of interest for the proposed study. Pathological changes will be briefly discussed as they pertain to decision making.
Two prominent cognitive aging theories pertinent to decision-making include the *frontal aging hypothesis* and *neuromodulation theories* (for review, see Lighthall, 2020). Briefly, the frontal aging hypothesis posits that the frontal lobes undergo age-related deterioration at faster rates and in a more severe fashion than other brain areas. This work has been extended to specify that specific frontal regions implicated in executive function undergo greater changes, whereas those regions subserving affective and social processes are relatively persevered (Lighthall, 2020). The neuromodulation theories are less clear but speculate that the aging brain undergoes changes in neurotransmitter systems, particularly decreases in dopamine, which is an important neurotransmitter in determining subjective values of choices (Lighthall, 2020).

The literature on the neural correlates of decision-making in older adults particularly point to volumetric loss in frontal and parietal regions (for review, see Lighthall, 2020). Specifically, areas such as the insula, ACC, PPC, lateral OFC, and DLPFC are highly susceptible to age related changes (for review see Lighthall, 2020; Raz & Rodrigue, 2006). For example, older adults who displayed increased activity in the vmPFC and striatum, performed advantageously on a complex decision-making task, whereas older adults with decreased activity in these areas displayed disadvantageous patterns (Halfmann et al., 2015). Moreover, it has been previously mentioned that older adults experience less loss aversion than their younger counterparts. Neural signatures support this notion, showing similar patterns of activation in response to anticipation of monetary gains as younger adults, but not for activations in anticipation to monetary losses (Samanez-Larkin et al., 2007; Samanez-Larkin & Knutson, 2015). Collectively, the aforementioned changes can result in changes in executive control, responses to rewarding and aversive stimuli, choice evaluation, and sensitivity to immediate and delayed outcomes (see Lampert et al., 2020; Lighthall, 2020).
Associations between Cognition and Aging

This section will focus on cognitive domains most significantly impacted by the aging process. Namely, attention, executive function, and episodic memory. The cognitive domain of attention is posited to contain three networks: 1) orienting, 2) vigilance, and 3) executive control (Fernandez-Duque & Posner, 2001). Briefly, these three components are important for attending to sensory stimuli, sustaining alertness, and demonstrating effortful control, respectively (Fernandez-Duque & Posner, 2001). Based on aforementioned relationships, it may be that positivity bias in older adults is most prominent in the orienting phase. Further, decreased visual processing may be a sign of decrements in this area.

Concerning the third function of the attention system, effortful control is also an aspect of executive function. While a specific and universal definition for executive function is lacking, it is generally agreed upon that executive function involves the ability to “make choices and to engage in purposeful, goal-directed and future-oriented behavior” (Suchy, 2009, p. 106). These abilities commonly include working memory (e.g., ability to hold and manipulate information in one’s mind), cognitive flexibility (e.g., task-switching) and inhibitory control (Lezak et al., 2004). Another concept used within the framework of executive function is cognitive control, or the process of joint manipulation of information in working memory and the purposeful retrieval of information from long-term memory (for review, see Hess et al., 2015). Along with reward processing, decrements in cognitive control are thought to most significantly impact selection of an effective or advantageous decision-making strategy (for review, see Hess et al., 2015). Diminishing cognitive control may be a product of age-related changes in the frontoparietal region, an area particularly sensitive to the aging process (for review, see Hess et al, 2015; Lighthall, 2020).
Memory is a broad construct. For the purposes of this review, episodic memory (e.g., ability to recall contextual information) will be emphasized, as working memory is conceptualized under executive function. Episodic memory decline is arguably one of the most common complaints in older age. This construct is reliant on intact encoding, storage and retrieval of information. It has been suggested that older adults are more susceptible to familiarity and source memory errors (for review, see Hess et al., 2015). One speculation is that with waning cognitive control and strategy selection ability, older adults may rely more on biases and heuristics, in turn contributing to lapses in memory functioning.

Normal aging is primarily characterized by declines in certain cognitive domains and relative stability in other domains, although this pattern is highly variable both within older adults and between older and younger adults (Salthouse, 2010). Areas associated with decline typically include cognitive control and flexibility, explicit learning, attention, processing speed, working memory, and episodic memory (Salthouse, 2010). Cognitive functions encompassed by the prefrontal cortex (PFC) are especially vulnerable to the aging process, given that the PFC is one of the first areas to deteriorate with age (Murman, 2015). In contrast, areas that appear relatively spared by the aging process are areas such as semantic memory, language, and vocabulary (Salthouse, 2010).

**Aging, Cognition and Decision-Making**

It can be argued that virtually all aspects of cognition are implicated in a decision-making process. However, prominent themes in the literature seem to point towards a significant influence of attention, executive control, and memory on the decision-making process. Notably, these areas are also considerably impacted by the aforementioned aging process in most
individuals. Therefore, these domains will provide the basis for this review regarding associations between age, cognition and decision-making.

As with several other lines of research discussed in this proposal, the literature regarding the impact of aging on the decision-making process is mixed. A broad strokes overview suggests that crystallized and semantic knowledge stay well preserved, while fluid cognitive abilities decline (for review see, Salthouse, 2010). Some research suggests that age-related decrements in processing speed and working memory may adversely impact pre-decision making information collection as well as strategy selection (for review, see Löckenhoff, 2018). Similarly, one study showed that older adults demonstrated a poorer performance on a task of decision-making under risk than did younger adults, however only in situations of loss (Pachur et al., 2017). The authors concluded older adults had lower levels of loss aversion, less risk aversion in situations of gain, and made more optimistic decision-weights for outcomes; a strategy in line with Kahneman and Tversky’s notion that humans are unskilled at finding congruence between the likelihood of an outcome, and how much we value the outcome. This pattern was linked to lower levels of fluid intelligence, consistent with research suggesting fluid cognition worsens with age (Pachur et al., 2017). Additionally, difficulty in applying decision rules appeared to be mediated by age-related declines in working memory and verbal fluency (Rosi et al., 2019).

While there are arguments for the positive association between cognitive decline and use of more simplistic decision-making strategies, this may be too narrow of a view. Decision-making strategies rely on both contextual information as well as the individual’s cognitive resources. In some cases, failure to use a more complex decision-making strategy is not necessarily reflective of an individual’s cognitive abilities, but rather more efficient use of a cost-benefit approach (Mata et al., 2007). If cognitive effort is conceptualized as a cost, and accuracy...
of the strategy selection as a benefit, sometimes it may behoove the individual to select a simpler strategy. In fact, some studies show that older adults may have improved strategy selection when compared to younger adults (Mata et al., 2007). To this end, some researchers have also observed no measurable differences between older and younger adults regarding search behavior and/or strategy selection when making decisions (Queen et al., 2012).

In sum, several points throughout the present review suggest that inconsistencies in decision-making behavior among older adults can be better understood through the integration of multiple factors. Relevantly, the Affect-Integration-Motivation (AIM) framework (Samanez-Larkin & Knutson, 2015) provides an elegant description of the complexities and inconsistencies previously outlined. The AIM framework proposes that simultaneous enhancements and decrements in cognitive functioning, along with age-related changes to affective goals may impact decision making in a context dependent manner. In other words, aging does not universally impair decision-making abilities and in some instances can improve it (Samanez-Larkin & Knutson, 2015).

Decision-Making and Cognitive Dysfunction

There has been an increasing focus on examining decision-making ability among older adults due to recent studies that suggest declines in decision-making may be predictive of underlying cognitive impairment as well as progression to dementia (Gerstenecker et al., 2016; Pèrès et al., 2008; Sudo & Laks, 2017; Triebel et al., 2009; Tolbert et al., 2019). Considering the complexity of many real-life decisions faced during older adulthood, and the notion that advantageous decision-making ability is reliant on intact cognitive functioning across a wide variety of domains, this construct is well poised to serve as a potentially sensitive marker for predicting cognitive decline.
A 2014 study investigating decision-making abilities in healthy older adults and older adults with mild cognitive impairment (MCI) showed stark differences in the two groups decision-making patterns (Lindbergh et al., 2014). In the MCI group, decision-making behavior was characterized by greater impulsivity for immediate rewards, and response patterns were significantly more inconsistent than in the normal aging group (Lindbergh et al., 2014). Steeper temporal discounting rates were also observed in individuals with mild Alzheimer’s disease, particularly in those participants whose cognitive decline worsened with time, suggesting potential for predictive qualities within decision-making tasks.

**Decisions in Context**

A framework with which to assess the quality and adaptability of decisions is a model defined as ecological rationality (Mata et al., 2012). This model posits that 1) the qualitative appraisal of a decision-making strategy should be made relative to the environment the decision takes place, 2) complex decision-making strategies are not always superior to simplistic strategies and 3) adapting to task with the given environment is usually demonstrated by most individuals (Mata et al., 2012). This work suggests that age-related cognitive decrements do not necessarily translate to poor decision-making and may rather be advantageous given the individual’s current environmental constraints.

**Socioeconomic Status**

An important environmental constraint relevant to the demographic composition of the surrounding area for the current study, is the decision-maker’s socioeconomic status (SES). SES is generally measured as a combination of education, income, and occupation. There has been growing interest in understanding the impact of SES on various cognitive and psychological processes, given associations between numerous health disparities and lower SES (Bosworth,
Considering most decision-making paradigms utilize monetary rewards, a decision-maker’s current annual income level becomes an important factor to analyze in relation to their decision-making preferences. In terms of decision-making behavior, research suggests individuals from lower SES backgrounds tend to display steeper temporal discounting rates, indicating a preference for more immediate monetary rewards (Housofer & Fehr, 2014). These effects have been even more pronounced in the context of COVID-19, as financial insecurity was found to increase discounting rates in adults and older adults but not younger adults (Fiorenzato & Cona, 2022). Mechanistically, it is thought this relationship may occur through higher levels of negative affect and stress that potentially shift attention to more salient (immediate) outcomes (Housofer & Fehr, 2014). It is unlikely that impulsivity and cognitive biases are more inherently prevalent in poorer individuals, but rather that when these behaviors are displayed in lower SES groups, smaller margins of error exist and there becomes greater potential for one impulsive decision to create adverse outcomes (Bertrand et al., 2006). Moreover, unfavorable outcomes can lead to increasingly poor decision making, thus maintaining a cycle of poverty that is difficult to break (Housofer & Feher, 2014). In line with these findings, Scarcity Theory suggests that poverty itself can induce a scarcity mindset and subsequently promote suboptimal decision-making (Mullainathan & Shafir, 2013). These findings raise important distinctions about what factors constitute a “good” vs. “bad” decision.

**Social Connections and Relationships**

Social connections and relationships with others are integral to individual well-being and often serve as protective factors against poor health outcomes (Holt-Lunstad et al., 2010). While isolation and loneliness are often used interchangeably, they represent distinct constructs with unique contributions to functionality and well-being. For example, it is possible for an individual
to be isolated, but not lonely, or lonely but not isolated. This distinction is important to recognize as interventions used to attenuate these factors are also likely not interchangeable. A current and frequently used definition of social isolation proposes it is “a state in which the individual lacks a sense of belonging socially, lacks engagement with others, has a minimal number of social contacts, and is deficient in fulfilling and quality relationships” (Nicholson, 2009, p. 1346). In other words, social isolation equates to a lack of social connections. In contrast, loneliness is commonly defined by an individual’s subjective experience regarding their social relationships, and whether these relationships are “deficient in some important way, either quantitatively or qualitatively” (Peplau & Perlman, 1982, p. 1), or whether there is a discrepancy between the relationships they have and the relationships they would like to have (Peplau & Perlman, 1982).

These constructs are particularly relevant in older adults who are at a collectively higher risk for being socially isolated and lonely as compared to younger individuals (see Malcolm et al., 2019). A report from the National Academies of Sciences, Engineering, and Medicine (NASEM) suggests that nearly one-fourth of adults aged 65 and older are considered to be socially isolated, whereas more than one-third of adults aged 45 and older feel lonely (NASEM, 2020). Reasons for these heightened risks are associated with the common life circumstances that many older adults face as they deal with loss of family members and friends, declining levels of cognitive and physical health, and the pitfalls of modern-day society in which adult children often do not live close by. This represents a problem, as social isolation and loneliness have been associated with higher rates of incident dementia in longitudinal cohorts (Kuiper et al. 2015) and mortality in older adults (Steptoe et al., 2013).

The emergence of the COVID-19 virus in 2020 created a global health crisis, and with it, a mental health crisis. The implementation of “shelter-in-place” and social distancing procedures
compounded risk for social isolation and loneliness for individuals of all ages, but particularly so for older adults. Individuals aged 65 and older confer a higher risk of contracting a COVID-19 infection as compared to other age groups, due to higher likelihood of preexisting health conditions and weaker immune systems (Wu, 2020). Further, given that this cohort tends to be more dependent on family members and community members, social distancing procedures were particularly problematic as they related to functionality and mental health support (Hwang et al., 2020; Wu, 2020). Social decision-making has become particularly important during the time of COVID-19, as individuals contend with the perceived trade-offs between the frequency of social interactions and both personal and public safety. This risk/benefit ratio has become especially prominent among older adults who are often more socially isolated, dependent on family members and community programs, and at heightened risk for disease transmission.

There is evidence to suggest that isolation and loneliness can independently impact decision-making in older adults. As it relates to financial and healthcare decision-making, loneliness has been shown to compromise decision-making in older adults with lower global cognition and working memory (Stewart et al., 2020). Given links between loneliness, decreased self-regulation, and prepotent responding, older adults with lower working memory who are lonely may rely more on rapid and intuitive-based judgments when making decisions (Stewart et al., 2020). This type of responding may be beneficial in some situations but is likely unhelpful when faced with complex decision-making. Social isolation has also been shown to have a negative impact on important aspects of cognitive functioning. Impacts of social restricting in the context of COVID-19 led to poorer, riskier, decision-making in adults and older adults (Ingram et al., 2021). Previous research also suggests that the stress of social isolation can impair
executive functioning and increase risky decision-making by way of physiological changes implicated in loss aversion (for review, see Bhatti & ul Haq, 2017).

Based on previously discussed theories of future time perspectives (Carstensen et al., 1999; Carstensen & Mikels, 2005), it may be that older adults engage in steeper levels of temporal discounting, especially when the delay for the reward is considerably large, as there may be concern time will run out before the prize is obtained (Löckenhoff & Rutt, 2015). In other words, older adults may show a preference for the "here and now." This preference may also extend to socially salient outcomes. In the context of the socially isolating impacts of the COVID-19 pandemic and considering that older adults are both prone to experiencing greater levels of loneliness and are at the highest risk for not abiding by socially distant protocols (for review, see Kaser & Karaman, 2021), preferences for immediate socially salient outcomes may be even more pronounced. This is in line with the future-self continuity hypothesis, which suggests individuals who perceive their identity as limited tend to behave more impulsively (Ersner-Hershfield et al. 2009). Understanding how isolation and loneliness uniquely impact decision-making has important implications on intervention selection.

Intact decision making is a complex skill that is linked to autonomy and functional well-being in older adults. From a broader perspective, decision-making behavior is largely responsible for nearly all modifiable risk health behaviors, with mounting evidence indicating certain decision behaviors, such as steeper temporal discounting are linked to several poor health outcomes including obesity, smoking, gambling, and substance abuse. While this paints a grim picture, it also indicates interventions for improving decision-making ability may result in profound health benefits. Part of this process should include identifying both driving and
restraining forces (Lewin, 1946) implicated in behavior change, and how changes to several small decisions may collectively be able to shift the balance of these forces.

Research experts in decision-making propose unique strategies for improving motivation to make optimal decisions, tailored to older adults (Strough et al., 2015). Broadly, these strategies include making information related to the decision relevant to the decision-maker, and targeted interventions to increase self-efficacy (Strough et al., 2015). As such, decision-making ability has the potential to be a powerful tool for change. Joining decision-making theories with affective and cognitive theories, along with considerations for the extent of environmental factors such as isolation and loneliness, may elucidate how an individual’s motivations and values can be shaped within the context of reference points, decision weighting, and biases to aid them in making needed changes or developing healthier habits.

**Summary**

In sum, the following factors are consistently highlighted throughout the literature as being important influences on decision-making behavior: the conditions of the outcome (e.g., immediate or delayed), the framing of the outcome (e.g., loss vs. gain) and the type of outcome (e.g., money, food, social or health consequences). Collectively, decision-making behavior among and within these contexts remains inconsistent and inconclusive in older adult populations. As such, there are several gaps in the literature that exist at various points of intersection between the areas of cognitive aging, affect, environmental context, and decision-making. Although there is well-documented research investigating the affective processes of aging and the cognitive processes of aging, these processes have not been fully explored as they relate to decision-making ability. Importantly, few studies have merged these two research lines together in efforts to understand how affect and cognitive control may serve as mechanisms in
the relationship between aging and decision-making ability. It also remains unknown how the confluence of these factors may impact decision-making in temporal discounting paradigms using both monetary and non-monetary outcomes. Finally, there is little in the way of determining how patterns in decision-making preferences may be predictive of real-life, consequential health behaviors.

**Study Objectives and Specific Aims**

The proposed study aimed to understand whether older adults behave differently when outcomes are framed as gains or losses within an intertemporal paradigm. Research suggests differential effects of condition and frame on behavior; however, this conclusion remains unclear and inconsistent in older adults. To further explore these inconsistencies, this study also aimed to investigate how the decision maker’s environment (e.g., social isolation and loneliness) influences the immediacy of both monetary and interpersonal decisions, particularly in the context of social disparities that arose for older adults during the COVID-19 pandemic. Given the unclear nature of how contextual factors are associated with decision making, the current study also attempted to understand how affective traits and executive control impact temporal discounting rates when choices are framed as gains or losses. Finally, the current study explored whether temporal discounting rates were associated with consequential real-life decision-making behavior.

**Specific Aim 1. To determine whether older adults exhibit different decision-making behavior as a function of condition, frame, and outcome type.**

As previously discussed, the tendency to devalue gains or losses as they occur further into the future is known as temporal discounting. In other words, we perceive the subjective value of a gain that occurs farther in the future as “less” than an immediate gain of the same
amount. Similarly, we also perceive the subjective value of a loss that occurs farther in the future as “less” than an immediate loss of the same amount. The degree to which an individual devalues these future outcomes relative to more immediate outcomes is known as their discount rate. To this end, steeper discounting rates are indicative of greater tendencies to discount future outcomes. Specifically, steeper temporal discounting rates reflect a greater preference for smaller immediate gains as opposed to larger delayed gains, as well as a greater preference for larger delayed losses as opposed to smaller immediate losses; a concept known as gain-loss asymmetry.

However, it is unclear how older adults behave in these decision-making scenarios, with some research suggesting greater temporal discounting rates, and other research indicating the tendency to not devalue future outcomes. Moreover, these mixed findings exist primarily for behavior observed during gain conditions. As such, little is known regarding decision making preferences in loss conditions. This remains a problematic gap given that many real-life decisions involve losses. Furthermore, the current body of research is limited to decision-making paradigms that predominantly utilize monetary outcomes. Therefore, Aim 1 seeks to investigate whether there are differences among temporal discounting functions for both gains and losses when outcomes are monetary as compared to interpersonal in nature.

Specific Aims include investigating the parameters of four separate best fitting hyperbolic delayed discounting functions: monetary gains, monetary losses, interpersonal gains, and interpersonal losses. The monetary discounting task will be adapted from a widely used and well validated paradigm (Du et al., 2002). The interpersonal decision-making paradigm will be partially based on Seaman and colleagues (2016) work that demonstrated older adults were more likely to exhibit steeper temporal discounting rates when outcomes were social or health related. Discounting rates of delayed monetary gains and losses will be compared to determine if
behavior during monetary intemporal choices differ for gains as compared to losses. Similarly, discounting rates of interpersonal gains and losses will also be compared to determine if behavior differs for gains and losses when outcomes are social in nature.

Specific Aim 1a. To determine whether monetary temporal discounting rates differ when choices are framed as gains or losses. Specifically, it is hypothesized that:

a. Older adults will demonstrate a preference for delayed gratification as evidenced by lower temporal discounting rates for monetary gains. As such, they will choose the larger delayed gain more often than the smaller immediate gain.

b. Older adults will demonstrate greater loss aversion as evidenced by steeper temporal discounting rates for monetary losses. Therefore, they will be more likely to choose the larger delayed loss as compared to the smaller immediate loss.

c. There will be a significant difference in the discounting rate between monetary gains and monetary losses. Specifically, the discounting rate and discounting function will be steeper for losses when compared to gains.

Specific Aim 1b. To determine whether interpersonal temporal discounting rates differ when choices are framed as gains or losses. Specifically, it is hypothesized that:

d. Older adults will demonstrate a preference for immediate social gratification as evidenced by steeper temporal discounting rates for interpersonal gains. As such, they will choose the smaller immediate gain more often than the larger delayed gain.

e. Older adults will demonstrate lesser loss aversion as evidenced by lower temporal discounting rates for interpersonal losses. Therefore, they will be more likely to choose the smaller immediate loss more often than the larger delayed loss.
f. There will be a significant difference in the discounting rate between interpersonal gains and interpersonal losses. Specifically, the discounting rate will be lower for losses when compared to gains, and the discounting function will therefore be more gradual for losses than for gains.

Specific Aim 2. To investigate whether social isolation and degree of loneliness were associated with decision-making preferences.

Prior research has suggested older adults display differing discounting rates for monetary gains as opposed to non-monetary gains (Seaman et al., 2016). Specifically, older adults prefer immediate but smaller socially salient rewards, and delayed but larger monetary rewards when compared to younger adults (Seaman et al., 2016). However, to our knowledge, these distinctions have not been investigated in loss conditions, nor is it clear what specific characteristics may contribute to these differences. One specific characteristic is the decision maker’s environment, particularly as it pertains to their accessibility and desire for interconnectedness. Prior research suggests older adults are at an increased risk for poor health outcomes due to isolation and loneliness. Additionally, both loneliness and social isolation have been found to impact decision-making by way of impulsivity and poor executive control. Furthermore, given the social disparities that arose for older adults in the context of the COVID-19 pandemic, we sought to determine whether social isolation and loneliness were associated with decision-making preferences.

Specifically, it is hypothesized that:

a. Individuals who report higher levels of social isolation will display steeper discounting for social gains and social losses (e.g., more frequently choosing the immediate social gain and the delayed social loss), but more shallow discounting for
monetary gains and losses (e.g., more frequently choosing the delayed monetary gain and the immediate monetary loss).

b. Individuals who report greater levels of loneliness will display steeper discounting for social gains and social losses (e.g., more frequently choosing the immediate social gain and the delayed social loss), as well as steeper discounting for monetary gains and losses (e.g., more frequently choosing the immediate monetary gain and the delayed monetary loss).

**Specific Aim 3. To examine the influence of potential moderating factors on decision-making behavior in older adults.**

As previously mentioned, literature is mixed regarding decision-making behavior and preferences in older adults. Some research suggests older adults outperform in their ability to maximize outcomes on temporal discounting tasks relative to younger age groups, while other research suggests the opposite behavior. Age-related changes in affect and cognition may represent key reasons for this variability. For example, older adults may experience improvements in emotion regulation abilities and increased positive affect that improve decision-making ability, particularly as it relates to experiential-based decisions. Relatedly, some research suggests positive affect is associated with a preference for delayed rewards by way of higher levels of self-reported gratitude. In contrast, age-related decrements in cognitive flexibility, inhibition and allocation of attentional resources may collectively impair decision-making ability. Further, it is thought that decisions made in loss conditions require more cognitively demanding resources than for decisions made in gain conditions. Taken together, affective, and cognitive processes may influence how older adults perform in decision-making tasks; however, these processes have not been comprehensively studied across gain and loss conditions. As such,
Aim 3 will examine the relative contributions of state positive affect and executive control on temporal discounting rates for monetary and socially salient outcomes.

Specific Aim 3a. To determine whether state positive affect and executive control predict temporal discounting rates for monetary gains and losses. Specifically, it is hypothesized that:

a. Greater state positive affect and executive control will both account for a significant amount of the variance in temporal discounting rates for monetary gains, and specifically will associate with lower temporal discounting rates.

b. Greater state positive affect and executive control will both account for a significant amount of the variance in temporal discounting rate for monetary losses, and specifically associate with a steeper temporal discounting rate.

Specific Aim 3b. To determine whether state positive affect and executive control predict temporal discounting rates for socially salient gains and losses. Specifically, it is hypothesized that:

c. Greater state positive affect and lesser executive control will both account for a significant amount of the variance in temporal discounting rate for socially salient gains, and specifically associate with a steeper temporal discounting rate.

d. Greater positive affect and lesser executive control will both account for a significant amount of the variance in temporal discounting rate for socially salient losses, and specifically associate with a lower temporal discounting rate.

Specific Aim 3c. To determine whether the magnitude of the associations between contextual factors (state positive affect and executive control) and discounting rates differ according to outcome type. Specifically, it is hypothesized that:
e. The magnitude of the relationship between positive affect and temporal discounting rate for socially salient gains will be stronger than the magnitude of the relationship between positive affect and temporal discounting rate for monetary gains as evidenced by larger correlation coefficients and positive z-values.

f. The magnitude of the relationship between executive control and temporal discounting rate for monetary losses will be stronger than the magnitude of the relationship between executive control and temporal discounting rate for socially salient losses as evidenced by larger correlation coefficients and positive z-values.

Specific Aim 4. To explore whether there is an association between laboratory-based decision-making behavior and real-life health behavior choices.

It is possible that affective and cognitive changes may collectively promote greater impulsive choices by way of waning impulse-control, over-evaluating present satisfaction compared to future well-being, and overestimating benefit in certain situations, while simultaneously underestimating it in others. These decision errors may translate to poor lifestyle choices, thereby increasing older adults’ risk for adverse health outcomes such as cardiovascular disease and dementia. For these reasons, an exploratory aim (Aim 4) will use a data-driven approach to explore the relative contributions of affective traits, executive control, and temporal discounting rate on self-reported health-behaviors. This secondary analysis will first test a rudimentary model to determine the associations amongst affective traits, executive control, and discounting rates on health behaviors, followed by a more comprehensive model that adjusts for relevant demographic factors and tests the statistically significant variables effect on health-behaviors.
CHAPTER 3

METHODS

Participants

One Hundred and forty participants aged 50 to 90 were recruited as part of the second wave of the Maine-Aging Behavior Learning Enrichment (M-ABLE) Study conducted at the University of Maine. The first wave of the M-ABLE study used community-based participatory research (CBPR) methods to enhance the recruitment of a socioeconomically diverse sample of older adults, most of whom eventually became part of the Cognition Aging Resiliency Enhancement (CARE) laboratory participant registry. The CARE Lab registry is comprised of over 150 older adults who gave permission to be contacted about future research studies. New participants for the current study were recruited through the same CBPR methods used during wave one (e.g., posting flyers in frequented locations such as the public library, grocery stores, gas stations, coffee shops, etc.). Return participants were obtained through the CARE Lab registry. Except for two tests, both new and returning participants underwent identical procedures for the current study.

Participants were first screened for eligibility and underwent informed consent procedures approved by the University of Maine Institutional Review Board (IRB #2022-09-13). Study visits were conducted via Zoom and telephone following Center for Disease Control (CDC) COVID-19 guidelines during the Delta and Omicron periods of the COVID-19 pandemic (November 2021 to May 2022). Study inclusion criteria were intentionally wide to improve the generalizability of findings. Inclusion criteria included: the ability to participate via Zoom given the modality of the decision-making paradigm, being 45 years of age or older, and willingness to complete assessment measures. Exclusion criteria included: a history of a neurodegenerative
disorder (e.g., Parkinson’s disease or Alzheimer’s disease), physical limitations (e.g., hearing impairments) that would preclude completion of study measures, or currently receiving treatment for a dementia disorder. Individuals diagnosed with an intellectual disability or any medically untreated severe mental illness (e.g., psychotic disorders) were also excluded. Participants were compensated with a $25 gift card to a local grocery store for completion of the study.

**Procedure**

**Self-Report Measures**

The following measures were administered during the study visit to assess demographic characteristics, state affect, sociability factors, and health behaviors.

**Demographic Information.** Participants provided date of birth, sex, race, ethnicity, years of education, occupational status, and income level. Regarding income level, participants' approximate family income (including wages, disability payment, retirement income, and welfare) was obtained via a confidential survey. Annual income levels were organized into nine choices: 1) < $10,000 (1%), 2) $10,00 - $19,999 (5%), 3) $20,000 - $29,999 (11%), 4) $30,000 - $39,999 (10%), 5) $40,000 - $49,999 (16%), 6) $50,000 - $59,999 (14%), 7) $60,000 - $69,999 (10%), 8) $70,000 - $100,000 (13%) and 9) > $100,000 (19%). One participant refused to disclose income information; therefore, their data was replaced with the sample mean income.

**Sociability.** Two separate measures addressing participant perceptions of loneliness and social isolation were administered. One item (“how isolated or cut off from family and friends are you feeling due to COVID-19?”) from the NACC COVID-19 Impact Survey was used to evaluate participants’ level of isolation (NACC, 2020). Participants answered the question using a five-point Likert scale ranging from 1 (not at all isolated) to 5 (extremely isolated).
Additionally, a two-item exit survey evaluating sociability was developed for this study. The first question ("did you have a special loved one you thought about when you were offered a choice about having more time with them later as opposed to having less time now?") required a yes/no response and aimed to capture further details about contextual factors driving social decision-making preferences. For the second question, participants rated on a four-point Likert scale, ranging from 1 (not at all) to 4 (very much), the degree to which they agreed with the statement: "I feel very lonely."

**Affect.** Self-reported trait and state affect were obtained through the Positive and Negative Affect Schedule (PANAS; Watson *et al.*, 1988). For trait affect, the 20-item PANAS was used. This is a 20 item self-report measure that assesses various emotions, with 10 items loading on to a positive affect factor, and 10-items loading onto a negative affect factor (Watson *et al.*, 1988). Examples of items that correspond to positive affect include “interested”, “excited”, and “enthusiastic”; while example items representing negative affect include “distressed”, “irritable”, and “afraid.” Participants were asked to rate the degree to which they experienced specific emotions within the past week according to a five-point Likert scale, ranging among the following options: 1 (*very slightly or not at all*), 2 (*a little*), 3 (*moderately*), 4 (*quite a bit*), and 5 (*very often*). Items were summed to create a total score for the Trait Positive Affect (Trait PA) scale and the Negative Affect (Trait NA) scale, in which higher scores represent greater endorsement of each construct. The PANAS has demonstrated excellent internal consistency as well as convergent and divergent validity (Watson *et al.*, 1988). Within the current sample, the trait PANAS demonstrated good reliability of the Trait PA (α = .892) and Trait NA (α = .851) scales among community-dwelling older adults. Both trait PA and NA scales were used as characterization variables in the current study.
Participants’ state affect was measured using a 10-item variation of the 20-item PANAS (Thompson, 2007). Five items corresponded to state positive affect (e.g., attentive, alert, determined, proud, strong) and five items corresponded to state negative affect (e.g., hostile, ashamed, upset, afraid, nervous). Participants were instructed to rate the degree to which they were experiencing each emotion “right now at the present moment” using a five-point Likert scale. Response options included: 1 (very slightly or not at all), 2 (a little), 3 (moderately), 4 (quite a bit), or 5 (very much). Participants completed this scale directly before engaging in the decision-making tasks. Items were summed to create a total score for the State Positive Affect (State PA) scale and the State Negative Affect (State NA) scale, in which higher scores represent greater endorsement of each construct. Internal consistency for the State PA ($\alpha = .758$) and the State NA ($\alpha = .628$) scales were deemed adequate based on recognition that shorter scales will produce lower alpha coefficients as a function of the Spearman Brown formula (Schmitt, 1996). State PA total score was used as a predictor variable for regressions in Aims 3 and 4. The State NA total score was also used as a predictor for the Aim 4 regression and results are framed in the context of reliability.

**Health Behaviors.** To further understand the specific behaviors and decisions that may be driving overall health functioning, participants completed the Good Health Practices Scale (GHP; Hampson *et al.*, 2019). The GHP is derived from a broader measure known as the Health Behavior Checklist (HBC) which loaded behaviors onto a four-factor solution of Wellness Maintenance, Accident Control, Traffic Risk, and Substance Use (Vickers *et al.*, 1990). Thirteen items did not load highly onto any one factor and were thus not included in the original scales but instead referred to as additional items (Vickers *et al.*, 1990). All 10- items from the Wellness Maintenance scale, five additional items, and one item from the Substance Use scale comprised
the GHP (Hampson et al., 2019). Women demonstrated significantly more favorable (e.g., healthier) scores than men in the Hampson 2019 sample. The 16-item GHP scale assesses various health behaviors (e.g., “I take vitamins”, “I see a doctor for regular checkups”, “I brush my teeth regularly”). Participants were asked to rate the degree to which they agree with how each item describes his or her typical behavior based on a 5-point Likert scale with the following options: 1 (strongly disagree), 2 (disagree), 3 (neither agree nor disagree), 4 (agree), and 5 (strongly agree). Higher scores indicated overall healthier behavior. The Good Health Practices Scale evidenced good reliability in the original sample (α = .83) and showed significant associations with chronic disease risk factors in an older adult sample (Hampson et al., 2019) above and beyond the original measure. Within the current sample, the scale demonstrated questionable internal item consistency (α = .684). Evaluation of the test items indicated a marginal improvement with the scale reaching the threshold for the minimum for satisfactory reliability (Lance et al., 2006) if the question, “I get shots to prevent illness”, was removed (α = .702). Therefore, the 15-item scale was used and the total score on this scale was used as a continuous outcome variable for the exploratory aim (Aim 4).

**Decision Making Paradigm**

For each decision-making task condition, participants completed five practice trials before moving on to test trials as outlined in a prior study of older adults (O’Brien & Hess, 2020). These trials were similar to test trials in terms of response format and question type but differed in content. These practice trials were conducted to familiarize participants with the task and present opportunities for clarification and ensure comprehension of the task. Participants were encouraged to ask clarifying questions during this time, and all participants demonstrated an understanding of the task. Decision-making task conditions were counterbalanced using a
balanced full Latin square design in which the four decision-making tasks (monetary gains, monetary losses, social gains, and social losses) were presented in differing order for every four participants, and then repeated as outlined in Table 1 below. The estimated time to complete each decision-making paradigm was approximately 7-8 minutes, for an overall total of 30 minutes.

Table 1. Latin Square Design for Test Condition Sequence

<table>
<thead>
<tr>
<th>Participant</th>
<th>Test Condition Sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A B D C</td>
</tr>
<tr>
<td>2</td>
<td>B C A D</td>
</tr>
<tr>
<td>3</td>
<td>C D B A</td>
</tr>
<tr>
<td>4</td>
<td>D A C B</td>
</tr>
</tbody>
</table>

Note. A = monetary gain task; B = monetary loss task; C = social gain task; D = social loss task

Temporal discounting was assessed with a task adapted from a well-validated decision-making paradigm (Du et al., 2002) and implemented using E-prime Version 3.0 experimental software. The decision-making paradigm was composed of four conditions (monetary gains, monetary losses, social gains, social losses) that were counterbalanced across participants as outlined above. In each condition, participants were presented with a series of hypothetical choices in which they were asked to choose between a smaller outcome available immediately, and a larger outcome available after a specified delay period. Participants were instructed to choose between an option on the left side of the screen and option on the right side of the screen for every trial, with the immediate and delayed choices randomly switching sides of the screen. Due to the online nature of the study, examiners were responsible for choosing the option communicated by the participant.
The delay periods consisted of one week, one month, six months, and one year. The amount of the delayed outcomes stayed fixed across trials within each condition. In contrast, the amount of the immediate outcome adaptively changed across trials, such that the options presented in the subsequent trial were contingent upon the choice made in the previous trial and is described in more detail below. This iterative algorithm (Frye et al., 2016) was used within each delay level of every condition and allowed for convergence on a subjective value of the delayed outcome. This yielded an indifference point, or the point at which the participant was indifferent to either outcome, for each delay level. Instructions for all conditions were adapted from Estle and colleagues (2006). Each participant made a total of 112 choices (7 trials at each delay period x 4 delay periods x 4 conditions). Condition-specific details are outlined as follows.

**Monetary Temporal Gains.** During the monetary gains condition, the delayed reward amount remained consistent across all trials at $100. Participants made seven choices at four delay levels (1 week, 1 month, 6 months, and 1 year) for a total of 28 trials. During the first trial of each delay period, participants were asked to choose between a delayed reward of $100 and an immediate reward whose amount was half of the delayed reward (e.g., $50 now vs. $100 in 1 week). Additionally, for each of the subsequent choices, the immediate reward amount was contingent on the participant’s choice on the previous trial. For example, if the participant chose the immediate reward on the first trial, the immediate reward amount on the second trial decreased in value. In other words, if the participant chose $50 now on the first trial, their choices on the second trial would be $25 now vs. $100 in one week. Relatedly, if the delayed reward was chosen on the first trial, the immediate reward amount on the second trial increased. Said differently, if the participant chose to gain $100 in one week on the first trial, the options for the second trial were between $75 now vs. $100 in one week. As such, the size of each
subsequent adjustment across trials decreased with each trial, until seven choices were made for each delay level. This procedure allowed for convergence on a subjective value of the delayed reward. This process was then repeated for each delay level, such that four separate indifference points were derived. Instructions for the monetary gains condition are as follows:

“In this task, you will be presented with hypothetical situations in which you will make a choice about different amounts of money you could GAIN. Two options will be presented to you. One option is an amount that can be received NOW, and the other amount can be received LATER. For instance, on the current screen, there are two boxes: The "Now" option is to Gain $1 and the "Later" option is to Gain $5 in 5 days. There are no “right” or “wrong” answers. We are only interested in your preferences! Before we begin, please note that the NOW and LATER choices will switch sides of the screen at times. Additionally, the amounts and durations will also change, so you will want to read each selection carefully before responding. Please sit comfortably in front of the computer and make your choice by telling me whether you prefer the "NOW" or "LATER" option. Any questions?”

Examiners allowed participants to read each option for themselves and communicate their choice before progressing to the next trial.

Figure 2. Example trail for the monetary gain condition

<table>
<thead>
<tr>
<th>Gain $50</th>
<th>Gain $100</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOW</td>
<td>LATER</td>
</tr>
<tr>
<td>In 1 week</td>
<td></td>
</tr>
</tbody>
</table>
**Monetary Temporal Losses.** The delay amount ($100) and delay period levels (1 week, 1 month, 6 months, and 1 year) were identical to the gain condition. A similar algorithm to that used in the gain condition was used for the loss condition, with the only difference being the direction in which the adjustments across trials were made. For example, if on the first trial, the participant chose to pay $50 now instead of paying $100 in one week, then the choices on the next trial would be between paying $75 now and $100 in one week. Similarly, if the participant chose to pay $100 in one week on the first trial, their options on the second trial would be between paying $25 now and $100 in one week. The instructions for this condition were as follows:

“In this task, you will be presented with hypothetical situations in which you will make a choice about different amounts of money you would have to PAY. Two options will be presented to you. One option is an amount that you would lose NOW, and the other amount you would lose LATER. For instance, see the screen now. There are two boxes: The "Now" option is to Pay $1 and the "Later" option is to Pay $5 in 5 days. There are no “right” or “wrong” answers. We are only interested in your preferences! Before we begin, please note that the NOW and LATER choices will switch sides of the screen at times. Additionally, the amounts and durations will also change, so you will want to read each selection carefully before responding. Please sit comfortably in front of the computer and make your choice by telling me whether you prefer the "NOW" or "LATER" option. Any questions?”
Examiners allowed participants to read each option for themselves and communicate their choice before progressing to the next trial.

Figure 3. *Example trial for the monetary loss condition*

![Example trial for the monetary loss condition](image)

**Social Temporal Gains.** The social paradigm was based on Seaman and colleagues (2016) work and utilized the same algorithms followed in the monetary temporal discounting procedures. In the social gain condition, participants again chose between a smaller reward available immediately, and a larger reward available after a certain period of time. However, instead of increments of money, the task utilized increments of time spent engaging in a hypothetical treasured activity with a loved one. The delayed amount of time was consistent across all trials at 180 minutes (3 hours). Participants made seven choices at four delay levels (1 week, 1 month, 6 months, and 1 year) for a total of 28 trials. The first choice was always between a delayed reward and an immediate reward whose amount of time was half of the delayed reward (e.g., 1.5 hours now vs. 3 hours in 1 week). For each of the subsequent choices, the immediate time amount was contingent on the participant’s choice on the previous trial. For example, if the participant chose the immediate amount of time on the first trial, the immediate time amount on the second trial decreased. In other words, if the participant chose 1.5 hours now on the first trial, their choices on the second trial would be .75 now vs. 3 hours in on week. Relatedly, if the delayed reward was chosen on the first trial, the immediate time amount on the
second trial increased. Said differently, if the participant chose 3 hours in one week on the first trial, their options for the second trial would be 2 hours and 15 minutes now vs. 3 hours minutes in one week. The size of each subsequent adjustment across trials decreased with each trial, until seven choices were made for each delay level. This procedure allowed for convergence on a subjective value of the delayed reward. This process was then repeated for each delay level, such that four separate indifference points were derived. Instructions for the social gains task are as follows:

“In this task, you will be presented with hypothetical situations in which you will make a choice about different amounts of TIME you could GAIN doing a social activity you enjoy. Imagine that you are doing this activity with a person you wish you could spend more time with, such as a loved one or a friend. Two options will be presented to you. One option is an amount that can be received NOW, and the other amount can be received LATER. For instance, see the screen now. There are two boxes: The "Now" option is to Gain 0.5 hours and the "Later" option is to Gain 2 hours in 5 days. There are no “right” or “wrong” answers. Make each decision as if you were being offered the choice for real. We are only interested in your preferences! Before we begin, please note that the NOW and LATER choices will switch sides of the screen at times. Additionally, the amounts and durations will also change, so you will want to read each selection carefully before responding. Please sit comfortably in front of the computer and make your choice by telling me whether you prefer the "NOW" or "LATER" option. Any questions?”
Examiners allowed participants to read each option for themselves and communicate their choice before progressing to the next trial.

Figure 4. Example trial for the social gain condition

![Example trial for the social gain condition](image)

**Social Temporal Losses.** The amount of delay time lost (3 hours) and the delay period levels (1 week, 1 month, 6 months, and 1 year) in the loss condition were identical to the gain condition. A similar iterative process used in the gain condition was used for the loss condition, with the only difference being the direction in which the adjustments are made. For example, if on the first trial, the participant chose to lose 1.5 hours now instead of losing 3 hours in one week, then the choices on the next trial were between losing 2.25 hours now and 3 hours in one week. Similarly, if the participant chose to lose 3 hours in one week on the first trial, the options on the second trial were between losing .75 hours now and losing 3 hours in one week. The instructions for this condition are as follows:

“In this task, you will be presented with hypothetical situations in which you will make a choice about different amounts of time you would have to LOSE doing a social activity you enjoy. Imagine that you are losing time doing this activity with a person you wish you could spend more time with, such as a loved one or a friend. Two options will be presented to you. One option is an amount that would be lost NOW, and the other amount would be lost LATER. For instance, see the screen now. There are two boxes: The "Now" option is to Lose 0.5 hours and..."
the "Later" option is to Lose 2 hours in 5 days. There are no “right” or “wrong” answers. Make each decision as if you were being offered the choice for real. We are only interested in your preferences! Before we begin, please note that the NOW and LATER choices will switch sides of the screen at times. Additionally, the amounts and durations will also change, so you will want to read each selection carefully before responding. Please sit comfortably in front of the computer and make your choice by telling me whether you prefer the "NOW" or "LATER" option. Any questions?"

Examiners allowed participants to read each option for themselves and communicate their choice before progressing to the next trial.

Figure 5. Example trail for the social loss condition

Executive Control Task

**Oral Trails A and B.** The Oral Trail Making Test Part A (OTMT-A) and Part B (OTMT-B; Ricker & Axelrod, 1994) are measures of auditory attention and sequential set-shifting. These tasks were created to remove the visual and motor demands present in the written TMT (WTMT; Reitan, 1958) and are widely viewed as oral analogs for the WTMT. In the OTMT-A task, participants are instructed to count out loud as quickly as possible from one to 25. Participants are allowed a maximum of 100 seconds to complete the task and are discontinued if not completed within this time frame. If the participant does not finish the task by 100 seconds,
the score is 100. The total time in seconds, total number of errors, and total number correct are recorded. On the OTMT-B task, participants are instructed to count by switching between numbers and letters (e.g., 1-A, 2-B, 3-C, etc.) until they reach the number 13. Errors are brought to the participant’s attention by the examiner and redirection is allowed (e.g., “you said [specific number] [specific letter], continue from there”) as it is nearly impossible for participants to correct a set-loss error without a prompt. Participants can also be reminded “number-letter” by the examiner to keep them on task if needed. The task is discontinued if not completed within the required 300 second time frame. If the participant does not finish the task by 300 seconds, the score is 300. The total time in seconds, total number of errors, and total number correct are recorded. The OMT-B total score served as an estimate of executive control and was used as a continuous predictor variable in Aims 3 and 4. The OMT-A total score was used as a covariate in Aims 3 and 4 regressions to adjust for the impact of processing speed on the OMT-B score.

Neuropsychological Assessment

As part of the larger M-ABLE study, cognitive functioning was measured with the National Alzheimer’s Coordinating Center (NACC) Uniform Data Set-Version 3 (UDS-V3) Telephone (T-Cog) Neuropsychological Battery (Version 3.0, July 2020). Although the Oral Trail Making Test was the only part of this battery used for the current study, collecting comprehensive neuropsychological data allowed for examination of potential contributing factors related to decision making for further study. The UDS-V3 T-Cog neuropsychological test battery is comprised of tests measuring various cognitive domains including episodic memory, non-contextual verbal memory, attention, working memory, language, and executive function. These tests were selected based on their collective sensitivity to detect healthy age-related
changes in cognitive function, cognitive dysfunction in Alzheimer’s disease (AD), cognitive change over time, and progression within the AD continuum (see Weintraub et al., 2018).

Study Visit Procedure

Participants were screened remotely for inclusion/exclusion criteria via phone. All study visits were conducted during via Zoom due to the COVID-19 pandemic. Examiners were required to conduct sessions from the CARE Lab at North Stevens Hall at the University of Maine. Participants were instructed to complete the visit in a quiet space and/or private room, switch cellphones to silent mode, and turn off TV/radio in efforts to limit distractions. The environment was further assessed by asking participants if they were able to hear the examiner well, put in hearing aids if they normally used them, and to repeat a sentence verbatim in order to evaluate comprehension. In the event of connectivity issues, participants were provided with the lab phone number and examiners had participant numbers nearby in case visits needed to be finished via telephone. The informed consent form was sent to participants in advance of their visit and was again reviewed at the beginning of the visit. Due to the online nature of the study, verbal consent was obtained from each participant before continuing with study procedures.

Demographic characteristics, medical history, and current medication information was collected from each participant. Next, participants answered questions about their perceived impact of COVID-19 on day-to-day life as well as questions about their physical activity levels. Participants were then asked about their levels of test anxiety (e.g., “on a scale of 1-5, with 1 being not at all and 5 being very much how worried are you about passing the tests?”) and information about the nature of neuropsychological tests was communicated to each participant. Examiners read the following description to each participant: “We will be asking you to do a number of things, some of which you may find easy, and others that they may be more
challenging. It is common to be nervous about memory and thinking measures but do not worry
the measures in this study cannot be “passed” or “failed”. They do help us understand how
someone performs compared to people of the same age. We really appreciate your volunteering
because learning about these individual differences can help us better understand thinking and
memory with age and may help us to develop new ways to keep the brain healthy.” Additionally,
for test validity purposes, participants were reminded to not write things down. Specifically, they
were instructed, “Before we get started, it is very important that the tasks we do today are done
in your head without any assistance or by writing things down. Do you have any pens/pencils or
paper in front of you right now? If you wouldn’t mind, can you push these out of the way for the
time being since we will not be using these during these games.” Participants were then
administered all neuropsychological measures followed by a five-to-ten-minute break. Next,
participants completed half of the study questionnaires via Qualtrics. Decision-making
paradigms were then administered, followed by the second half of questionnaires. The visit
ended with an exit survey and information was collected to compensate participants for their
time. In total, study procedures took approximately three hours to complete.
Analyses

Preliminary Analyses

For Aim 1, initial power analyses using G*Power (Faul *et al.*, 2009) indicated that a sample of 134 participants was sufficiently powered (.80) to detect within-group differences between decision-making conditions based on an expected effect size of .25. For Aim 2, a priori power analyses revealed that a sample of 128 participants were sufficiently powered (.80) to detect medium effects (.50) in an independent t-test for two groups. For hierarchical regression analyses used in Aims 3 and 4, power analyses suggested that a sample of 123 participants was sufficiently powered (.80) to detect medium effects (.15) in the most complex model to be tested, which included eleven tested predictors. Given that Aim 1 required the greatest number of participants, this Aim was used as a target for enrollment. Data from an additional six participants were collected in order to account for the potential need to remove subjects due to artifacts or incomplete data. Preliminary analyses examined for patterns of missing values within the data set. Missing data included three participants’ OMT-B scores, one participant’s annual income, and one participant’s social gains and social loss discounting values. Various missing data methods were ruled out. Namely, trimming the data was not used so as to retain as many cases as possible. Moreover, while mean imputation is generally not suggested as a method for replacing missing data, some studies point out that the limits of mean imputation are nearly absent if less than 10% of the data is missing and correlation between the variables are low (see Lodder, 2013 for review). Since the missing income data represented less than 0.1% of total values, the missing income value was replaced using series mean. The OMT-B missing scores were replaced using a comparative value based on the respective TMT-A z-score for the
participant. This procedure was also used to replace the social discounting rates for a single participant.

Discounting data was examined for validity by identifying participants who demonstrated a non-systematic responding (NSR) pattern. Briefly, NSR occurs when participants respond in such a way that their subjective values of delayed outcomes increase and decrease in a nonsensical or haphazard way. Twenty-two unique participants were identified as NSR according to a variation of Criterion 1 of the algorithm proposed by Johnson and Bickel (2008). This algorithm identifies indifference points that do not monotonically decrease with the delay period. A variation of Criterion 1 was used to identify NSR, which met that if any indifference point (starting with the second delay) was greater than the preceding indifference point by a magnitude greater than 30% of the larger later reward (i.e., $30 for monetary trials and 0.9 hours for social trials) it was considered NSR. This method is preferred over R^2 when determining the goodness of fit for discounting data due to systemic confounds with R^2 (Johnson & Bickel, 2008). Namely, R^2 tends to be more stringent with lower discounting rates and is therefore more biased toward steeper discounters. Overall, it introduces a bias toward shallow discounters (Johnson & Bickel, 2008). The percentage of systematic data in the current sample was within the expected range (see Smith et al., 2018). Participants who were identified as non-systematic responders did not differ in age, education, income level, sociability factors, executive control, positive state affect (two-tailed independent sample t-tests, ps > 0.2), or sex (χ^2 tests; p > 0.5) when compared to those participants with systematic data. Additionally, no order effects were observed in those participants identified as NSR. Thus, based on prior outlined recommendations (Johnson & Bickel, 2008; Smith et al., 2018), analyses were conducted using all available data.
Descriptive statistics were generated for demographic variables of the overall sample, including age, sex, years of education, and income level, as well as sociability variables (e.g., loneliness and isolation). Descriptive statistics were also computed for the executive control variable (e.g., Oral Trail Making Test B time), and self-report measures (e.g., state positive affect, state negative affect, trait positive affect, trait negative affect, and health behaviors) to obtain characteristics of the sample and to determine if assumptions of normality were violated according to recommended guidelines (Field, 2013). Discounting rates, neuropsychological variables and self-report measures were visually inspected for outliers, skew, and kurtosis. Significant outliers (z-scores exceeding ± 3.29 standard deviations from the mean) were winsorized (e.g., extreme values were replaced with the next closest non-outlier value) to reduce skew of the distribution and utilize as many cases as possible in efforts to accurately reflect sample variance (Tabachnick & Fidell, 2007). Significant skew was defined as skew > 3 and significant kurtosis defined as kurtosis > 10 (Tabachnick & Fidell, 2007). In addition to univariate assumptions of normality, multicollinearity, homoscedasticity, and multivariate outliers were also assessed to ensure that variables also met multivariate assumptions of normality for Aims 3 and 4 (Tabachnick & Fidell, 2007). To examine multicollinearity, collinearity tests were used to determine if predictor variables were correlated too highly. Multicollinearity among predictor variables was therefore defined as Tolerance <.10 and VIF >10; Field, 2013). The Durbin–Watson test was also used to assess for serial correlations between residual terms for Aims 3 and 4. Values less than one or greater than three were considered a violation of the assumption of independence (Field, 2013). Multivariate outliers were defined with the approach that allowed for the largest number of cases to be retained (e.g., Cooks distance <1) as outlined in Fields, 2013.
Discounting rates ($k$-values) were not normally distributed (e.g., significant skew and kurtosis) and were also non-amenable to transformations. While AUC values met skew and kurtosis assumptions, the residuals of these measures were non-normally distributed as evident by QQ plots and significant Shapiro-Wilk Tests ($p<.001$). Therefore, nonparametric robust methods were utilized for Aim 3. Robust statistics have the advantage of controlling for Type I error while still maintaining adequate statistical power (Ecreg-Hurn & Mirosevich, 2008). Specifically, bootstrapping procedures were used for the proposed hierarchical regressions in Aim 3. Bootstrapping is a nonparametric approach to statistical inference that uses computation in place of traditional distributional assumptions and asymptotic results (Efron, 1979). It is a method that does not make assumptions about the distribution of $\beta$ or the errors but rather rests on the premise that the observed sample is a good representation of the actual population (Davison & Hinkley, 1997; Efron, 1979; Efron & Tibshirani, 1993). It is a computationally intensive method that involves repeatedly sampling from the data and estimating the regression weights over and over again in each resampled data set. By repeating this process thousands of times, an empirical approximation of the sampling distribution of the $B$-weights is built, and the standard deviation of $\beta$ becomes the empirical estimate of the standard error for that $\beta$. In essence, it helps build a confidence interval around a sample statistic and generates standard errors without imposing normality on the sampling distribution. This is a widely used and accepted method for dealing with issues of non-normality in dependent variables of a multiple regression (Ecreg-Hurn & Mirosevich, 2008). If confidence intervals are the desired outcome from the bootstrap, then 1000 or more bootstrap samples are recommended. As such, 2000 samples were used for the current study.
All tests of significance were two-tailed. To reduce the likelihood of type I errors associated with multiple comparisons, Bonferroni corrections were applied within families of planned contrasts, and adjusted \( p \)-values are presented. For parametric tests, the Cohen’s \( d \) statistic served as a measure of effect size, with the values of 0.2, 0.5, and 0.8 representing small, medium, and large effects, respectively (Cohen, 1988). Adjusted \( R^2 \) also served as a measure of effect size in the hierarchical multiple regressions, in which 0.01, 0.09, and 0.25 were estimates of small, medium, and large effect sizes, respectively. For non-parametric tests, effect sizes were derived by dividing the \( z \) statistic by the square root of the total sample size in order to obtain an \( r \) value (Field, 2013). Thus, for nonparametric tests, Pearson’s \( r \) served as an effect size, with the ranges of \([±0.1 – 0.3]\), \([±0.3 – 0.5]\), and \([±0.5 and higher]\) representing small, medium, and large effects respectively (Cohen 1977; Cohen 1988). Nonlinear curve-fitting analyses were performed using GraphPad Prism Version 9.0 software, and all other statistical analyses were performed using SPSS Version 28.

**Analytic Approach to Testing Primary Aims**

**Aim 1.** Aim 1 sought to determine whether there were differences in temporal discounting rates between gain and loss conditions when outcomes were monetary or interpersonal in nature. Considerable research indicates that temporal discounting rates are best approximated and described by a partial hyperbolic function (Du et al., 2002; Estle et al., 2006; Green et al., 1996; Kable & Glimcher, 2007; Laibson, 1997; Levy & Glimcher, 2011; Löckenhoff et al., 2011; Mazur, 1987; McClure et al., 2004; Rachlin et al., 1991; Whelan & McCue, 2009). Therefore, discounting rates were first derived using a partial hyperbolic function \[ V = A/(1 + kD) \] posited to best represent and quantify temporal discounting rates (Mazur, 1987). Within this equation, \( V \) represents the subjective value of the delayed outcome, \( A \) is equal to the
objective value of the delayed outcome, \( k \) is the discounting rate, and \( D \) is the magnitude of the delay period.

Due to the iterative nature of the decision-making paradigm, the last choice made by each participant within each delay level was equivalent to their indifference point for that delay. Thus, four indifference points were derived for each participant for each condition. Second, group median indifference points for each delay level within each condition were calculated. Medians were utilized, given that distributions for discounting functions are typically skewed due to the limits imposed on choice options (Green et al., 1996). Next, group median indifference points were fit to the aforementioned hyperbolic model using least squares nonlinear regression in GraphPad Prism Version 9.0 to determine discounting rates, \( k \), for each condition plotted as a function of time in weeks. Individual discounting rates from select participants are shown for both monetary (Figure 6) and social (Figure 9) conditions to demonstrate the possible range of discounting rates (e.g., shallow to steep). Group median discounting rates for each condition are depicted in the results (Figures 7 & 10). As expected, \( k \)-values were significantly skewed, non-normally distributed, and non-amenable to transformations. Therefore, non-parametric tests were used to determine if there were significant differences in discounting rates between conditions. Specifically, Wilcoxon-Signed Rank tests compared individual discounting rates between conditions.

In order to address issues of non-normality, a second well-established method for representing discounting rates, known as area under the curve (AUC; Myerson et al., 2001) was derived. Briefly, the AUC is calculated based on observed subjective values, rather than the values predicted by a particular theoretical equation (Myerson et al., 2001). It thus has the advantage of quantifying discounting rates without committing to a particular mathematical form.
of the discounting function and is posited to have a normal distribution making it ideal for skewed discounting data (Myerson et al., 2001). Data was first normalized so that the delay value and subjective value fall on a scale from 0 to 1. That is, the delay was expressed as a proportion of the maximum delay, and the subjective value was expressed as a proportion of the maximum delayed nominal amount. These normalized values were used as x and y coordinates respectively, to construct a graph of the discounting data. Vertical lines were then drawn from each data point to the x-axis, subdividing the graph into a series of trapezoids. The area for each trapezoid was derived \( \{ (x_2 - x_1) \times (y_2 + y_1) / 2 \} \), where \( x_1 \) and \( x_2 \) are successive delays, and \( y_1 \) and \( y_2 \) are the subjective values associated with these delays. All trapezoid areas within each condition were summed to yield the AUC for each condition. The area measure is normalized so that it ranges from 0.0 to 1.0, where 0.0 represents the steepest possible discounting and 1.0 represents no discounting at all (Myerson et al., 2001). AUC values met assumptions of normality for within-group comparison tests. Therefore, paired samples t-tests were used to determine if there were significant differences in discounting rates between conditions. AUC graphs for monetary and social conditions are presented in the results section (Figures 8 & 11).

Previous studies have suggested utilizing both methods to present results, particularly when dealing with relatively high or low discounting populations (Yoon et al., 2017). Further, AUC values may yield significantly different results than k-values, particularly for data that contains shallow discounting curves (Mitchell et al., 2015). Therefore, analyses for Aim 1 were completed for both methods. Correlations between k-values and corresponding AUC for each condition were all significantly and strongly associated with each other \((p<.01)\). Since these measures are highly associated, prior research suggests it is acceptable to interpret results from the measures in similar ways. As such, AUCs were used instead of k-values for subsequent
analyses in Aims 3 and 4 since AUCs better approximated a normal distribution. Correlations between \(k\)-values and AUC are depicted below (Table 2).

Table 2. Correlations between \(k\)-values and AUCs

<table>
<thead>
<tr>
<th>Measure</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Monetary Gains (k)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Monetary Losses (k)</td>
<td>.287**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Social Gains (k)</td>
<td>.420**</td>
<td>.136</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Social Losses (k)</td>
<td>.401**</td>
<td>.254**</td>
<td>.378**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Monetary Gains AUC</td>
<td>-.991**</td>
<td>-.314**</td>
<td>-.436**</td>
<td>-.416**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Monetary Losses AUC</td>
<td>-.317**</td>
<td>-.951**</td>
<td>-.126</td>
<td>-.270**</td>
<td>.340**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Social Gains AUC</td>
<td>-.443**</td>
<td>-.152</td>
<td>-.952**</td>
<td>-.371**</td>
<td>.456**</td>
<td>.132</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Social Losses AUC</td>
<td>-.410**</td>
<td>-.246**</td>
<td>-.378**</td>
<td>-.972**</td>
<td>.422**</td>
<td>.259**</td>
<td>.396**</td>
<td></td>
</tr>
</tbody>
</table>

Note: \(k\) = discounting rate; AUC = Area Under the Curve; ** = \(p < .01\)

Aim 2. Aim 2 sought to determine whether degree of social isolation and loneliness were associated with demographic factors, affective characteristics, executive control, and AUCs for monetary and social decision-making conditions. To test Aim 2’s hypotheses, loneliness levels were separated into two groups in which one group represented participants who endorsed no loneliness and the other group represented participants who indicated any level of loneliness (e.g., a little, some, or very much). Independent t-tests were conducted to observe potential differences in characteristics between not lonely and lonely groups. Isolation levels were also
examined, and participants were again categorized into two groups: one group who did not report feeling isolated or cut off from family and friends due to COVID-19 and a second group who reported any degree of isolation (e.g., a little isolated, somewhat isolated, very isolated, or extremely isolated). Independent t-tests were conducted to observe potential differences in characteristics between isolation groups. Follow-up analyses sought to better characterize isolation. Spearman correlation was used to evaluate the relationship between isolation and loneliness. Next, the degree of isolation was examined in the context of marital status and living situation to understand if these factors accounted for degree of isolation. Living situation was collapsed into two groups: living alone vs. living with one or more people. Marital status was similarly collapsed into two groups, with one group representing those who were married, and the other group representing participants who were not married (e.g., widowed, divorced, never married/single, etc.). Chi square tests were used to determine if significant differences existed in isolation levels between participants who lived alone vs. with others, as well as if differences were apparent between participants who were married vs. participants who were not married.

**Aim 3.** The goal of Aim 3 was to determine the influence of potential moderating contextual factors on temporal discounting rates for both monetary and non-monetary outcomes. In order to test Aim 3’s hypotheses, we employed a series of multiple hierarchical regression to assess the relative contributions of demographic variables, self-reported state positive affect and executive control on the temporal discounting rate for monetary outcomes, as well as the temporal discounting rates for interpersonal outcomes. Due to issues of non-normality, robust nonparametric bootstrapping procedures were used. As such, bias corrected and accelerated (BCa) 95% confidence intervals were used to understand if predictor variables incrementally and significantly explained the proportion of variance in the outcome variables explained by the
overall model. BCa 95% confidence intervals were used, as these are posited to be the most robust and representative of true values. Standardized coefficients (β) and corresponding BCa 95% confidence intervals assessed the independent contribution of each predictor to the outcome variables. Separate SPSS syntax (Cheung et al., 2022) was used to calculate bootstrapped 95% confidence intervals for several model parameters including R, R², Adj. R², change in R², change in F, and significance values.

In these models age, education, income level and sex were entered in Step 1. Next, state positive affect and executive control were entered in Step 2 as continuous predictor variables. State positive affect was represented by the total state PA score on the 10-item PANAS, whereas executive control was represented by the time in seconds to complete the Oral Trails B task and the corresponding Oral Trails A score to account for influences of processing speed demands on executive control. Finally, step 3 included the interaction term between state positive affect and executive control. The outcome variables were represented by the various AUCs obtained from Aim 1. Therefore, four hierarchical regressions were performed using the aforementioned predictor variables in steps 1-3, with four separate AUCs as outcome variables (e.g., monetary gains, monetary losses, social gains, and social losses). Fisher r-to-z transformations were planned to be conducted on any significant findings in order to test whether the magnitude of associations between contextual factors (positive affect and executive control) and AUCs differed according to outcome type.

**Aim 4.** Aim 4 sought to better characterize the relationships between laboratory based decision-making behavior and consequential real-life choice behavior. To test Aim 4, we used a hierarchical multiple regression and first tested a rudimentary model to determine the associations amongst affective traits, executive control, and discounting rates on health
behaviors. As such, affective traits (state positive affect and state negative affect) were entered in step 1, followed by executive control variables entered in step 2 (OTMT-A to account for processing speed demands of OTMT-B, and OTMT-B scores), and lastly with discounting AUC values (monetary gains, monetary losses, social gains, and social losses) entered in step 3. Follow-up analysis using a more comprehensive model to adjust for relevant demographic factors and testing the statistically significant variables effect on health-behaviors was then performed. As such, in our comprehensive model we entered demographic variables (age, sex, education, and income) in step 1, and statistically significant variables from the rudimentary model in step 2. Model statistics, including $R^2$ value, change in $R^2$ value, and corresponding $p$-values, were obtained to understand if variables entered in each step significantly improved the proportion of variance in the outcome variable explained by the overall model (Tabachnick & Fidell, 2007). Contributions from individual predictors were measured by standardized coefficients ($\beta$) and corresponding $p$-values. Adjusted $R^2$ served as measures of effect size and are reported in the final models. As previously described, the AUC values were used for the discounting rates as these better approximated a normal distribution than $k$-values. The total score on the 15-item Good Health Practices scale served as the outcome variable, in which higher scores indicated healthier lifestyle choices.
CHAPTER 4

RESULTS

Descriptive Statistics for the Study Variables

Table 3 presents the demographic characteristics of all 140 participants included in the final sample. There was a larger proportion of women as compared to men. The almost entirely white sample reflected the 90.8% non-Hispanic white population estimate for the state of Maine (U.S. Census Bureau, 2020). There were broad ranges of both years of education (11-20 years) and annual income levels (<$10,000 - > $100,00).

Table 3. Demographic Characteristics of Sample

<table>
<thead>
<tr>
<th>Variables [range]</th>
<th>Total (N = 140)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age [50-90 years]</td>
<td>71.7 (7.5)</td>
</tr>
<tr>
<td>Education [11-20 years]</td>
<td>16.4 (2.2)</td>
</tr>
<tr>
<td>% Female</td>
<td>75 (n = 105)</td>
</tr>
<tr>
<td>Race: % Identified White</td>
<td>99.3 (n = 139)</td>
</tr>
<tr>
<td>Income range (median dollars)</td>
<td>$50,000 – 59,999</td>
</tr>
</tbody>
</table>

Note. Values indicate Mean (Standard Deviation) unless otherwise noted.

Next, the social, affective, and cognitive characteristics of participants within the total sample were examined (See Table 4). On an exit survey, the majority of participants did not report feeling lonely; however, most participants endorsed some degree of feeling isolated from
friends and family due to COVID-19. Participants on average reported higher levels of trait positive affect than trait negative affect on a self-report measure (PANAS Trait Affect). This pattern was also observed for state affect (PANAS State Affect), in which participants reported higher levels of positive state affect as compared to negative state affect. The average time (in seconds) to complete the OMT-B measure was approximately 30 seconds, in which less time indicated better performance. Health behaviors, as assessed by total scores on the 15-item Good Health Practices Scale, indicated participants tend to engage in healthy behaviors.
Table 4. *Social, Affective and Cognitive Characteristics of the Total Sample*

<table>
<thead>
<tr>
<th>Variables</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loneliness</td>
<td></td>
</tr>
<tr>
<td>Not at all Lonely</td>
<td>84 (60%)</td>
</tr>
<tr>
<td>A Little Lonely</td>
<td>39 (27.9%)</td>
</tr>
<tr>
<td>Somewhat Lonely</td>
<td>14 (10%)</td>
</tr>
<tr>
<td>Very Much Lonely</td>
<td>3 (2.1%)</td>
</tr>
<tr>
<td>Isolation</td>
<td></td>
</tr>
<tr>
<td>Not at all Isolated</td>
<td>48 (34.3%)</td>
</tr>
<tr>
<td>A Little Isolated</td>
<td>47 (33.6%)</td>
</tr>
<tr>
<td>Somewhat Isolated</td>
<td>25 (17.6%)</td>
</tr>
<tr>
<td>Very Isolated</td>
<td>15 (10.7%)</td>
</tr>
<tr>
<td>Extremely Isolated</td>
<td>5 (3.6%)</td>
</tr>
<tr>
<td>PANAS Trait Affect</td>
<td></td>
</tr>
<tr>
<td>Positive</td>
<td>37.1 (6.2)</td>
</tr>
<tr>
<td>Negative</td>
<td>17.3 (5.1)</td>
</tr>
<tr>
<td>PANAS State Affect</td>
<td></td>
</tr>
<tr>
<td>Positive</td>
<td>19.7 (3.1)</td>
</tr>
<tr>
<td>Negative</td>
<td>6.1 (1.5)</td>
</tr>
<tr>
<td>Oral Trails B (seconds)</td>
<td>31.7 (13.1)</td>
</tr>
<tr>
<td>Good Health Practice Scale-15 item</td>
<td>62.6 (6.3)</td>
</tr>
</tbody>
</table>

*Note.* Data presented are the number (n) and the percentage (%) of participants in the sample, unless otherwise noted.
Primary Aims Results

Aim 1 Results

Example ranges of monetary discounting rates are presented in Figure 6 to be used as reference.

Figure 6. Example Monetary Discounting Rates

Note. Figure 6 represents various degrees of discounting rates for the monetary condition, in which participant “A” represents the shallowest discounting rate (e.g., the participant always chooses the larger delayed gain or the smaller immediate loss—known as negative discounting), and participant “G” represents the steepest discounting rate (e.g., the participant always chooses the smaller immediate gain or the larger delayed loss).
Nonlinear curve-fitting analyses using a partial hyperbolic equation revealed differing group median discounting rates for monetary gains and monetary losses (Figure 7).

Figure 7. Monetary Discounting Rates

Note. Figure 7 depicts the group median indifference points for each delay level (one week, one month, six months, and one year) fitted to a hyperbolic model $[V = A/(1 + kD)]$ for monetary decision-making. Y-axis values indicate dollar amounts. Slopes of the models represent the discounting rate ($k$) for each condition. Steeper slopes indicate preferences for immediate gains and delayed losses. Wilcoxon Signed-Rank tests indicated significantly steeper discounting rates for monetary gains as compared to monetary losses; ** = p<.001 for group comparisons.
Discounting rates for monetary gains ($k = .007$) were higher than discounting rates for monetary losses ($k = <.001$). This suggested that participants were more sensitive to delay periods for monetary gains than for monetary losses, and more often chose the smaller immediate gain over the larger delayed gain. It also indicated participants most often chose the smaller immediate loss as compared to the larger delayed loss, meaning they negatively discounted future losses. Non-parametric analysis using Wilcoxon Signed Rank tests indicated that participants more steeply discounted monetary gains when compared to monetary losses ($Z = -7.12, p<.001, r = -.603$), at a large effect size. A paired samples t-test yielded similar results for AUC values (see Figure 8). Namely, AUCs for monetary gains ($M = .73, SE = .02$) were smaller than AUCs for monetary losses ($M = .91, SE = .01$), suggesting steeper discounting for monetary gains as compared to monetary losses. In other words, participants more often chose the smaller immediate gain than the larger delayed gain, and likewise more often chose the smaller immediate loss as opposed to the larger delayed loss. This difference was significant, $t(139) = -8.61, p<.001$, Cohen’s $d = .727$, and yielded a medium effect size.
Figure 8. *Area Under the Curve for Monetary Conditions*

**Monetary Conditions: Area Under the Curve**

![Bar chart showing comparison between Monetary Gains and Monetary Losses with AUC values.]

*Note.* Figure 8 depicts the group median differences in Area Under the Curve (AUC) for monetary gain and monetary loss conditions. AUCs are based on a zero to one scale, in which lower values are indicative of steeper discounting, and higher values are representative of more shallow discounting. Paired sample t-tests indicated significantly steeper discounting rates for monetary gains as compared to monetary losses; ** = p<.001 for group comparisons.
Example ranges of social discounting rates are presented in Figure 9 to be used as reference.

Figure 9. Example Social Discounting Rates

Note. Figure 9 represents various degrees of discounting rates for the social condition, in which participant “A” represents the shallowest discounting rate (e.g., the participant always chooses the larger delayed gain or the smaller immediate loss—known as negative discounting), and participant “G” represents the steepest discounting rate (e.g., the participant always chooses the smaller immediate gain or the larger delayed loss).
Nonlinear curve-fitting analyses also revealed differing group median discounting rates for social gains and social losses (Figure 10).

**Figure 10. Social Discounting Rates**

![Social Discounting Function](image)

*Note.* Figure 10 depicts the group median indifference points for each delay level (one week, one month, six months, and one year) fitted to a hyperbolic model \[V = A/(1 + kD)\] for social decision-making. Y-axis values indicate time in hours. Slopes of the models represent the discounting rate \((k)\) for each condition. Steeper slopes indicate preferences for immediate gains and delayed losses. Wilcoxon Signed-Rank tests indicated significantly steeper discounting rates for social gains as compared to social losses; ** = p<.001 for group comparisons.
Discounting rates for social gains \((k = .044)\) were higher than discounting rates for social losses \((k = .009)\), suggesting that participants were more sensitive to delay periods for social gains than for social losses (see Figure 10). Non-parametric analysis using Wilcoxon Signed Rank tests indicated that participants more steeply discounted social gains than social losses, suggesting that they more often chose the smaller immediate social gain as opposed to the larger delayed social gain, and also chose the smaller immediate loss as opposed to the larger delayed loss. In other words, they had more of a tendency to discount future gains than they did future losses. This difference was significant at a small effect size, \(Z = -3.50, p<.001, r = .296\).

A paired samples t-test was conducted for Social AUCs and yielded similar results (see Figure 11). Namely, AUCs for social gains \((M = .46, SE = .02)\) were smaller than AUCs for social losses \((M = .62, SE = .03)\), suggesting steeper discounting for social gains as compared to social losses. This difference was significant and yielded a medium effect size, \(t(139) = -5.99, p<.001, Cohen’s d = .507\).
Figure 11. Area Under the Curve for Social Conditions

Social Conditions: Area Under the Curve

Note. Figure 11 depicts the group median differences in Area Under the Curve (AUC) for social gain and social loss conditions. AUCs are based on a zero to one scale, in which lower values are indicative of steeper discounting, and higher values are representative of more shallow discounting. Paired sample t-tests indicated significantly steeper discounting rates for social gains as compared to social losses; ** = p<.001 for group comparisons.

Overall behavior for gain conditions vs. loss conditions was also examined. Wilcoxon Signed-Rank tests revealed that participants discounted social gains more steeply than monetary gains (Z = -8.07, p<.001, r = -.681) and social losses more steeply than monetary losses (Z = -8.42, p<.001, r = -.712), indicating greater sensitivity to delay periods for social outcomes as opposed to monetary outcomes, both at large effect sizes. This pattern was also observed for
AUCs for gain conditions \( t(139) = 11.21, p < .001, \text{Cohen’s } d = .948 \) and AUCs for loss conditions \( t(139) = 11.02, p < .001, \text{Cohen’s } d = .932 \), both at large effect sizes. All within-subjects analyses remained significant after Bonferroni correction.

**Aim 2 Results**

Characteristics of loneliness groups are presented in Table 5. Lonely participants reported lower annual income \( t(138) = 3.77, p < .001, \text{Cohen’s } d = .651 \), greater levels of trait negative affect \( t(138) = -3.42, p < .001, \text{Cohen’s } d = -.590 \], and greater levels of state negative affect \( t(138) = -2.93, p = .004, \text{Cohen’s } d = .559 \] than their non-lonely counterparts, each at a medium effect size. Differences in state positive affect between not lonely and lonely groups approached significance and with a small effect size, \( t(138) = 1.67, p = .096, \text{Cohen’s } d = .289 \). Additionally, differences in health behavior choices \( t(138) = 1.68, p = .094, \text{Cohen’s } d = .291 \] also approached significance and with a small effect size, with lonely participants yielding lower scores and thus endorsing worse health behavior choices. Significant group differences survived Bonferroni corrections \( (p < .025) \).
Table 5. *Characteristics of Loneliness Groups*

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Not Lonely ( (n = 84) )</th>
<th>Lonely ( (n = 56) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>71.4 (7.9)</td>
<td>71.9 (6.8)</td>
</tr>
<tr>
<td>% Female</td>
<td>75% ( (n = 63) )</td>
<td>75% ( (n = 42) )</td>
</tr>
<tr>
<td>Education</td>
<td>16.5 (2.2)</td>
<td>16.1 (2.1)</td>
</tr>
<tr>
<td>Income</td>
<td>$56,000 ($12,000)</td>
<td>$42,000 ($9,999)**</td>
</tr>
<tr>
<td>Monetary Gains AUC</td>
<td>.73 (.2)</td>
<td>.71 (.3)</td>
</tr>
<tr>
<td>Monetary Losses AUC</td>
<td>.90 (.2)</td>
<td>.91 (.2)</td>
</tr>
<tr>
<td>Social Gains AUC</td>
<td>.44 (.3)</td>
<td>.48 (.3)</td>
</tr>
<tr>
<td>Social Losses AUC</td>
<td>.62 (.3)</td>
<td>.59 (.3)</td>
</tr>
<tr>
<td>Oral Trails B</td>
<td>30.6 (12.0)</td>
<td>33.3 (14.5)</td>
</tr>
<tr>
<td>Trait Positive Affect</td>
<td>37.8 (5.5)</td>
<td>36.1 (6.9)</td>
</tr>
<tr>
<td>Trait Negative Affect</td>
<td>16.1 (4.6)</td>
<td>19.1 (5.3)**</td>
</tr>
<tr>
<td>State Positive Affect</td>
<td>20.1 (2.9)</td>
<td>19.2 (3.4)†</td>
</tr>
<tr>
<td>State Negative Affect</td>
<td>5.7 (1.1)</td>
<td>6.6 (1.9)*</td>
</tr>
<tr>
<td>Good Health Practices Scale (^a)</td>
<td>63.4 (6.1)</td>
<td>61.2 (6.4)†</td>
</tr>
</tbody>
</table>

*Note.* Values indicate Mean (Standard Deviation) unless otherwise noted; AUC = Area Under the Curve; Oral Trails B = Oral Trail Making Test Part B time in seconds. * = \( p < .05 \); ** = \( p < .001 \); † = \( ps = [.094 - .096] \).

\(^a\) Indicates total score from the 15-item Good Health Practices Scale.
Characteristics of isolation groups also differed (Table 6). Isolated participants reported less years of education \([t(138) = -2.31, p = .022, \text{Cohen’s } d = - .411]\), with a medium effect size, than those participants who reported no isolation. In terms of decision-making, isolated participants engaged in more shallow temporal discounting for both monetary gains \([t(138) = - 3.14, p = .002, \text{Cohen’s } d = - .560]\) and monetary losses \([t(138) = 2.52, p = .014, \text{Cohen’s } d = - .518]\), both at a large effect size when compared to participants who did not feel isolated. Therefore, isolated participants tended to delay gratification more often by choosing the larger delayed monetary gain, and also more often chose to pay a debt immediately as opposed to paying the larger delayed amount when compared to participants reporting no isolation. Further, isolated participants endorsed greater levels of trait negative affect \([t(138) = -3.42, p<.001, \text{Cohen’s } d = - .590]\), at a large effect size when compared to participants who did not feel isolated. Finally, differences in state negative affect between not isolated and isolated groups approached significance and with a medium effect size, \([t(138) = -1.92, p = .057, \text{Cohen’s } d = - .341]\). Significant group differences survived Bonferroni corrections (\(ps<.025\)).
<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Not Isolated</th>
<th>Isolated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><em>(n = 48)</em></td>
<td><em>(n = 92)</em></td>
</tr>
<tr>
<td>Age</td>
<td>72.3 (7.2)</td>
<td>71.3 (7.6)</td>
</tr>
<tr>
<td>% Female</td>
<td>77% <em>(n = 37)</em></td>
<td>74% <em>(n = 68)</em></td>
</tr>
<tr>
<td>Education</td>
<td>15.8 (2.4)</td>
<td>16.7 (1.9)*</td>
</tr>
<tr>
<td>Income</td>
<td>$48,500 ($16,000)</td>
<td>$51,100 ($10,000)</td>
</tr>
<tr>
<td>Monetary Gains AUC</td>
<td>.64 (.3)</td>
<td>.77 (.2)*</td>
</tr>
<tr>
<td>Monetary Losses AUC</td>
<td>.86 (.2)</td>
<td>.93 (.1)*</td>
</tr>
<tr>
<td>Social Gains AUC</td>
<td>.43 (.3)</td>
<td>.47 (.3)</td>
</tr>
<tr>
<td>Social Losses AUC</td>
<td>.65 (.3)</td>
<td>.60 (.3)</td>
</tr>
<tr>
<td>Oral Trails B</td>
<td>34.53 (16.0)</td>
<td>30.2 (11.0)</td>
</tr>
<tr>
<td>Trait Positive Affect</td>
<td>37.58 (7.6)</td>
<td>36.84 (5.3)</td>
</tr>
<tr>
<td>Trait Negative Affect</td>
<td>15.63 (5.2)</td>
<td>18.23 (4.8)*</td>
</tr>
<tr>
<td>State Positive Affect</td>
<td>20.17 (3.7)</td>
<td>19.48 (2.7)</td>
</tr>
<tr>
<td>State Negative Affect</td>
<td>5.73 (1.4)</td>
<td>6.24 (1.5)†</td>
</tr>
<tr>
<td>Good Health Practices a</td>
<td>62.90 (6.7)</td>
<td>62.51 (6.1)</td>
</tr>
</tbody>
</table>

*Note.* Values indicate Mean (Standard Deviation) unless otherwise noted; AUC = Area Under the Curve; Oral Trails B = Oral Trail Making Test Part B time in seconds. *= p<.05; ** = p<.001; † = p = .057.

* a Indicates total score from the 15-item Good Health Practices Scale.
Follow-up analyses were conducted to understand if degree of isolation was associated with degree of loneliness, and whether isolation could be better explained by the participant’s living situation or marital status. Pearson’s correlations revealed that isolation and loneliness variables were not significantly associated with each other ($p = .434$). Chi square tests indicated there were no significant differences between participants’ isolation levels based on whether they lived alone or were married ($p > .05$). As such, these additional factors were not considered for further analyses.
**Aim 3 Results**

For Aim 3, a series of bootstrapped hierarchical multiple regressions were performed to quantify the independent contributions of relevant demographic, affective, and cognitive factors on the AUCs of each decision-making condition. Because *p*-values can fluctuate based on which iteration of the bootstrap analysis is provided, variables were determined to be significant if, in addition to *ps*<.05, bootstrapped bias corrected accelerated 95% confidence intervals did not include the value zero. Otherwise, variables were considered nonsignificant predictors. Bootstrapped coefficients and model summaries for each condition are included in separate tables.

**Monetary Gains.** For Step 1, no demographic variables (age, sex, education, or income) were found to be significant predictors of monetary gain AUC, and the overall model was not significant. For Step 2, neither state positive affect nor executive control significantly predicted variance in monetary gain AUC. In Step 3, there were no interaction effects of state positive affect and executive control, and all predictors were nonsignificant. Overall, there were no significant predictors (see Table 7) and the final model was also nonsignificant as presented in Table 8.
Table 7. Bootstrapped Coefficients for Monetary Gain AUC*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\beta$</td>
<td>95% BCa CI</td>
<td>$\beta$</td>
</tr>
<tr>
<td>Age</td>
<td>.010</td>
<td>[.007 - .014]</td>
<td>.014</td>
</tr>
<tr>
<td>ED</td>
<td>.181</td>
<td>[.177 - .185]</td>
<td>.183</td>
</tr>
<tr>
<td>Income</td>
<td>.019</td>
<td>[.015 - .024]</td>
<td>.007</td>
</tr>
<tr>
<td>PA</td>
<td>.097</td>
<td>[.093 - .101]</td>
<td>.084</td>
</tr>
<tr>
<td>OTMT-B</td>
<td>-.089</td>
<td>[-.092 - -.085]</td>
<td>-.102</td>
</tr>
<tr>
<td>Interaction</td>
<td>-.101</td>
<td>[-.105 - -.097]</td>
<td></td>
</tr>
</tbody>
</table>

*Note. *All values based on 2000 bootstrap samples, and standard errors for all values $\leq .002$. ED = education; PA = state positive affect; OTMT-B = Oral Trail Making Test Part B; Interaction = interaction term between state positive affect and Oral Trail Making Test Part B; SE = bootstrapped standard error; BCa CI = bias corrected and accelerated confidence interval.
### Table 8. Bootstrapped Model Summaries for Monetary Gain AUC Hierarchical Regression*

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R²</th>
<th>Adj. R²</th>
<th>R²Δ</th>
<th>FΔ</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>1ᵃ</td>
<td>.238</td>
<td>.062</td>
<td>.033</td>
<td>.062</td>
<td>2.27</td>
<td>.197</td>
</tr>
<tr>
<td>2ᵇ</td>
<td>.304</td>
<td>.097</td>
<td>.049</td>
<td>.035</td>
<td>1.74</td>
<td>.318</td>
</tr>
<tr>
<td>3ᶜ</td>
<td>.328</td>
<td>.112</td>
<td>.058</td>
<td>.015</td>
<td>2.29</td>
<td>.337</td>
</tr>
</tbody>
</table>

*Note.* *All values based on 2000 bootstrap samples. Values indicate [BCa Bootstrap 95% Confidence Intervals]. Adj. R² denotes adjusted R²; Δ R² denotes change in R²; ΔF denotes change in the F statistic; Durbin Watson value for final model = 1.89.

ᵃ Age, Sex, Education, and Income were variables.

ᵇ State Positive Affect, and Oral Trail Making Test Part B were variables.

ᶜ Interaction term was a variable.
**Monetary Losses.** For Step 1, no demographic variables (age, sex, education or income) were found to be significant predictors of monetary loss AUC, and the overall model was not significant. For Step 2, neither state positive affect or executive control significantly predicted variance in monetary loss AUC. In Step 3, there were no interaction effects of state positive affect and executive control, and all predictors were nonsignificant. There were no significant independent predictors at any step as shown in Table 9. The final model was also nonsignificant (see Table 10).

Table 9. *Bootstrapped Coefficients for Monetary Loss AUC*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1</th>
<th></th>
<th>Model 2</th>
<th></th>
<th>Model 3</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β</td>
<td>95% BCa CI</td>
<td>β</td>
<td>95% BCa CI</td>
<td>β</td>
<td>95% BCa CI</td>
</tr>
<tr>
<td>Age</td>
<td>.003</td>
<td>[.000 - .005]</td>
<td>.027</td>
<td>[.024 - .030]</td>
<td>.013</td>
<td>[.010 - .016]</td>
</tr>
<tr>
<td>Sex</td>
<td>.053</td>
<td>[.049 - .057]</td>
<td>.067</td>
<td>[.063 - .071]</td>
<td>.076</td>
<td>[.072 - .080]</td>
</tr>
<tr>
<td>Income</td>
<td>.030</td>
<td>[.026 - .035]</td>
<td>.039</td>
<td>[.035 - .045]</td>
<td>.037</td>
<td>[.032 - .042]</td>
</tr>
<tr>
<td>PA</td>
<td>.004</td>
<td>[-.001 - .008]</td>
<td>-.003</td>
<td>[-.008 - .002]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OTMT-B</td>
<td>-.085</td>
<td>[-.090 - -.081]</td>
<td>-.086</td>
<td>[-.090 - -.082]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interaction</td>
<td>-.126</td>
<td>[-.132 - -.120]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note.* *All values based on 2000 bootstrap samples and standard errors for all values ≤.002. ED = education; PA = state positive affect; OTMT-B = Oral Trail Making Test Part B; Interaction = interaction term between state positive affect and Oral Trail Making Test Part B; SE = bootstrapped standard error; BCa CI = bias corrected and accelerated confidence interval.
Table 10. *Bootstrapped Model Summaries for Monetary Loss AUC Hierarchical Regression*

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R²</th>
<th>Adj. R²</th>
<th>ΔR²</th>
<th>ΔF</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.184</td>
<td>.039</td>
<td>.010</td>
<td>.039</td>
<td>1.38</td>
<td>.398</td>
</tr>
<tr>
<td>2</td>
<td>.262</td>
<td>.074</td>
<td>.025</td>
<td>.035</td>
<td>1.74</td>
<td>.352</td>
</tr>
<tr>
<td>3</td>
<td>.311</td>
<td>.104</td>
<td>.049</td>
<td>.030</td>
<td>4.66</td>
<td>.254</td>
</tr>
</tbody>
</table>

*Note.* *All values based on 2000 bootstrap samples. Adj. R² denotes adjusted R²; ΔR² denotes change in R²; ΔF denotes change in the F statistic; Durbin Watson value for final model = 1.53.

a Age, Sex, Education, and Income were variables.

b State Positive Affect, and Oral Trail Making Test Part B were variables.

c Interaction term was a variable.
Social Gains. For Step 1, no demographic variables (age, sex, education or income) were found to be significant predictors of social gain AUC, and the overall model was not significant. For Step 2, neither state positive affect or executive control significantly predicted variance in social gain AUC. In Step 3, there were no interaction effects of state positive affect and executive control, and all predictors were nonsignificant. No predictors were significant in any step (see Table 11). The final model was also nonsignificant as presented in Table 12.

Table 11. Bootstrapped Coefficients for Social Gain AUC*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β</td>
<td>95% BCa CI</td>
<td>β</td>
</tr>
<tr>
<td>Age</td>
<td>.134</td>
<td>[.131 -.139]</td>
<td>.133</td>
</tr>
<tr>
<td>Sex</td>
<td>.093</td>
<td>[.089 -.096]</td>
<td>.099</td>
</tr>
<tr>
<td>ED</td>
<td>.009</td>
<td>[.006 -.135]</td>
<td>.023</td>
</tr>
<tr>
<td>Income</td>
<td>-.021</td>
<td>[-.025 -.017]</td>
<td>-.014</td>
</tr>
<tr>
<td>PA</td>
<td>-.020</td>
<td>[-.025 -.016]</td>
<td>-.025</td>
</tr>
<tr>
<td>OTMT-B</td>
<td>-.032</td>
<td>[-.036 -.028]</td>
<td>-.037</td>
</tr>
<tr>
<td>Interaction</td>
<td>.004</td>
<td>[.001 -.009]</td>
<td></td>
</tr>
</tbody>
</table>

Note. *All values based on 2000 bootstrap samples, and standard errors for all values ≤.002. ED = education; PA = state positive affect; OTMT-B = Oral Trail Making Test Part B; Interaction = interaction term between state positive affect and Oral Trail Making Test Part B; SE = bootstrapped standard error; BCa CI = bias corrected and accelerated confidence interval.
Table 12. *Bootstrapped Model Summaries for Social Gain AUC Hierarchical Regression*

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R²</th>
<th>Adj. R²</th>
<th>ΔR²</th>
<th>ΔF</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.229</td>
<td>.057</td>
<td>.029</td>
<td>.057</td>
<td>2.10</td>
<td>.224</td>
</tr>
<tr>
<td>2</td>
<td>.300</td>
<td>.095</td>
<td>.047</td>
<td>.037</td>
<td>1.85</td>
<td>.307</td>
</tr>
<tr>
<td>3</td>
<td>.316</td>
<td>.104</td>
<td>.049</td>
<td>.009</td>
<td>1.44</td>
<td>.446</td>
</tr>
</tbody>
</table>

*Note.* All values based on 2000 bootstrap samples. Adj. R² denotes adjusted R²; ΔR² denotes change in R²; ΔF denotes change in the F statistic; Durbin Watson value for final model = 2.04.

a Age, Sex, Education, and Income were variables.

b State Positive Affect, and Oral Trail Making Test Part B were variables.

c Interaction term was a variable.
**Social Losses.** For Step 1, no demographic variables (age, sex, education, or income) were found to be significant predictors of social loss AUC, and the overall model was not significant. For Step 2, neither state positive affect or executive control significantly predicted variance in social loss AUC. In Step 3, there were no interaction effects of state positive affect and executive control, and all predictors were nonsignificant. Overall, there were no significant independent predictors at any step (see Table 13). The final model was also nonsignificant as presented in Table 14.

Table 13. *Bootstrapped Coefficients for Social Loss AUC* *

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β</td>
<td>95% BCa CI</td>
<td>β</td>
</tr>
<tr>
<td>Age</td>
<td>-.141</td>
<td>[-.145 - -.137]</td>
<td>-.167</td>
</tr>
<tr>
<td>Sex</td>
<td>.054</td>
<td>[.051 - .058]</td>
<td>.060</td>
</tr>
<tr>
<td>ED</td>
<td>-.061</td>
<td>[-.065 - -.057]</td>
<td>-.029</td>
</tr>
<tr>
<td>Income</td>
<td>-.063</td>
<td>[-.067 - -.059]</td>
<td>-.088</td>
</tr>
<tr>
<td>PA</td>
<td>.159</td>
<td>[.155 - .164]</td>
<td>.156</td>
</tr>
<tr>
<td>OTMT-B</td>
<td>-.052</td>
<td>[-.056 - -.048]</td>
<td>-.057</td>
</tr>
<tr>
<td>Interaction</td>
<td></td>
<td></td>
<td>-.035</td>
</tr>
</tbody>
</table>

*Note. *All values based on 2000 bootstrap samples and standard errors for all values ≤.002. ED = education; PA = state positive affect; OTMT-B = Oral Trail Making Test Part B; Interaction = interaction term between state positive affect and Oral Trail Making Test Part B; SE = bootstrapped standard error; BCa CI = bias corrected and accelerated confidence interval.
Table 14. *Bootstrapped Model Summaries for Social Loss AUC Hierarchical Regression*

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R²</th>
<th>Adj. R²</th>
<th>ΔR²</th>
<th>ΔF</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.235</td>
<td>.061</td>
<td>.033</td>
<td>.061</td>
<td>2.24</td>
<td>.211</td>
</tr>
<tr>
<td>2</td>
<td>.327</td>
<td>.113</td>
<td>.066</td>
<td>.052</td>
<td>2.65</td>
<td>.198</td>
</tr>
<tr>
<td>3</td>
<td>.343</td>
<td>.123</td>
<td>.069</td>
<td>.010</td>
<td>1.52</td>
<td>.435</td>
</tr>
</tbody>
</table>

*Note.* All values based on 2000 bootstrap samples. Adj. R² denotes adjusted R²; Δ R² denotes change in R²; ΔF denotes change in the F statistic; Durbin Watson value for final model = 1.98.

a Age, Sex, Education, and Income were variables.

b State Positive Affect, and Oral Trail Making Test Part B were variables.

c Interaction term was a variable.

**Aim 4 Results**

For Aim 4, a hierarchical multiple regression was performed to quantify the independent contributions of demographic, affective, cognitive, and temporal discounting factors on health behavior choices. First, we tested a rudimentary model (see Table 15) to determine the associations amongst affective traits, executive control, and discounting rates on health behaviors. This was followed by a more comprehensive model that adjusted for relevant demographic factors and tested the statistically significant variables effect on health-behaviors.

In the rudimentary model, for Step 1, state positive affect (β = .338, p < .001), but not state negative affect (β = .018, p = .829), was a significant predictor of health behavior, and accounted for 11% of the overall variance at a small effect size. Specifically, higher state positive affect was associated with higher health behavior choices (e.g., healthier behavioral choices).
For step 2, neither processing speed (OTMT-A) or executive control (OTMT-B) significantly contributed to health behavior; however, OTMT-A approached significance ($\beta = -.156, p = .066$) as an independent predictor of health behavior. This trend association was characterized by faster processing speed with better health behavior.

In step 3, none of the temporal discounting functions (monetary gains AUC, monetary losses AUC, social gains AUC, and social losses AUC) significantly contributed to health behavior ($ps>.05$).

Overall significant results for the rudimentary model survived Bonferroni corrections ($ps<.025$).

Table 15. *Rudimentary Model: Affective, Cognitive and Temporal Discounting Rates*

*Contributions to Health Behavior Choices*

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>$R^2$</th>
<th>Adj. $R^2$</th>
<th>$\Delta R^2$</th>
<th>$\Delta F$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1$^a$</td>
<td>.334</td>
<td>.112</td>
<td>.099</td>
<td>.112</td>
<td>8.60</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>2$^b$</td>
<td>.366</td>
<td>.134</td>
<td>.108</td>
<td>.022</td>
<td>1.74</td>
<td>.180</td>
</tr>
<tr>
<td>3$^c$</td>
<td>.370</td>
<td>.137</td>
<td>.084</td>
<td>.003</td>
<td>.122</td>
<td>.975</td>
</tr>
</tbody>
</table>

*Note.* Adj. $R^2$ denotes adjusted $R^2$; $R^2\Delta$ denotes change in $R^2$; $\Delta F$ denotes change in the F Statistic; Durbin Watson value for final model = 1.81.

$^a$ State Positive Affect and State Negative Affect were variables.

$^b$ Oral Trail Making Test Parts A and B were variables.

$^c$ Monetary Gains AUC, Monetary Losses AUC, Social Gains AUC, and Social Losses AUC were variables.
We next tested a comprehensive model (see Table 16) that adjusted for relevant demographic factors and tested the statistically significant variables effect on health-behaviors. In the comprehensive model, for Step 1, sex ($\beta = .189, p = .029$), but not age, education, or income, was a significant predictor of health behavior; however, did not account for a significant amount of the overall variance. To follow up on sex’s significant contribution to everyday health behavior, post-hoc analyses investigated for group differences in health behavior choices between men and women. The difference between women and men’s endorsements on the 15-item Good Health Practices Scale approached significance [$F(1, 139) = 3.71, p = .056$], with women ($M = 63.2, SD = 6.3$) endorsing slightly higher scores than men ($M = 60.8, SD = 6.1$) indicating healthier behavior.

In step 2, state positive affect ($\beta = .354, p < .001$) was considered a significant predictor of everyday health behavior, and significantly accounted for an additional 11% of the overall variance above and beyond that of demographic variables in step 1 at a medium effect size. Higher state positive affect was associated with higher health behavior choices (e.g., healthier behavioral choices). Sex ($\beta = .174, p = .033$) remained a significant independent predictor of health behavior even after the addition of state positive affect. State positive affect results remained significant after Bonferroni correction ($ps < .025$); however, the sex results were no longer significant ($ps > .025$).
Table 16. *Comprehensive Model: Demographic and Affective Contributions to Health Behavior Choices*

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R²</th>
<th>Adj. R²</th>
<th>ΔR²</th>
<th>ΔF</th>
<th>p</th>
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<td>1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>.218</td>
<td>.047</td>
<td>.019</td>
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<td>1.68</td>
<td>.158</td>
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<td>.165</td>
<td>.134</td>
<td>.117</td>
<td>18.21</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

*Note. Adj. R² denotes adjusted R²; R²Δ denotes change in R²; ΔF denotes change in the F Statistic; Durbin Watson value for final model = 1.79.*

<sup>a</sup> Age, Sex, Education, and Annual Income were variables.

<sup>b</sup> State Positive Affect was a variable.
CHAPTER 5

DISCUSSION

The framing, temporal condition, and content of decision-making are widely viewed as representing important influences on decision-making behavior. However, decision-making behavior among and within these contexts remains largely inconsistent and inconclusive in older adult populations. Better understanding the heterogeneity inherent in decision-making behavior in older adults remains an important endeavor given that mounting evidence suggests decrements in decision-making behavior may predict future cognitive decline. This picture may be elucidated by further understanding of the underlying affective and cognitive factors that have been implicated in shaping decision-making ability across the lifespan. Therefore, the focus of this dissertation project was to improve understanding of how demographic, social, cognitive, and affective processes may impact decision-making behavior in community-dwelling older adults.

The following sections provide a discussion of the present study’s findings as they relate to the literature as well as clinical and research implications. First, older adults’ decision-making behavior is discussed in the context of condition (e.g., gain vs. loss) and content (e.g., monetary vs. social) and relevant differences within each context are explained. Next, the associations between loneliness and isolation with various demographic, affective, and decision-making behaviors are explored. Then, the contribution of affective and executive control variables on decision-making behavior are examined. We then present a discussion on the relationship between temporal discounting in the laboratory and everyday health behavior choices. Finally,
we conclude with a summary of the main findings, strengths and limitations of the current study, and suggestions for future research directions.

**Temporal Discounting Behavior Among Community-Dwelling Older Adults**

As previously discussed, the tendency to assign a lesser value to an outcome the further that outcome occurs into the future is known as temporal discounting (Green & Myerson, 2004; Mazur, 1987; Rachlin *et al.*, 1991). Said differently, delayed gains become less enticing and delayed losses become less aversive. The degree to which an individual devalues a future outcome as compared to an immediate outcome is known as the individual’s discounting rate. As such, those individuals with steeper temporal discounting rates more often choose a smaller immediate gain as opposed to a larger delayed gain, and more often choose a larger delayed loss as opposed to a smaller immediate loss, the latter of which is primarily influenced by loss aversion (Kahneman & Tversky, 1979). The degree to which an individual temporally discounts a future outcome is therefore dependent on whether the outcome is perceived as a gain or loss as well as the content of the outcome (e.g., money, food, time, etc.). The elusiveness as to how older adults behave in decision-making scenarios in which they are asked to make decisions about the present and the future was therefore the impetus for the first aim of the current study.

Aim 1 sought to better understand potential differences in decision-making behavior among community-dwelling older adults when choices were presented as gains or losses, and the content of these choices were either monetary or interpersonal in nature. Decision-making conditions therefore included scenarios in which older adults were asked to make decisions between an immediate outcome and a delayed outcome in the context of monetary gains, monetary losses, social gains, and social losses. Aim 1’s analyses used a partial hyperbolic model with nonlinear regression and Area Under the Curves to determine participant discounting
rates for each condition. Discounting rates were then compared to understand if differences existed between conditions. Overall, older adults showed temporal discounting behavior (e.g., preference for immediate gains and delayed losses) for all conditions except monetary losses, in which negative discounting was found (e.g., preference for the immediate loss). Further, they discounted gains more steeply than losses, consistent with the “sign effect.” Finally, they also discounted social outcomes more steeply than monetary outcomes. The upcoming sections outline these results in further detail.

**Monetary Decision Making**

We hypothesized that older adults would demonstrate a preference for delayed gratification as evidenced by more shallow discounting rates for monetary gains, and greater levels of loss aversion as evidenced by steeper temporal discounting rates for monetary losses. We also hypothesized there would be a significant difference in discounting rates between the two conditions. In contrast to these hypotheses, findings within the present study suggest an opposite relationship, in which community-dwelling older adults displayed steeper temporal discounting rates for monetary gains as compared to monetary losses, yielding large effect sizes. Thus, participants tended to choose the smaller immediate gain more often than they chose the larger delayed gain, as well as the smaller immediate loss more often than they chose the larger delayed loss. In this way, participants devalued future monetary gains more than future monetary losses. These results suggest that older adults may favor more instant gratification and not be as sensitive to loss aversion when it pertains to monetary outcomes.

In all types of decision-making, the decision-maker is tasked with determining a) how certain the outcome is and b) how valuable he or she believes the outcome to be (Schwartz *et al.*, 2011). As suggested by the current study findings, older adults may prefer immediate, albeit
smaller, monetary gains as compared to larger delayed monetary gains. These results contrast with select prior studies of age and temporal discounting that found decreased temporal discounting for monetary gains (Eppinger et al., 2012; Green et al., 1994; Löckenhoff et al., 2011). While several studies conceptualize greater temporal discounting as a proxy for impulsivity, alternative mechanisms may better explain the relationship. For example, temporal discounting in older adults may be a product of limited time horizons and the increased likelihood of mortality (see Seaman et al., 2022). Typically, uncertainty is discussed in relation to probability discounting or risky decision-making. While choices made in temporal discounting paradigms do not involve calculating probabilities or evaluating risk, they do involve uncertainty, as the future is uncertain for all individuals. Limited time horizons and increased risk for mortality that occur as a product of aging may collectively intensify the desire to choose more immediate outcomes by way of contributing greater uncertainty to the future. Estimates of uncertainty are most prominently studied in risk paradigms, in which several researchers suggest older adults as compared to younger adults, display higher levels of risk aversion when outcomes are framed as gains (Mather et al., 2012; Tymula et al., 2013; Boyle et al., 2012; Weller et al., 2011). In this regard, uncertainty may be the underlying mechanism by which individuals, particularly older adults, are driven to choose immediate gains. Another potential mechanism subserving the desire for immediacy is reduced sensitivity to the reward magnitude. In essence, individuals who care less about the magnitude of the reward, may not be incentivized to wait a longer period for the larger reward. Relatedly, the perceived utility the individual places on the delayed outcome may be lower. This may be explained in part by age-related neuroanatomical changes, such as decreased activation in the ventral striatum, which may result in reduced reward
anticipation for higher monetary gains and increased neural responses for smaller monetary losses (Dhingra et al., 2020).

In terms of discounting of monetary losses, older adults in the current sample showed negative discounting. Interestingly, nearly every participant chose to pay the smaller immediate amount as compared to the larger delayed amount, a behavior inconsistent with devaluation of future losses. One possible explanation for this behavior is that some individuals may be “minimizers” when it comes to making decisions about monetary losses, in that they always choose the smallest possible loss (Myerson et al., 2017). In a study of young to middle-aged adults, participants were identified as either minimizers, debt averse (those who showed reverse discounting in which the likelihood of choosing to pay latter decreased with the delay period) or loss averse (those who showed the expected pattern of discounting in which the likelihood of choosing to pay later increased with the delay; Myerson et al., 2017). It was unclear as to whether the decision-making strategy of minimizers represented extreme debt aversion or extreme loss aversion based on their concurrent attitudes toward gain conditions. For example, the minimizing group did not show more preference for delayed gains or have lower impulsiveness than the debt averse group which lessened support that minimizers exhibited extreme forms of debt aversion. Conversely, minimizers also did not choose delayed gains less often than those who were loss averse (Myerson et al., 2017).

However, if gains and losses are quantitatively and qualitatively conceptualized differently, it may not be prudent to study factors related to behavior in one condition as the basis for understanding behavior in the other condition. It may be the case that different environmental factors account for differing attitudes in gains vs. losses (e.g., impulsiveness might explain behavior in gains but not losses). Relatedly, evidence suggests that different areas of the brain
have been linked to gains and losses (ventral striatum are activated during reward anticipation) whereas the ventrolateral PFC appears to respond specifically to the anticipation of loss (Dugre et al., 2018), providing further evidence for dissociation of behavior in gains vs. loss conditions. Further, behavior in gain conditions may not be mutually exclusive with behavior in loss conditions. For example, an individual may be extremely debt averse as evidenced by always choosing the smaller immediate loss, while still preferring choosing the smaller immediate gain. One might argue that this behavior would make sense in someone who is debt averse because there is a certainty in obtaining the smaller immediate outcome that does not exist with the larger delayed outcome.

Another reason for virtually no discounting behavior for monetary losses in the current sample could be partially explained by cohort effects on attitudes toward debt. Historically, the cohort of people born between the years 1928-1945 (also known as the “Silent Generation”) and those born between 1946-1964 (also known as “Baby Boomers”), have each evidenced a strong objection toward debt (Leach et al., 2013), with the former group showing a greater aversion. Research has pointed to the proximity to the Great Depression as a contributor to attitudes toward debt, resulting in a desire to pay off debts immediately among older generations. Further, the option of “paying later” did not become an option until the emergence of credit lines in the 1950’s, meaning many individuals in the Silent Generation learned conservative financial behaviors during their formative years.

Social Decision-Making

As part of Aim 1, we also hypothesized that older adults would demonstrate a preference for immediate social gratification and therefore choose the smaller immediate gain more often than the larger delayed gain resulting in steep discounting rates for social outcomes. In contrast,
we hypothesized participants would display more shallow discounting rates for social losses and more often choose the smaller immediate loss as compared to the larger delayed loss. Overall, we expected there to be significant differences in the discounting rates between social gains and losses. Results from the present study suggested older adults showed temporal discounting behavior in both conditions, such that they more often chose the smaller immediate social gain as opposed to the larger delayed gain, as well as the larger delayed loss as compared to the smaller immediate loss. As expected, they discounted social gains more steeply than social losses, yielding large effect sizes.

In line with our hypotheses, participants displayed temporal discounting for social gains, meaning that they more often chose the smaller immediate gain as opposed to the larger delayed gain. Therefore, participants were more apt to choose to spend time with a loved one now, as opposed to later. Relevantly, these findings were like those found in a study conducted concurrently to the present study, which found that a racially diverse group of older adults displayed a preference for immediate social and health rewards when compared to their younger counterparts (Seaman et al., 2023). This finding replicated work done by this group previously, which indicated older adults may be more motivated, as compared to younger adults, to obtain more immediate social outcomes (Seaman et al., 2016). In essence, older adults may exhibit a preference for the “here and now.” Based on previously discussed theories of future time perspectives that suggest shortening time horizons influence older adults’ perspectives and priorities (Carstensen et al., 1999; Carstensen & Mikels, 2005), it may be that older adults prioritize their social connections as a means to maximize their emotional experience. Further, they may prefer the immediate gain due to concern that time will run out before the delayed outcome is obtained (Löckenhoff & Rutt, 2015). Relatedly, the impact of diminishing health and
uncertainty about one’s longevity may have also influenced older adults’ decisions to choose now over later.

A second concept that may help explain our results of older adults’ decision-making behavior in intemporal conditions for social gains is the future-self continuity hypothesis. This idea focuses on the ways an individual’s concept of their present and future self, and the degree of overlap between these two entities, impacts decision-making behavior (Hershfield, 2011). It has been suggested that individuals who perceive their future identity as limited tend to behave more impulsively (Ersner-Hershfield et al. 2009). Other research supports the analog of this idea, in that those individuals who feel more similarity, vividness, and positivity with their future selves, tend to display less temporal discounting and instead can “save” for the future (for review, see Hershfield, 2011). Research further suggests that not only do older adults embody these traits, but that as we age, our self-concept may evolve to include close loved ones (e.g., children and grandchildren) thus further influencing the tendency to make decisions for the future (Hershfield, 2011). However, when coupled with the concept of socioemotional selectivity theory and waning time horizons, it may be that because of this increased connectedness and positivity toward their future selves, that older adults view the present and future as one and of the same, influencing their decisions for immediacy. Similarly, if their self-concept has shifted to include that of their offspring, “saving” for the future may make sense from a monetary standpoint; but it is likely the opposite perspective is true from a social standpoint, as this would support the importance of others and underscore spending precious time with loved ones in the present.

Regarding social losses, older adults showed temporal discounting toward future losses such that they showed preference for larger delayed losses as compared to smaller immediate
losses. These results, in contrast to our hypotheses, indicated that older adults evidenced slight loss aversion for amounts of time spent with loved ones. Overall, they did not discount social losses as steeply as they discounted social gains. The temporal discounting behavior observed in both social conditions may be due to the same reason, such that older adults recognize their time horizons are shortening. This acknowledgement may contribute to older adults wanting to gain time now but prefer to lose time in the future, given that the future may not arrive.

**Condition and Outcome**

Across gain and loss conditions, community-dwelling older adults in the current sample discounted social outcomes more steeply than monetary outcomes. Further, they also discounted gains more steeply than losses across both monetary and social paradigms. Taken together, older adults showed the steepest discounting for social gains and the shallowest discounting for monetary losses.

The gain-loss asymmetry observed in the present study is consistent with the robust finding in prior research indicating steeper discounting rates for gains as opposed to losses, known as “the sign effect” (Benzion et al., 1989; Frederick *et al*., 2002; Thaler, 1981). While this effect has been widely verified in monetary paradigms, there has been little investigation as to whether this pattern exists for gains and losses in non-monetary scenarios; however, emerging research suggests that this phenomenon exists for discounting time as well. Our results among community-dwelling older adults are consistent with that observed in young adults regarding discounting rates for periods of time (Abdellaoui *et al*., 2018). Overall, these findings suggest that older adults may be more motivated to receive rewards, whether in monetary or social forms, than they are motivated to avoid a loss. As such, older adults may make more optimal
financial decisions or savvy interpersonal decisions, if information is framed in such a way that it highlights the gains instead of the losses.

In regard to the differences observed across monetary and social conditions, older adults discounted social outcomes significantly more steeply than monetary outcomes. One explanation for this pattern as it relates to gains, may be that monetary rewards are not as motivating to older adults and social rewards may be more salient, therefore enhancing reward-related signals in the brain (Seaman et al., 2016). Seaman and colleagues (2016) found that older adults discounted social and health rewards more steeply than monetary rewards and speculated this may be due to brain changes, citing a region of the striatum that appears to be more sensitive to social rewards as compared to monetary rewards in older adults as opposed to younger adults. Further, the extended common currency schema, which postulates that a single neural circuit determines the motivational significance of both social and non-social situations, suggests that while social and non-social choices may result in identical activity in reward areas of the brain, they may differ in their functional connectivity to other brain regions (Wake & Izuma, 2017). When considering losses, older adults also more steeply discounted social losses as opposed to monetary losses. These results suggest that the anticipation of a monetary loss or debt may be more aversive than the anticipation of a time loss. Prior research investigating the influence of anticipation on decision-making preferences postulates that this behavior toward monetary losses may be due to the present bias effect (Hardisty et al., 2013). This bias suggests that the anticipation of a bigger future loss is so averse that the individual wishes to have the negative outcome over with immediately.

The striking differences in discounting rates between monetary and social outcomes should also be considered within the context of COVID-19. It may be that social restrictions
executed during quarantine and shelter-in-place protocols disproportionaly affected older adults' desire for immediate social outcomes as opposed to monetary outcomes. These results have important implications as it relates to eliciting behavioral change or increasing motivation among older adults. Using socially-based incentives and present-time focused strategies may be beneficial in nudging older adults to make better decisions.

**Environmental Associations with Decision-Making**

To further explore differences in decision-making behavior between gain vs. loss conditions and monetary vs. social content decisions, we considered the social environment of the decision-maker. Specifically, loneliness and social isolation have been found to impact decision-making by way of impulsivity and poor executive control. This relationship is particularly important to examine in older adults considering their increased risk for poor health outcomes due to isolation and loneliness. Thus, we sought to determine whether social isolation and loneliness were associated with decision-making behavior. We hypothesized that individuals reporting a higher level of social isolation would display steeper discounting for both social gains and social losses, such that they would more frequently choose the smaller, immediate social gain and social loss. We further hypothesized these individuals would exhibit more shallow discounting for monetary gains and losses, and thus more often choose the larger, delayed monetary gain and the smaller, immediate monetary loss. In terms of loneliness, we hypothesized that individuals reporting greater levels of loneliness would display steeper discounting across all conditions and would therefore show a preference for immediate gains but delayed losses.

**Isolation**

While isolation and loneliness are often used interchangeably, they represent distinct constructs with unique contributions to functionality and well-being. For example, it is possible
for an individual to be isolated, but not lonely, or lonely but not isolated. This distinction is important to recognize as interventions used to attenuate these factors are also likely not interchangeable. A current and frequently used definition of social isolation proposes it is “a state in which the individual lacks a sense of belonging socially, lacks engagement with others, has a minimal number of social contacts, and is deficient in fulfilling and quality relationships” (Nicholson, 2009, p. 1346). In other words, social isolation equates to a lack of social connections. Several studies suggest social isolation is associated with many unfavorable factors among all age groups including increased risk of mortality and non-fatal health outcomes such as cardiovascular disease, stroke, diabetes, and worse cognitive functioning (Evans et al., 2019; Holt-Lunstad et al., 2015; Valtorta et al., 2016). More specifically, social isolation was associated with an increased risk of developing dementia independent of other social risk factors such as loneliness (Penninkilampi et al., 2018; Shen et al., 2022). These risk factors appear pronounced among older adults (Cacioppo & Hawkley, 2003) and further include decreased physical activity in conjunction with increased sedentary time, hearing loss, and worsening anxiety and depression, (Mick et al., 2014; Robb et al., 2020; Schrempft et al., 2019). Our study extends these findings to include associations with decision-making behavior, affect, and socioeconomic characteristics.

Results from the present study revealed that participants who endorsed any level of feeling isolated, ranging from a little isolated to extremely isolated, had fewer years of education, more shallow rates of discounting for both monetary gains and losses, and greater levels of trait negative affect as compared to those participants who did not consider themselves isolated. These results are in line with prior research that suggests individuals with higher years of education have larger and more diverse social circles than their less-well-educated counterparts.
(McPherson et al., 2006). It is thought that higher levels of education promote conversational discussion with both family and non-family members and foster more opportunities for developing connections (McPherson et al., 2006). Further, the association between greater social isolation and less education is consistent with epidemiologic findings describing the sociodemographic correlates of social isolation in older adults (Cudjoe et al., 2020).

Interestingly, prior research also indicates that social isolation is linked to worse cognitive function (e.g., poor memory recall), but only in those older adults with fewer years of education (Shankar et al., 2013). The shared mechanisms between isolation and educational attainment may be apparent as early as childhood. A prominent longitudinal study showed that individuals who were socially isolated as children were more likely to subsequently acquire less educational attainment during adulthood and be positioned in a less advantaged social class (Lacey et al., 2014).

Surprisingly, the present study found that greater levels of isolation were also linked to more shallow rates of discounting for both monetary gains and losses. In other words, isolated participants displayed a preference for the larger delayed gain and the smaller immediate loss. Typically, shallow delay discounting has been positively associated with future-mindedness, conscientiousness, openness, and inhibitory control, as well as negatively associated with impulsivity and neuroticism (Keidel et al., 2021). Our findings suggest that isolated individuals may be less influenced by others in their social network by virtue of not seeing them as often or by simply not having as many relationships as their non-isolated peers. Thus, they may be less likely to make impulsive monetary decisions. Further, given that ratings of isolation were made in the context of and in relation to COVID-19, isolated individuals may have been better at practicing more responsible behavior (e.g., social distancing and self-isolating) as it related to
attenuating virus transmission. As such, it may be that individuals who practiced more socially responsible behavior during the COVID-19 lockdown were better able to consider future consequences and exhibit higher levels of self-continuity and future-oriented thinking. While future research is needed to confirm this hypothesis, it is in line with prior conceptualizations that shallow discounting may be a proxy for conscientiousness or responsible behavior (Joireman & King, 2016).

Our study also found that isolation was associated with higher levels of trait negative affect. While the directionality of this association was outside the scope of this study, some research suggests that trait affect influences the degree to which an individual seeks out social connectedness, such that positive affect is associated with approach behavior and negative affect is associated with socially avoidant behavior (see Elliot & Thrash, 2002 for review). An avenue of future research would be to test the directionality of this relationship to better understand the temporal ordering of social isolation and negative affect among community-dwelling older adults. It is also unclear as to whether participants’ trait negative affect was representative of an underlying inherent disposition toward negativity, or if participants’ responses on the PANAS were highly reflective of COVID-19 induced distress during the past two years. Several studies point toward associations between the pandemic and increased emergence of depressive and anxiety-related disorders among the general population (Salari et al., 2020). Further, a recent study longitudinally examined affective symptoms and social isolation among community-dwelling older adults both before and during the pandemic and found greater influence of social isolation on affective symptoms (e.g., worsening depressive and anxiety symptoms) along with an increased vulnerability to developing affective disorders (Yu & Mahendran, 2021). This finding lends credence to the idea that COVID-19 may be shifting affective processes within
individuals. In regard to future research, a more comprehensive assessment of isolation is warranted. For example, stratifying degrees of isolation to understand if differences emerge in decision-making behaviors or affect across varying levels of isolation. Further, investigating the structural (e.g., the size and frequency of social support) and functional (e.g., the quality of the support) factors (Broadhead et al., 1989), and how they independently and collectively impact decision-making among older adults, is also an area for future examination.

**Loneliness**

Social connections and relationships with others often serve as protective factors against poor health outcomes (Holt-Lunstad et al., 2010). Loneliness is typically conceptualized as an individual’s subjective appraisal of his or her personal relationships as deficient in some way (e.g., either in quality or quantity) and therefore not meeting one’s needs (Peplau & Perlman, 1982). According to prior research, loneliness is a well-established risk factor for health concerns, as well as poorer cognitive function (e.g., worse executive functioning and faster rates of cognitive decline), negativity, and increased likelihood of depression (Cacioppo & Hawkley, 2009). In general, older adults are more likely to experience loneliness as compared to their middle age and younger counterparts (Malcolm et al., 2019); a critical difference that was significantly widened during the COVID-19 epidemic (Dahlberg, 2021). Loneliness has also been linked to increased mortality among older adults by various behavioral, psychological, and biological mediators (Donovan & Blazer, 2020). Pertinent to the current study, making poor health decisions resulting in poor sleep, physical inactivity, and smoking, is thought to mediate the relationship between social connectedness and mortality (Donovan & Blazer, 2020).

Our findings indicated that any level of loneliness, ranging from a little to very much, was associated with lower annual family income, greater trait negative affect, greater state negative
affect, and trends toward lower state positive affect and worse health behavior choices as compared to individuals who did not endorse any loneliness. As it relates to socioeconomic and affective characteristics, these results are similar to our isolation findings, in that aspects of lower socioeconomic status and greater negative affect were collectively associated with worse sociability factors. These results are also consistent with prior research suggesting loneliness is higher among individuals with lower household incomes (McQuaid et al., 2021), particularly in the context of COVID-19 (Fancourt et al., 2021), and among older adults (Cohen-Mansfield et al., 2016). Proposed mechanisms for this relationship include financial restrictions in one’s ability to attend social events and the impact of limited financial resources on one’s self-efficacy and self-esteem leading to reductions in social contacts. It has been suggested that an individual’s economic status also influences their decision-making preferences, particularly as it relates to monetary outcomes (Fiorenzato & Cona, 2022; Houshofer & Fehr, 2014), and appraising decisions as “good” or “bad” is heavily dependent on one’s financial state. As such, it may be that sociability and financial factors build and interact to influence monetary decisions.

Loneliness was also associated with greater state and trait negative affect. This is consistent with a robust body of literature linking loneliness and negative affect by way of potentially aversive biological signal facilitating, reduced arousal to affective stimuli, and hypervigilance to social threats (for review, see Wong et al., 2022). Our study extends these findings by replicating this association specifically within older adults. As with our isolation findings, the directionality of this association between loneliness and negative affect is unclear; thus, future research should examine causal effects between these two constructs. Similarly, more mechanistic research is needed to identify potential modifiable factors driving this association among older adults.
In contrast to mechanistic research, intervention-based research points to both group-based interventions (e.g., support groups or videoconferencing) as well as one-to-one interventions (e.g., computer training, animal companions, telephone conversations, volunteer visitors) with the goal of enhancing social support and increasing accessibility and opportunities for social interaction (see Kasar & Karaman, 2021 for review; see Landeiro et al., 2017 for review). Moreover, many of these interventions can be provided at a community-based location (e.g., area on aging, senior center, etc.). Given the documented associations between loneliness and poor quality of life, as well as the increased risk for loneliness among older adults, it is imperative that interventions be used to abate loneliness among this group. Finally, although not significant, we did reveal a trend association between loneliness with lower state positive affect and worse everyday decision-making choices. Future research should examine both the independence and overlap in causal mechanisms driving high negative affect and low positive affect among lonely older adults, with an emphasis on behavioral mediators and moderators.

**Neuropsychological and Affective Influences of Decision-Making**

Within the current literature there exists great heterogeneity in decision-making behavior among older adults. One proposed reason for this heterogeneity are age-related changes in affect and cognitive functioning. Namely, a large body of literature suggests that, due to waning time horizons and shifting emotional priorities, older adults may exhibit higher levels of positive affect (Carstensen et al., 1999; Carstensen, Fung, & Charles, 2003; Carstensen & Mikels, 2005; Kennedy & Mather, 2007; Mather, 2006), which may lead to preference for immediate, “feel good” choices, as well as preferential focus for the present moment, thereby impacting decision-making choices (Cartensen et al., 2003; Kennedy & Mather, 2007). Additionally, research highlights age-related decrements in cognitive abilities (e.g., cognitive flexibility, inhibition,
working memory; Grady, 2012; Harada, Love, & Triebel, 2013; Murman, 2015; Salthouse, 2010) which have been associated with influencing temporal discounting rates in decision-making behavior (Lempert, et al., 2018; Lempert et al., 2020a; Löckenhoff & Samanez-Larkin, 2020; Samanez-Larkin et al., 2011). These constructs represent important areas of investigation given prior studies that suggest declines in decision-making may be predictive of underlying cognitive impairment as well as progression to dementia (Gerstenecker et al., 2016; Pérès et al., 2008; Sudo & Laks, 2017; Triebel et al., 2009; Tolbert et al., 2019). Importantly, these affective and cognitive processes have not been comprehensively studied across gain and loss conditions among older adults, thus we sought to examine the relative contributions of state positive affect and executive control on temporal discounting rates for monetary and socially salient outcomes. Briefly, we hypothesized that greater state positive affect and better executive control would predict shallower rates of discounting for monetary gains and steeper rates of discounting for monetary losses. We further hypothesized that greater state positive affect and lower executive control would be associated with steeper discounting rates for social gains and more shallow discounting rates for social losses. Overall, our findings add to a literature that is not well-characterized as it relates to affective processes, cognitive functioning, and decision-making in community-dwelling older adults.

In a series of hierarchical multiple regressions, neither state positive affect nor executive control accounted for a significant amount of variance in temporal discounting rates for any of the decision-making conditions, including monetary gains, monetary losses, social gains, and social losses. These findings were contrary to our hypothesis that state positive affect would be associated with steeper social temporal discounting rates as a function of the positivity effect and shifting priorities. Our findings are also incongruent with a previous study suggesting positive
affect was associated with temporal discounting rates for monetary gains among older adults (Löckenhoff et al., 2011). Moreover, our results are inconsistent with studies suggesting older adults may discount future outcomes more steeply than middle aged adults as a function of limited time horizons and declines in executive function (see Seaman et al., 2022 Table 1 for review). More generally speaking, positive affect has been broadly associated with improved thinking, cognitive flexibility, and innovation, thereby facilitating decision-making behavior (see Isen, 2008 for review). As such, our null findings for relationships between state positive affect and decision-making tendencies are unexpected. Given the highly motivating and emotionally salient content of the outcomes (money and time spent with loved ones), we speculated that state affect would be the most appropriate measure to understand if associations emerged between affect and discounting behavior. However, it may be that other estimates, such as trait affect or mood, would be better markers by which to assess influence on decision-making behavior. Further, the current study’s small monetary and social magnitudes may have contributed to the null effects. For example, one prior research study showed an influence of positive affect on temporal discounting rates, but only when the difference between the immediate and delayed gain was moderately large, and not when the difference was small (Pyone & Isen, 2011). The difference between immediate and delayed amounts may not have been high enough for state positive affect to have an impact on choice preference.

Our results were also inconsistent with our hypotheses that better executive control would be associated with less monetary and social discounting. Considerable evidence points to changes in executive function as a product of aging and strong associations between executive control and decision-making processes (for review, see Löckenhoff, 2018; Salthouse, 2010). Relevantly, some research suggests significant differences in decision-making abilities between
healthy older adults and older adults with MCI, with the latter group displaying greater impulsivity and inconsistent response patterns (Lindbergh et al., 2014). One possible explanation for our null findings may be that the current study’s decision-making paradigms were not complex enough in their design to reveal an effect of executive control. Perhaps aspects of executive function become more salient and strongly associated with decision-making behavior when there are multiple steps to consider, risks to assess, or complex information gathering strategies to employ. Further, executive function is a complex domain comprised of heterogenous cognitive abilities such as set-shifting, planning, organizing, problem-solving, and abstract reasoning (Yuchy et al., 2009). Within the current study, we only examined one aspect of executive functioning (executive control as assessed by set-shifting). As such, it may be that other facets of executive function more appropriately associate with temporal discounting or decision-making in general. In contrast to the aforementioned research, some studies found that performance on executive function measures were unrelated to temporal discounting rates, suggesting instead an association with episodic memory (Lempert et al., 2020b). The study further indicated that episodic memory partially mediates the relationship between parentorhinal thickness and temporal discounting rates across individuals with both normal cognition and MCI. Thus, future research may consider better understanding what aspects of cognition map on to various decision-making profiles.

**Health Behaviors and Decision-Making**

Research suggests that affective and cognitive changes brought on by aging may impact decision-making behavior through waning-impulse control, over emphasizing present satisfaction, and disproportionally estimating future benefits or losses from available choices. Moreover, these decision errors may translate to suboptimal lifestyle choices and increase older
adults’ risks for poor health outcomes. Therefore, our final aim focused on investigating potential links between affect, executive control, and laboratory based decision-making behavior with day-to-day health behavior. We used a hierarchical multiple regression to first test a rudimentary model to determine the associations amongst affective traits, executive control, and discounting rates on health behaviors. We then followed this by using a more comprehensive model adjusting for relevant demographic factors and testing the statistically significant variables from the rudimentary model to assess their effect on health-behaviors. Our results indicated that state positive affect and sex were significant predictors of health behavior. Specifically, higher state positive affect and female sex were associated with better health behaviors, such as exercising, eating a balanced diet, regularly visiting the doctor, obtaining adequate sleep, and gathering information on one’s health. Surprisingly, we did not uncover any significant associations between executive control or temporal discounting rates with health behavior choices.

Positive Affect

Our finding that state positive affect was associated with better health behavior is consistent with a large body of research suggesting that both state and trait dependent positive affect are associated with better health across a wide spectrum of physical health outcomes (e.g., lower disease risk, disease severity, morbidity, and mortality; Pressman et al., 2019; Steptoe et al., 2009). In particular, state affect has been shown to alter in-the-moment physiological markers as well as health behavior choices. On a more mechanistic level, individuals with higher positive state affect have been consistently identified with having elevated vagal tone and lower levels of cortisol and inflammatory markers such as interleukin-6 (Pressman et al., 2019; Steptoe et al., 2013). Therefore, it may be the case that state positive affect, by way of continuous
mechanistic and physiological changes, collectively promote longevity and wellness. While much of the work investigating the relationship between affect and health outcomes is done via self-report measures, there is also mounting evidence to suggest that in-vivo measurements of affect yield similarly promising results (Pressman et al., 2019). Importantly, these associations appear to be independent of negative affect, suggesting that positive affect may have unique physiological pathways by which it promotes good health outcomes (Steptoe et al., 2013).

In this context, the current study’s results have important clinical implications, such that interventions targeted at promoting or maintain positive affect may help improve health. Specifically, borrowing from the field of positive psychology, interventions documented to increase positive affect include practicing gratitude, mindfulness meditation, engaging in random acts of kindness, and cognitive reframing (Pressman et al., 2019). As it relates to decision-making, we may be able use positive affect as a way to leverage better decisions. For example, eliciting behavioral change in the form of healthier choices by framing health messages in a positive light (e.g., ways to increase longevity or resilience rather than focusing on mitigating risk), as this approach focuses on the reward rather than the loss in a specific situation. In this regard, focusing on the immediacy of day-to-day smaller rewards may help older adults indirectly make incremental changes toward avoiding a larger negative consequence in the future (e.g., chronic disease). Further, we may also consider encouraging older adults to make decisions guided by values, gratitude, or their interpersonal relationships (e.g., increasing physical activity to spend more time with grandchildren or cooking a healthy meal with a close friend).

Along the lines of future research, studies should also explore potential mechanisms linking state positive affect with health behaviors, as it relates to in the moment decision-making. Potential areas of exploration include investigating temporal discounting rates in a more
comprehensive design (e.g., a greater number of delay levels as well as longer periods of delay levels) to better characterize how decision-making preferences such as delaying gratification, emphasizing the present moment, loss aversion, debt aversion, or utility value may benefit or hinder everyday health behavior choices. Additionally, assessing how state positive affect might optimize decision-making in other areas such as financial, social, and risk domains are needed areas of research. Relatedly, future research may also consider what dimensions (e.g., high activation vs. low activation) of positive affect might differentially predict better health outcomes, with the goal of utilizing these characteristics in decision-making scenarios or particular interventions.

**Sex**

Findings from the current study also revealed that sex was a significant predictor of health behavior. Follow-up analyses indicated a trend toward significance for female sex being associated with better health behavior choices. However, after adjusting for multiple comparisons, the relationship between sex and health behavior was no longer significant. Results are thus interpreted within the context of medium effect sizes and limitations of the conservative nature of Bonferroni corrections (e.g., risk of increased type II errors; Perneger, 1998). There are known differentials in health risk among males and females, with some studies suggesting women are ill more often than men, but with relatively mild health problems as compared to the more serious illnesses and injuries observed among men (Verbrugge, 1982). In addition to morbidity differences, there are also marked differences in mortality rates with women enjoying higher life expectancy rates than men (Verbrugge, 1982). While there are several proposed reasons for these differences (e.g., inherited and acquired risk of injury and illness, prevention, and reporting behavior), our results suggest health behavior choices may also contribute to these
group differences. Further, women may approach decision-making differently from men, particularly as it relates to health behavior choices. Although beyond the scope of this study, future research should investigate whether temporal discounting rates differ for gain and loss conditions between men and women, and whether discounting rates differ as a function of outcome (e.g., money, food, health, etc.). Furthermore, understanding why these differences exist, (e.g., differences in perceptions of utility, value, or personality characteristics such as conscientiousness) is also a potential avenue for investigation.

**Executive Control and Temporal Discounting Rate**

We were surprised to find no relationship between either executive control or temporal discounting rates and health behavior, seeing as how several of the behaviors listed on the Good Health Practices Scale require, on some level, the decision-maker to prioritize the future above the present. For example, flossing one’s teeth is often viewed as a tedious chore in the current moment, but brings with it a future gain of minimizing risk for periodontal disease. Additionally, collecting information on health and going to the doctor to receive care may not be enjoyable ways of spending one’s current time; however, these behaviors increase the likelihood that one is able to spend more time doing the activities they enjoy in the future. Despite these proposed connections, it may be that older adults’ underlying motivations for their choices made in monetary and social paradigms did not translate to behavioral health domains. Future research should therefore address mechanistic similarities and differences driving decision-making preferences across various domains. In terms of cognitive functioning, similar to our null findings in Aim 3, it may be that the aspect of executive function chosen for the current study (e.g., executive control) may not have been a sensitive measure to detect variability in health behavior choices.
Study Limitations and Future Directions

This study adds valuable information to the current body of literature on decision-making in older adults. Strengths of the current study include recruitment of a socioeconomically diverse sample, comprehensively assessing the relationships between decision making, affective processes, and cognitive processes, and linking laboratory-based behavior with real world behavior. Further, these constructs were studied in a videoconferencing format, expanding inclusivity to older adults who would otherwise be unable to travel to the study location.

However, this study is not without limitations that warrant future research. First, the study utilized a cross sectional design to assess associations between demographic, affective, and cognitive characteristics with decision-making preferences. Future research should consider a longitudinal research design to better understand the collective and individual predicative utility of these constructs for predicting cognitive dysfunction and/or decline among community-dwelling older adults.

Additionally, there were concerns with scale reliability. Conventional standards for alpha’s coefficient vary and caution must be taken against uniformly applying cut-off criteria (e.g., Lance et al., 2006; Nunnally, 1967; Schmitt, 1996). Within this study, the state NA scale’s internal consistency ($\alpha = .628$) could be considered questionable, while some suggest it is acceptable (Ursachi et al., 2015). Similarly, in efforts to improve the reliability of the Good Health Practices (GHP) scale, we removed one scale items to raise the Cronbach’s alpha. As such, this shortened scale may have attenuated associations between our predictor and outcome variables (e.g., increased type II error rate). While the GHP evidenced good reliability in the original older adult sample, our null Health Behavior findings may be a product of suboptimal reliability in the current sample. Reasons for this are unclear, but items may have not loaded onto
similar dimensions in the current sample as in the original sample. Given that this measure was administered during a time of risk and precaution in the context of the COVID-19 pandemic, perhaps items from Risk Avoidance would have demonstrated better reliability in the current sample. Similarly, although the GHP items were related to important risk factors for chronic disease in the original sample, the tendencies underlying health behavior choices may not have generalized to preferences for monetary and social decisions.

The nature of the temporal discounting data also presented challenges that limited the current study. First, the discounting data, by nature of its design, was significantly skewed and non-amenable to transformations. This therefore limited the statistical approaches we were able to use. In addition, while AUC and Mazur’s $k$ are both well-established methods for assessing discounting behavior and were both highly correlated in our study, we were unable to use the $k$ value in our analysis due to significant non-normality characteristics. Research suggests the $k$-value is a superior method for capturing the variance in discounting rates, particularly when used in groups of either steep or shallow discounters, the latter of which we observed in the current sample (see Yoon et al., 2017 for review). Second, some of our participants completed the decision-making task in such a way that their data followed a non-systematic responding (NSR) pattern, meaning that their subjective values of delayed outcomes increased and decreased in a nonsensical or haphazard way. Prior studies have found that increasing fronto-executive demands on decision-making tasks decreases participants’ ability to maintain consistent preferences across trials (e.g., choice consistency, see Lempert et al., 2020b for review). It is therefore feasible that worse executive functioning may be associated with non-systematic responding. While Johnson & Bickel (2008) caution against removing NSR data from analysis, including these participants in analyses may alter findings, or important group differences may
be missed. As such, future research should consider this in their methodology and run analyses with and without NSR data to understand if significant differences in findings emerge.

A third overall limitation of our study was the abbreviated decision-making paradigm design. Our decision to abbreviate the number of decision-making trials was made to lessen fatigue, increase task engagement, and keep the overall study visit to a reasonable amount of time for our participants. The typical decision-making paradigm commonly uses 5-8 delay periods to assess discounting rates. As such, restricting the delay periods to just four levels, may have meant that we did not observe the same normative delay effect or steep discounting arc seen in other studies. This could be one possible explanation for the shallow discounting rates we observed as compared to other studies. Nevertheless, it should be noted that our justification for using four delay levels has been previously validated and supported as appropriate methodology (Yi et al., 2010)

Fourth, our study design was limited through investigating decision-making behavior in a laboratory-based setting instead of a real-life setting. While research generally shows that participants’ decisions for real and hypothetical outcomes are similar (Johnson & Bickel, 2002; Madden et al., 2003), there is also striking evidence to suggest that bias is inflated and ecologically validity is minimized in laboratory-based studies (Shiffman et al., 2008). As such, it may be the case that hypothetical rewards are not viewed as motivating or enticing as real rewards. Similarly, hypothetical losses may not be felt as aversively as real losses. Moreover, it may be easier to behave in an ideal way when faced with a hypothetical situation as opposed to a real situation. For example, when older adults were asked if they wanted to pay a small amount now vs. a bigger amount of later, nearly all of them chose the smaller option. In this hypothetical scenario, it would be unlikely for someone to willingly choose a larger amount. However, in a
real-life situation, such as making a credit card payment now or later, decision-making behavior might look drastically different due to practical limitations. In other words, participants may experience a well-known phenomenon in choice experiments known as hypothetical bias (see Murphy et al., 2005 for review). Notably, this phenomenon is typically observed in younger adults and in the context of monetary outcomes; thus, it will be important to study whether this phenomenon exists in older adults and with non-monetary outcomes. Furthermore, using more ecologically valid methods to assess the nuances of decision-making behavior, such as ecological momentary assessment, is an important area for future exploration.

Finally, within our social losses condition, the outcome was more difficult for participants to conceptualize when compared to a monetary loss. Because money is a tangible construct, positive outcomes can easily be viewed as gains while negative outcomes are defined as losses. The valuation of time on the other hand is more ambiguous, particularly the loss of time. While we provided the prompt of losing time with a loved one, this proved a difficult concept for participants to imagine. Future studies may consider instead first identifying an exogenous reference point (e.g., imagine you had X number of hours, and now you are losing Y amount), in efforts to standardize the definition of a loss of time.

While not a limitation, it is important to note that while within group-analysis suggested clear differences in decision-making behavior as a function of gains vs. losses and social vs. monetary outcomes among community-dwelling older adults, labeling these results as “steep” or “shallow” needs to be considered within the context of the greater body of discounting data literature. For example, when compared to other studies, the present study’s discounting rates across conditions (.<001 - .043) yield relatively shallow outcomes. In studies examining differences in discounting rates between controls and drug users, discounting rates were seen as high as .364 in drug users
and .042 in controls (Petry, 2003). While the current study’s discounting rates are still meaningfully interpretable and may be an accurate reflection of older adults’ discounting tendencies, the qualitative labels of steep and shallow are used only within the context of the current sample to compare within group differences.

Future avenues for research include further examining cohort effects and their potential influence on both monetary and social decision-making behavior by including a wider range of age groups. Additionally, studying decision-making preferences in a racially and ethnically diverse sample is also needed in order to increase generalizability of the current findings. Within these areas, given the well documented magnitude effects that exist in temporal discounting research, it would be interesting to assess attitudes toward short-term debt (e.g., credit cards, medical bills) vs. long-term debt (e.g., student loans, mortgages, auto loans), or short-term social commitments vs. long-term social commitments (e.g., marriage). Finally, assessing monetary and social gain and loss paradigms within disease populations may reveal behavioral patterns that can better inform disease prognosis and trajectory.

**Summary and Conclusions**

Decision-making is an often-complex process influenced by temporal ordering, context, and the decision-maker’s own values, preferences, and reference points. Prior research investigating decision-making behavior among older adults has been inconsistent and inconclusive. However, investigating age associated changes in affective and cognitive processes that may independently and collectively impact optimal decision-making abilities, may elucidate reasons for these inconsistencies. Furthermore, considering that recent evidence suggests that decision-making decrements may serve as a predictive tool for cognitive decline, or as an
indication of existing impairments within subserving cognitive domains, it remains an important endeavor to understand how, and why decision-making abilities may change in older adults.

Within the present study, community-dwelling older adults displayed steeper temporal discounting rates for gains as compared to losses, and for social outcomes as compared to monetary outcomes. Thus, they evidenced the steepest discounting rates for social gains and the shallowest discounting rates for monetary losses, all at large effect sizes. These results indicate that older adults showed an expected temporal discounting pattern, such that they devalued future outcomes as compared to immediate outcomes, when outcomes were framed as rewards or contained social content. They exhibited negative discounting, or a preference for a smaller immediate loss as compared to a larger delayed loss, when outcomes were framed as monetary losses or debts. These findings are consistent with the robust finding that individuals tend to discount gains more steeply than losses, known as the “sign-effect.” Our findings are also consistent with prior research indicating older adults may place more value on social outcomes as opposed to monetary outcomes.

Results from this study also suggest that isolation and loneliness are associated with differential aspects of low socioeconomic status and trait negative affect among community-dwelling older adults. Interventions to independently address loneliness and isolation, may be most beneficial if done so by targeting ways to increase positive affect among individuals in low-income settings. Our findings also indicated that experimental laboratory decision-making tasks were not associated with state affect or executive control. As such, there is a need for more in-vivo, day-to-day life studies to better understand how individuals make decisions in emotional states or when faced with complex decisions that require intact cognitive flexibility, strategy, and planning. Finally, our study findings show that state positive affect and sex differentially predict
health behavior choices, such that higher state positive affect and female sex are associated with healthier choices.

Taken together, our findings demonstrated that community-dwelling older adults show preference for immediate gains that are social in content, individuals from lower socioeconomic backgrounds may be more prone to isolation and loneliness, and state positive affect and female sex predict healthier behavioral choices. These findings can be used to leverage decision-making abilities such that decision outcomes are optimized.
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APPENDICES

Appendix A: M-ABLE Wave 2 Phone Screening

Appendix B: Informed Consent Forms: First and Follow-up Study Visits

Appendix C: Demographic Form

Appendix D: National Alzheimer’s Coordinating Center COVID-19 Impact Questionnaire

Appendix E: Oral Trail Making Test Parts A and B

Appendix F: Trait Positive and Negative Affective Schedule

Appendix G: State Positive and Negative Affective Schedule

Appendix H: Good Health Practices Scale

Appendix I: M-ABLE Wave 2 Exit Survey
APPENDIX A:

M-ABLE Wave 2 Phone Screening
M-ABLE Wave 2 Phone Screening

Hi, my name is _______________. I am an [assistant professor/graduate student/research assistant] in the Department of Psychology at the University of Maine. I am responding to your email/returning your call to provide more information about our study. Thank you so much for your time and interest in our research. We are looking for volunteers to participate in a paid research study that will help us learn more about brain health.

If you qualify, you may be eligible to receive a $25 gift card to Hannaford as a thank you for your time and effort in participating in the study. This session will be about 2 hours.

During the study, you will be asked to complete reading, memory, and thinking tasks and questionnaires about your health and well-being.

Before I schedule your study visit, I will first need to ask you some questions about your medical and mental health history to help determine eligibility. This screening should take about 5 minutes. Should you meet the initial criteria, I will then schedule your Zoom study visit.

Your participation in the screening and study is entirely voluntary. We will keep all the information I receive from you by phone today, including your name and any other identifying information confidential. Also, if you do not qualify for the study, or if you decide not to participate, we will destroy the information that was collected.

Does this sound like something you would be interested in hearing more about?

- If yes proceed to next section
- If no, query “may I ask you why do not want to continue?” At this time, clarify any questions that they might have and if not interested in participating thank them for their time and assure them that this does not affect their ability to participate in future studies we may conduct should they be interested.

Please feel free to stop me at any time if you have any questions or concerns. You may feel uncomfortable answering questions about your medical or mental history. You do not have to answer any questions you do not wish to answer and you may stop at any time. However, it is possible that we may not be able to include you if we cannot determine your eligibility from your responses. Do you have any questions or concerns so far? [Answer questions as appropriate and make sure you obtain verbal agreement before proceeding to questions on next page].

**Screening Questions:** If no to any of the responses below, the participant is ineligible for study: (conclude screening here):

1. Participant is 45 years or older? __________
2. Is participant willing to schedule a 2.5 hour time block for the study visit? __________

If “yes” to any of the responses below, the participant is ineligible for study:
1. Do you have trouble hearing over the phone? _____Y _____N

2. Do you have any difficulty hearing me right now? _____Y _____N

3. Please repeat this statement after me: I have a cat, so all I need is a dog.”
   __Y__N

   a. If yes, proceed to next question.

   b. If no, repeat again: “I have a cat, so all I need is a dog.”

      i. If NO, but you think from your interaction up to this point
         his/her poor hearing can be compensated for (e.g., able to repeat the
         majority of
         sentence correctly, such as "I have a cat and I need a dog") you may
         proceed; however, speak as loudly and distinctly as possible.

      ii. If you think hearing will severely bias the cognitive test results, DO NOT
          continue. Read the appropriate exclusion script to participant.

4. Does participant have untreated Schizophrenia or Bipolar Disorder (i.e., are they adhering
   to physicians prescribed treatment for disorder)? ______

5. Participant has had a major stroke in the past year And/OR a major stroke
   and still experiencing significant neurological problems (e.g., speech impairments,
   loss of movement on one side of body) that require regular medical attention?
   ______

6. Participant has had a moderate to severe traumatic brain injury in which they have lost
   consciousness for longer than 30 minutes? ______

7. Participant is receiving treatment for a dementia disorder (e.g., Aricept medication for
   suspected Alzheimer’s Disease)? ______

8. Does participant have hearing, visual, motor or behavioral conditions that would preclude
   them study procedures?

   9. Does participant have an intellectual disability (formerly known as mental
      retardation and still commonly referred to as such, so also inquire using this term if
      uncertain)?

10. Is the participant affiliated with the University of Maine system as an employee?
    i. if they are employees - let them know that unfortunately employees are not
        eligible for the giftcards due to university policy, and we understand this seems unfair
        and they may change their decision to participate.
If subject is ineligible for study: Please read appropriate “Exclusion Script” to participant. If unable to determine eligibility based on participant non-responses, they will be excluded.

If subject is eligible for study: Based on your answers to the questions, it appears you are eligible to participate in the research study. [Schedule study visit if interested]. Once scheduled, ask whether it is okay to contact them, and what is their best method of contact. Confirm that we have the most up-to-date phone number, email address, and mailing address for them.
APPENDIX B:

Informed Consent Forms: First and Follow-up Study Visits
INFORMED CONSENT TO PARTICIPATE IN A RESEARCH STUDY

First Study Visit

You are invited to participate in the research project titled the “Maine Aging Behavior & Learning Enrichment (M-ABLE) Study” being conducted by Dr. Rebecca MacAulay, an assistant professor in the Department of Psychology at the University of Maine. The purpose of this research is to help us learn more about brain health in older adults and the tools we use to measure thinking and memory in older adults. You must be 45 years or older to participate. Your participation will be about a two-hour visit and you will have the option to participate by phone or a Zoom televideo call. To participate via Zoom, you will need to have reliable internet access and a computer, tablet or smartphone device for the video session.

What Will You Be Asked to Do?

You are asked to read this informed consent form and have it handy during your scheduled study visit. The study staff will review the form with you at this time and answer any questions that you may have about the following information.

To determine eligibility, you will be asked some questions about your medical and mental health history. The following are some examples of questions about your medical and mental health history you will be asked:

- Have you had a stroke? If yes, has this happened within the last year? Do you still need medical care for it?
- Have you had a heart attack? If yes, has this happened within the last year? Do you still need medical care for it?
- Have you ever been told by a health care professional you have bipolar disorder or schizophrenia?

You may be excluded from the study if you have a history of a serious brain injury (such as a stroke or traumatic brain injury) or significant problems related to your mental health or thinking abilities.

If eligible to participate, you will be asked to:
1. Be in a private room, where you will not be interrupted or observed by others. This room should also be relatively quiet and free of distractions.
2. If you use hearing aids or wear glasses (or contacts) for vision correction, we ask that you use these during the session.
3. During the interview, we will ask questions about your demographics (e.g., age and education) and medical history. Your responses to these questions will be collected using paper and pencil.
4. We will also ask questions that ask how much you agree with the statements about different attitudes, activities (e.g., exercise and things you do to cope with stress), life experiences, and perceptions of health. These questions will be read to you, and if you are on Zoom, we will also show you the survey questions using the "Shared Screen" feature. We will enter your
answers to the questions into an online survey form on your behalf. The following are examples of the types of questions you will be asked:

- On a scale of "not at all" to "very much" rate how often you generally feel “Interested” and “Angry”
- Thinking about both the good and bad things that make up your quality of life, how would you rate the quality of your life as a whole?
- How much difficulty do you have falling or staying asleep?
- Indicate how much you agree or disagree with “I rush through activities without being really attentive to them”
- Indicate whether you have experienced harmful events in your childhood (e.g., whether you were hit by an adult or inappropriately fondled)

5. Perform thinking, memory, attention, and reading tasks. We will record your responses to these tasks using paper and pencil. Some examples are:

- We will read you a list of words and ask you to repeat as many as you can later on.
- We will read you some numbers and ask you to repeat back numbers

For those participating via Zoom, you will also be invited to participate in an optional task that will ask you to play a computer game online that asks you to make choices about gains and losses. This part of the study should take about 10 minutes to complete.

Risks

The following study has minimal risks:

- There is a chance that you become tired during the tasks. If you become tired, you may request a break at any time. We will also take scheduled 5-10 minute breaks every hour and will encourage you to stand up and move around every hour to help with energy.
- There is the possibility that you may become uncomfortable during the interview or answering some of the questionnaires. If you become uncomfortable answering any of the questions you may skip any that you do not want to answer.
- Zoom and are our online survey (Qualtrics) are considered to be a secure electronic platform. However, there are risks to privacy and confidentiality with the use of electronic services. For example, there is a risk that others could get access to private conversations. To reduce this risk, we will use a private Zoom meeting link that we will email to you. We ask that you not share this meeting link with anyone else. We also do not enter any identifying information into the online survey.

Benefits

- Your participation might help us to improve measures we use to identify those at higher risk of dementia, so we can do a better job of identifying people who might benefit from treatment.
- Your participation will help research scientists better understand activities that might help improve mood, memory and/or thinking as we get older.
Compensation

- You may be eligible to receive a $25 gift card to Hannaford for completing the study. You may skip any questions that you do not want to answer and still be eligible.
- If you do not complete the study, you will be prorated $10 an hour (up to $20) for your participation.

Confidentiality

Every effort will be made to maintain the confidentiality of your information collected in the study. Your name or any other identifying information will not be on any of the study data. You will be given a code number to protect your identity that will be used for the study database. The consent and compensation forms with your name on them are stored in a locked filing cabinet in Dr. MacAulay's locked office. Computer records will be stored on locked personal computers with special software that provides additional security in the CARE laboratory in N. Stevens Hall at the University of Maine campus located in Orono. The password-protected key linking your name to your study ID will be destroyed by August 2023. The de-identified study database will be kept indefinitely on a password-protected computer. Only study staff will have access to the study database. Study consent and compensation forms, paper measures used during the clinical interview and cognitive tasks will be destroyed by August 2029. Information from the online survey questions will be downloaded and securely stored using IT-approved electronic storage indefinitely. The online survey data will be deleted from the account website by August 2023. Ineligible participants' data will be deleted within one week of the visit. Paper records will be shredded and the devices’ storage media will be physically overwritten to destroy all electronic information. Results of the study may be published but will not include any information that would identify you.

Voluntary

- Participation is entirely voluntary - you may refuse to participate at any time (e.g., you can skip questions you do not want to answer)
- If you choose to take part in this study, you may stop at any time. You may also request that any information collected not be included in the study database up to one week after your study visit.

Optional Research Registry and CARE Lab Data Repository

Additionally, you may choose to participate in two optional aspects of the study. Participation in the following is not necessary for enrollment in the study. You are being asked to provide consent to add your name and contact information into a research registry. The registry will include your name, place of residence, preferred contact information, and age. By agreeing to participate in the registry, you may be contacted about other studies that you may be eligible for by Dr. MacAulay or one of her graduate students. You are under no obligation to participate in any of the studies you are contacted about, should you agree to be included in the registry.

You may at any time ask that your name be removed from the research registry by phoning or writing Dr. MacAulay, who will remove you from the list by two weeks of notice from you.

You are being asked to provide consent for your data collected for this study to be saved for
future research conducted by Dr. MacAulay and the CARE lab. This information will be not shared with other researchers. If you consent to have your data stored, your name will be entered into a password-protected document with a key linking your name to your study ID. Your de-identified data will be kept indefinitely. The purpose of storing your research information is to gather information about your health over time for future research that may help us to better understand how to keep the brain healthy.

Risks

Participation in the Research Registry may involve the potential risk of a breach of confidentiality of the information and associated privacy of the participants.

Benefits

There are no direct benefits associated with participation in the Research Registry. Participants in the Research Registry will be informed of future research studies for which they may be eligible. Participants in the Data Repository may benefit from having a reduced time burden as certain procedures will not need to be repeated in future studies the CARE lab conducts.

Contact Information

If you have any questions about this study, please contact the Principal Investigator (PI), Dr. Rebecca MacAulay using the information below:

Rebecca K. MacAulay, Ph.D. at the University of Maine Department of Psychology, Assistant Professor
Telephone: 207-581-2044 Email: Rebecca.macaulay@maine.edu

If you have any questions about your rights as a research participant, please contact the Office of Research Compliance, University of Maine, 207/581-2657 (or e-mail umric@maine.edu).

I would like to hear about other research studies being conducted by Dr. MacAulay. I agree to be contacted by the registry about other studies that I may be eligible for. However, I am under no obligation to participate in these studies, should I agree to be included in the registry.

Yes________ No________ Initials ____________

I consent to being added to the CARE lab registry to have my data stored for future use in research conducted by Dr. MacAulay and the CARE lab. This information will be not shared with other researchers.

Yes________ No________ Initials ____________
This study has been discussed with me and I have read the study description provided above. I understand that by providing my verbal agreement, I willingly agree to participate in this study and to allow the information collected about me in this study to be used for research purposes. You will receive a copy of this form for your records.

Printed Name of Volunteer ____________________________________________________________ Date __________

________________________

Verbal Consent Provided (Yes or No)
INFORMED CONSENT TO PARTICIPATE IN A RESEARCH STUDY

Follow-up Visit

You are invited to participate in the research project titled the “Maine Aging Behavior & Learning Enrichment (M-ABLE) Study” being conducted by Dr. Rebecca MacAulay, an assistant professor in the Department of Psychology at the University of Maine. The purpose of this research is to help us learn more about brain health in older adults and the tools we use to measure thinking and memory in older adults. You are invited to participate in a second follow-up visit that allows us to better understand how emotional, physical and cognitive health changes over time. You must be 45 years or older to participate. Your participation will be about a two-hour visit and you will have the option to participate by phone or a Zoom televideo call. To participate via Zoom, you will need to have reliable internet access and a computer, tablet or smartphone device for the video session.

What Will You Be Asked to Do?

You are asked to read this informed consent form and have it handy during your scheduled study visit. The study staff will review the form with you at this time and answer any questions that you may have about the following information.

To determine eligibility, you will be asked some questions about your medical and mental health history. The following are some examples of questions about your medical and mental health history you will be asked:

• Have you had a stroke? If yes, has this happened within the last year? Do you still need medical care for it?
• Have you had a heart attack? If yes, has this happened within the last year? Do you still need medical care for it?
• Have you ever been told by a health care professional you have bipolar disorder or schizophrenia?

You may be excluded from the study if you have a history of a serious brain injury (such as a stroke or traumatic brain injury) or significant problems related to your mental health or thinking abilities.

If eligible to participate, you will be asked to:
1. Be in a private room, where you will not be interrupted or be observed by others. This room should also be relatively quiet and free of distractions.
2. If you use hearing aids or wear glasses (or contacts) for vision correction, we ask that you use these during the session.
3. During the interview, we will ask questions about your demographics (e.g., age and education) and medical history. Your responses to these questions will be collected using paper and pencil.
4. We will also ask questions that ask how much you agree with the statements about different attitudes, activities (e.g., exercise and things you do to cope with stress), life experiences, and perceptions of health. These questions will be read to you, and if you are on Zoom, we will also show you the survey questions using the "Shared Screen" feature. We will enter your
answers to the questions into an online survey form on your behalf. The following are examples of the types of questions you will be asked:

• On a scale of "not at all" to "very much" rate how often you generally feel “Interested” and “Angry”
• Thinking about both the good and bad things that make up your quality of life, how would you rate the quality of your life as a whole?
• How much difficulty do you have falling or staying asleep?
• Indicate how much you agree or disagree with “I rush through activities without being really attentive to them”
• Indicate whether you have experienced harmful events in your childhood (e.g., whether you were hit by an adult or inappropriately fondled)

5. Perform thinking, memory, attention, and reading tasks. We will record your responses to these tasks using paper and pencil. Some examples are:

• We will read you a list of words and ask you to repeat as many as you can later on.
• We will read you some numbers and ask you to repeat back numbers

For those participating via Zoom, you will also be invited to participate in an optional task that will ask you to play a computer game online that asks you to make choices about gains and losses. This part of the study should take about 10 minutes to complete.

Risks

The following study has minimal risks:

• There is a chance that you become tired during the tasks. If you become tired, you may request a break at any time. We will also take scheduled 5-10 minute breaks every hour and will encourage you to stand up and move around every hour to help with energy.
• There is the possibility that you may become uncomfortable during the interview or answering some of the questionnaires. If you become uncomfortable answering any of the questions you may skip any that you do not want to answer.
• Zoom and our online survey (Qualtrics) are considered to be a secure electronic platform. However, there are risks to privacy and confidentiality with the use of electronic services. For example, there is a risk that others could get access to private conversations. To reduce this risk, we will use a private Zoom meeting link that we will email to you. We ask that you not share this meeting link with anyone else. We also do not enter any identifying information into the online survey.

Benefits

• Your participation might help us to improve measures we use to identify those at higher risk of dementia, so we can do a better job of identifying people who might benefit from treatment.
• Your participation will help research scientists better understand activities that might help improve mood, memory and/or thinking as we get older.
Compensation

• You may be eligible to receive a $25 gift card to Hannaford for completing the study. You may skip any questions that you do not want to answer and still be eligible.
• If you do not complete the study, you will be prorated $10 an hour (up to $20) for your participation.

Confidentiality

Every effort will be made to maintain the confidentiality of your information collected in the study. Your name or any other identifying information will not be on any of the study data. You will be given a code number to protect your identity that will be used for the study database. The consent and compensation forms with your name on them are stored in a locked filing cabinet in Dr. MacAulay's locked office. Computer records will be stored on locked personal computers with special software that provides additional security in the CARE laboratory in N. Stevens Hall at the University of Maine campus located in Orono. The password-protected key linking your name to your study ID will be destroyed by August 2023. The de-identified study database will be kept indefinitely on a password-protected computer. Only study staff will have access to the study database. Study consent and compensation forms, paper measures used during the clinical interview and cognitive tasks will be destroyed by August 2029. Information from the online survey questions will be downloaded and securely stored using IT-approved electronic storage indefinitely. The online survey data will be deleted from the account website by August 2023. Ineligible participants' data will be deleted within one week of the visit. Paper records will be shredded and the devices’ storage media will be physically overwritten to destroy all electronic information. Results of the study may be published but will not include any information that would identify you.

Voluntary

• Participation is entirely voluntary - you may refuse to participate at any time (e.g., you can skip questions you do not want to answer)
• If you choose to take part in this study, you may stop at any time. You may also request that any information collected not be included in the study database up to one week after your study visit.

Optional Research Registry and CARE Lab Data Repository

In your last study visit, you agreed to join our research registry and data repository. By agreeing to participate in the registry, you agreed to be contacted about other studies that you may be eligible for by Dr. MacAulay or one of her research assistants. This research registry includes your name, place of residence, preferred contact information, and age. The data repository includes data collected from each of your study visits and is saved for future research conducted by Dr. MacAulay and the CARE lab. As part of the data repository, your name is entered into a password-protected document with a key linking your name to your study ID. The purpose of storing your research information is to gather information about your health overtime for future research that may help us to better understand how to keep the brain healthy. This information is not shared with other researchers. Your de-identified data will be kept indefinitely.
As a reminder, you are under no obligation to participate in any of the studies you are contacted about, should you agree to be included in the registry. You may at any time ask that your name be removed from the research registry by phoning or writing Dr. MacAulay, who will remove you from the list by two weeks of notice from you. We will also ask you to provide consent at each visit in case you change your mind about being enrolled in it.

**Risks**

Participation in the Research Registry may involve the potential risk of a breach of confidentiality of the information and associated privacy of the participants.

**Benefits**

There are no direct benefits associated with participation in the Research Registry. Participants in the Research Registry will be informed of future research studies for which they may be eligible. Participants in the Data Repository may benefit from having a reduced time burden as certain procedures will not need to be repeated in future studies the CARE lab conducts.

**Contact Information**

If you have any questions about this study, please contact the Principal Investigator (PI), Dr. Rebecca MacAulay using the information below:

Rebecca K. MacAulay, Ph.D. at the University of Maine Department of Psychology, Assistant Professor
Telephone: 207-581-2044  Email: Rebecca.macaulay@maine.edu

If you have any questions about your rights as a research participant, please contact the Office of Research Compliance, University of Maine, 207/581-2657 (or e-mail umric@maine.edu).

I would like to hear about other research studies being conducted by Dr. MacAulay. I agree to be contacted by the registry about other studies that I may be eligible for. However, I am under no obligation to participate in these studies, should I agree to be included in the registry.

Yes________  No________  Initials __________________

I consent to being added to the CARE lab registry to have my data stored for future use in research conducted by Dr. MacAulay and the CARE lab. This information will be not shared with other researchers.

Yes________  No________  Initials __________________
This study has been discussed with me and I have read the study description provided above. I understand that by providing my verbal agreement, I willingly agree to participate in this study and to allow the information collected about me in this study to be used for research purposes. You will receive a copy of this form for your records.

_________________________________________  ________________________
Printed Name of Volunteer                      Date

_________________________________________

Verbal Consent Provided (Yes or No)
APPENDIX C:

Demographic Form
Demographics Form

Participant Demographics Form (circle number(s) and/or fill in all blanks)

1. Month and Year of Birth: _____ / ______

2. Sex
   1= Male
   2= Female

3. Race (circle to indicate response):
   1=White
   2= Black or African American
   3=American Indian or Alaska Native
   4=Asian
   5=Latina/o
   6=Other

4. Primary Language:
   1=English
   2=Spanish
   8=Other (specify language): ______

5. Highest Grade Level completed:
   <12 (indicate GED, 0=no, 1=yes)
   12=high school degree
   16=bachelor’s degree; degree name: __________________
   18=master’s degree; degree name: __________________
   19=JD (law degree); degree name: __________________
20=doctorate (e.g., Ph.D., M.D.); degree name:____________________

6. Participant's Occupation Status:
1=Employed full time
2=Employed part time
3=Retired
4=Unemployed

7. Participant's current marital status (Circle to indicate response):
1=Married
2=Widowed
3=Divorced
4=Separated
5=Single/Never married
6= Domestic partner

8. Living Situation
1=Lives alone
2=Lives a spouse or partner
3=Lives with a relative, friend, or roommate
4=Lives with caregiver who is not spouse/partner, relative, or friend
5=Lives with a group (related or not related) in a private residence
6=Lives in group home (e.g., assisted living, nursing home, convent)

9. Are there first-degree relatives (biological parents, full siblings, or biological children) having dementia?
0=No
1=Yes
If yes, indicate which family member and what type if known (e.g., Alzheimer’s, Lewy Body Dementia, Frontotemporal Dementia) ________________________

2=Don't Know

10. Handedness:

1=Right-handed

2=Left-handed

3=Ambidextrous

11. Vision: without corrective lenses, is the participant's vision functionally normal?

0=No

If no, do they see well with corrective lenses? No = 0, Yes = 1

If no, list reason why (e.g., macular degeneration): ________________

1=Yes

12. Hearing: without a hearing aid, is the participant's hearing functionally normal?

0=No

If no, do they hear well with a hearing aid? No = 0, Yes = 1

If no, list reason why: ________________

1=Yes

13. Motor: Does the participant have any motor problems that affects their ability to write or use a computer mouse?

0=No

1=Yes
If yes, list condition:__________________

14. Income: Please circle the response that best describes your approximate family income including wages, disability payment, retirement income and welfare?

1. Less than $10,000
2. $10,000 - $19,999
3. $20,000 - $29,999
4. $30,000 - $39,999
5. $40,000 - $49,999
6. $50,000 - $59,999
7. $60,000 - $69,999
8. $70,000 - $100,000
9. More than $100,000
APPENDIX D:

National Alzheimer’s Coordinating Center COVID-19 Impact Questionnaire
FORM F2: COVID-19 Impact Survey: Participant

ADC name: __________________________ Subject ID: __________ Form data: __________ Examiner's initials: __________

The following COVID-19 survey is an optional form we would like you to fill out (or, alternatively, the survey may be administered to you by research study staff). We are asking these questions because COVID-19 presents very new challenges for us all, and we would like to learn about your experience. We also would like to learn how COVID-19 affects memory and health. As a research participant, you may decline to answer any of these questions, and it is all right to do so, but please answer as many of the questions as you feel comfortable with. Your research center may also have additional questions regarding COVID-19.

1. During the COVID-19 pandemic, have you experienced new or worsening symptoms (see below) that led you to think you had COVID-19 (novel coronavirus) such as fever, cough, difficulty breathing, persistent pain or pressure in the chest, chills, repeated shaking with chills, muscle pain, headache, sore throat, new loss of taste or smell, new confusion or inability to arouse, or bluish lips or face?
   - No
   - Yes
   - Other (SPECIFY): __________________________
   - Decline to answer
   - Unsure/unknown

2. Have you ever been tested for acute COVID-19 infection?
   - No, not tested (SKIP TO QUESTION 4)
   - Yes, I was tested once (CONTINUE)
   - Yes, I was tested more than once (CONTINUE)
   - Decline to answer (SKIP TO QUESTION 4)
   - Unsure/unknown (SKIP TO QUESTION 4)

3. If yes, on approximately what date(s) did you have the test? If you were tested more than once, please report the 3 most recent dates.
   3a1. Date of most recent test: __________
   (Enter 88/88/8888 if "Decline to answer" is selected.)
### 3a2. What type of test did you have?

1. Swab of nose or throat
2. Blood test
3. Decline to answer
4. Unsure/unknown

### 3b1. Date of next most recent test:

(Enter 88/88/8888 if “Decline to answer” is selected. Enter 99/99/9999 if not applicable because only tested once, and SKIP TO QUESTION 4)

### 3b2. What type of test did you have?

1. Swab of nose or throat
2. Blood test
3. Decline to answer
4. Unsure/unknown

### 3c1. Date of next most recent test:

(Enter 88/88/8888 if “Decline to answer” is selected. Enter 99/99/9999 if not applicable because only tested twice, and SKIP TO QUESTION 4)

### 3c2. What type of test did you have?

1. Swab of nose or throat
2. Blood test
3. Decline to answer
4. Unsure/unknown

### 4. Have you been diagnosed with COVID-19 (you tested positive or were presumed to have COVID-19 by a healthcare provider)?

1. No
2. Yes, positive test for acute infection
3. Yes, presumed COVID-19 by healthcare provider but not tested
4. Decline to answer
5. Unsure/unknown
5. Were you admitted to a hospital for treatment of COVID-19?
   0 No (skip to question 7)
   1 Yes, but not the intensive care unit (ICU) (continue)
   2 Yes, including a stay in the ICU and/or ventilator support (breathing tube in your throat) (continue)
   8 Decline to answer (skip to question 7)
   9 Unsure/unknown (skip to question 7)

6. If yes, on approximately what date(s) were you admitted to the hospital? If you were hospitalized more than once, please report the 3 most recent dates.

6a1. Date of most recent hospitalization:
   (Enter 88/88/8888 if “Decline to answer” is selected.)
   _ _ / _ _ / _ _ _ _
   (MM/DD/YYYY)

6a2. How many days were you hospitalized?
   (Enter 888 if “Decline to answer” is selected.)
   _ _ _ days

6b1. Date of next most recent hospitalization:
   (Enter 88/88/8888 if “Decline to answer” is selected. Enter 59/59/9999 if not applicable because only hospitalized once, and skip to question 7)
   _ _ / _ _ / _ _ _ _
   (MM/DD/YYYY)

6b2. How many days were you hospitalized?
   (Enter 888 if “Decline to answer” is selected)
   _ _ _ days

6c1. Date of next most recent hospitalization:
   (Enter 88/88/8888 if “Decline to answer” is selected. Enter 59/59/9999 if not applicable because only hospitalized twice, and skip to question 7)
   _ _ / _ _ / _ _ _ _
   (MM/DD/YYYY)

6c2. How many days were you hospitalized?
   (Enter 888 if “Decline to answer” is selected)
   _ _ _ days

7. On a scale of 1–5, how worried are you that you will get COVID-19 (or, if previously infected, worried that you will get it again)?
   1 1 = Not at all worried
   2 2 = A little worried
   3 3 = Somewhat worried
   4 4 = Very worried
   5 5 = Extremely worried
   8 8 = Decline to answer
8. On a scale of 1–5, how isolated or cut off from family and friends are you feeling due to COVID-19?
   - 1 = Not at all isolated
   - 2 = A little isolated
   - 3 = Somewhat isolated
   - 4 = Very isolated
   - 5 = Extremely isolated
   - 8 = Decline to answer

9. On a scale of 1–5, how disruptive has the COVID-19 pandemic been to your everyday life?
   - 1 = Not at all disruptive
   - 2 = A little disruptive
   - 3 = Somewhat disruptive
   - 4 = Very disruptive
   - 5 = Extremely disruptive
   - 8 = Decline to answer

10. Has your household’s income been significantly reduced due to COVID-19?
    - 0 = No
    - 1 = Yes
    - 8 = Decline to answer
    - 9 = Unsure/Unknown

11. On a scale of 1–5, since the start of COVID-19, how often have you felt that you were unable to control the important things in your life?
    - 1 = Never
    - 2 = Almost never
    - 3 = Sometimes
    - 4 = Fairly often
    - 5 = Very often
    - 8 = Decline to answer

12. Have you noticed any changes in your memory and thinking, depression, anxiety, or behavioral symptoms since the COVID-19 pandemic began (due to need for social distancing, sheltering in place, worries about getting infected, or other causes)?
    - 1 = No changes (SKIP TO QUESTION 14)
    - 2 = Some changes, but nothing out of the ordinary (CONTINUE)
    - 3 = A great deal of change (CONTINUE)
    - 8 = Decline to answer (SKIP TO QUESTION 14)
<table>
<thead>
<tr>
<th></th>
<th>If yes, please tell us what has changed?</th>
<th>NO</th>
<th>YES</th>
<th>Decline to answer</th>
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<tbody>
<tr>
<td>13a.</td>
<td>Memory and thinking</td>
<td>0</td>
<td>1</td>
<td>2</td>
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<tr>
<td>13b.</td>
<td>Depression</td>
<td>0</td>
<td>1</td>
<td>2</td>
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<td>13c.</td>
<td>Anxiety</td>
<td>0</td>
<td>1</td>
<td>2</td>
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<td>13d.</td>
<td>Behavior</td>
<td>0</td>
<td>1</td>
<td>2</td>
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<tr>
<td>13e.</td>
<td>Other (SPECIFY):</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

14. On a scale of 1–5, how much has COVID-19 changed your willingness to participate in clinical research if it requires in-person visits to the research clinic?

- 1 = Not at all
- 2 = A little
- 3 = Somewhat
- 4 = Very much
- 5 = Extremely
- 8 = Decline to answer
APPENDIX E:

Oral Trail Making Test Parts A and B
Oral Trail Making Test (Optional)

Part A

Examiner: “OK, here is something a little different. I’d like you to count from 1 to 25 as quickly as you can. 1, 2, 3, 4, and so on. Ready? Begin.”

Start timing as soon as you say “Begin.” If a mistake is made, stop the participant and have them continue with the series from the last correct number by saying: “You last said ‘[specific number],’ please continue from there.” Do not stop timing during corrections.

If the participant stops for 5 seconds or more before completing, you may prompt with “Please keep going.” If the participant does not recall where they are, provide the last correct response by saying: “You last said ‘[specific number],’ please continue from there,” and score as an error. After a further delay of 15 seconds or more, discontinue. Enter the appropriate reason code 995-998 from the key and leave total number of errors and correct responses blank. Allow a maximum of 100 seconds for the test. If the participant is not finished by 100 seconds, the score is 100.

Record the time in seconds to complete the series, including the time to offer corrections. Be sure to write down where errors occurred on the score sheet. You will record the total number of errors as well.

|   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |

Time to completion: ____________ (seconds)

Total number of errors: ____________

Total number correct: ____________
PART B

Examiner: “Now I’d like you to switch between numbers and letters when you count. So you would say the number 1, and then say the letter A, then number 2, then letter B and so on as quickly as you can. Let’s do a practice trial first. Count to the number 4, switching between numbers and letters. Ready? Begin.”

If participant makes a mistake, say, “No, that was incorrect, it should be 1, A, 2, B, 3, C, 4.” Allow participant to practice up to three attempts. Repeat instructions with guidance twice. If participant still does not understand, discontinue Part B and go on to the next task. Record the time to completion as “300,” enter the appropriate reason code 995-998 from the key, and leave total number of errors and correct responses blank.

If participant is able to complete the practice say: “Now I want you to switch between numbers and letters when you count 1, A, 2, B, 3, C, and so on until you reach the number 13. Ready, begin.”

Start timing as soon as you say “Begin.” If a mistake is made, stop the participant and have them continue with the series from the last correct pair by saying: “You said ‘[specific number] [specific letter];’ Continue from there.” Do not stop timing during corrections. If the participant stops for 5 seconds or more before completing, you may prompt with “Please keep going.” If the participant does not recall where they are, provide last correct pair by saying: “You said ‘[specific number] [specific letter];’ continue from there,” and score as an error. You can remind the participant “Number-letter” to keep them on task. After a further delay of 15 seconds or more, discontinue “Number-letter” to keep them on task. After a further delay of 15 seconds or more, discontinue Part B and go on to the next task. Record the time to completion as “300,” enter the appropriate reason code 995-998 from the key, and leave total number of errors and correct responses blank. Allow a maximum of 300 seconds for the test. If the participant is not finished by 300 seconds, the score is 300. Record the time in seconds to complete the series, including the time to offer corrections. Be sure to write down where errors occur on the score sheet. You will record the total number of errors as well.

Time to completion: ___________ (seconds)

Total number of errors: ___________

Total number correct: ___________
**Oral Trail Making Test, Par B**

**Scoring Worksheet**

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<td>B</td>
<td>3</td>
<td>C</td>
<td>4</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Attempt</th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A</td>
<td>2</td>
<td>B</td>
<td>3</td>
<td>C</td>
<td>4</td>
<td>D</td>
<td>5</td>
<td>E</td>
<td>6</td>
<td>F</td>
<td>7</td>
<td>G</td>
<td>8</td>
</tr>
</tbody>
</table>
APPENDIX F:

Trait Positive and Negative Affective Schedule
The Positive and Negative Affect Schedule (PANAS; Watson et al., 1988)

This scale consists of a number of words that describe different feelings and emotions. Read each word and then list the number from the scale in the box next to each word.

On a scale of 1 to 5, rate how often in general you tend to feel this way with “1” indicating “Very slightly” and a “5” indicating that you experience this emotion “Very Often”.

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Very Slightly” or “Not at All”</td>
<td>A little</td>
<td>Moderately</td>
<td>Quite a bit</td>
<td>Very Often</td>
</tr>
</tbody>
</table>

| Interested | Irritable |
| Distressed | Alert |
| Excited | Ashamed |
| Upset | Inspired |
| Strong | Nervous |
| Guilty | Determined |
| Scared | Attentive |
| Angry/Hostile | Jittery |
| Enthusiastic | Active |
| Proud | Afraid |
APPENDIX G:

State Positive and Negative Affective Schedule
PANAS-Brief State Affect

This scale consists of a number of words that describe different feelings and emotions. Read each word and then list the number from the scale in the box next to each word.

On a scale of 1 to 5, rate how you feel right now at the present moment with “1” indicating you are “Very slightly or not at all” experiencing the emotion and a “5” indicating that you are “Very Much” experiencing the emotion.

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Slightly or Not at All</td>
<td>A little</td>
<td>Moderately</td>
<td>Quite a bit</td>
<td>Very much</td>
</tr>
</tbody>
</table>

| Attentive | | | | |
| Hostile | | | | |
| Alert | | | | |
| Ashamed | | | | |
| Determined | | | | |
| Upset | | | | |
| Proud | | | | |
| Afraid | | | | |
| Strong | | | | |
| Nervous | | | | |
APPENDIX H:

Good Health Practices Scale
**Good Health Practices Scale (Hampson et al., 2019)**

1. **I exercise to stay healthy.**
   - 1: Strongly Disagree
   - 2: Disagree
   - 3: Neither agree nor disagree
   - 4: Agree
   - 5: Strongly Agree

2. **I eat a balanced diet.**
   - 1: Strongly Disagree
   - 2: Disagree
   - 3: Neither agree nor disagree
   - 4: Agree
   - 5: Strongly Agree

3. **I take vitamins.**
   - 1: Strongly Disagree
   - 2: Disagree
   - 3: Neither agree nor disagree
   - 4: Agree
   - 5: Strongly Agree

4. **I see a dentist for regular checkups.**
   - 1: Strongly Disagree
   - 2: Disagree
   - 3: Neither agree nor disagree
   - 4: Agree
   - 5: Strongly Agree

5. **I watch my weight.**
   - 1: Strongly Disagree
   - 2: Disagree
   - 3: Neither agree nor disagree
   - 4: Agree
   - 5: Strongly Agree

6. **I limit my intake of foods like coffee, sugar, and fats.**
   - 1: Strongly Disagree
   - 2: Disagree
   - 3: Neither agree nor disagree
   - 4: Agree
   - 5: Strongly Agree

7. **I gather information on things that affect my health.**
   - 1: Strongly Disagree
   - 2: Disagree
   - 3: Neither agree nor disagree
   - 4: Agree
   - 5: Strongly Agree

8. **I watch for possible signs of major health problems.**
   - 1: Strongly Disagree
   - 2: Disagree
   - 3: Neither agree nor disagree
   - 4: Agree
   - 5: Strongly Agree

9. **I take health food supplements.**
   - 1: Strongly Disagree
   - 2: Disagree
   - 3: Neither agree nor disagree
   - 4: Agree
   - 5: Strongly Agree
10. I see a doctor for regular checkups.

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neither agree nor disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>

11. I use dental floss regularly.

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neither agree nor disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>

12. I discuss health with friends, neighbors, and relatives.

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neither agree nor disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>

13. I don’t smoke.

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neither agree nor disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>


<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neither agree nor disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>

15. I get shots to prevent illness.*

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neither agree nor disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>

16. I get enough sleep.

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neither agree nor disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>

*Removed from the current study analysis.
APPENDIX I:

M-ABLE Wave 2 Exit Survey
M-ABLE WAVE 2 EXIT SURVEY

Subject ID: ________

Instructions: Please ask the following questions and circle the appropriate response. Skip questions 1 and 2 if visit was conducted via phone.

1. Did you have a special loved one you thought about when you were offered a choice about having more time with them later as opposed to having less time now?

   Circle: Yes or No

2. How much do you agree with the following: "I feel very lonely"

   Not at all    A little    Some    Very much

   1          2          3          4

3. Were you nervous about taking memory and thinking tests before you came today (e.g., worried about “passing” the tests)? Which best applies.

   Not at all    A little    Some    Very much

   1        2        3        4

4. Were you nervous during the memory and thinking tests?

   Not at all    A little    Some    Very much

   1        2        3        4

Qualitative Feedback

Is there anything else you would like us to know about your experience?

Is there anything we could have done to improve your experience as a valued research participant?
BIOGRAPHY OF THE AUTHOR

Amy Beth Halpin was born in Gloversville, New York on September 26, 1984. In 2003 she graduated from Mayfield Jr./Sr. High School in Mayfield, New York. She attended Boston University in Boston, Massachusetts and received her Bachelor of Science degree in Human Physiology in 2007. After graduation, Amy worked as a research assistant at the J. Philip Kistler Stroke Research Center at the Massachusetts General Hospital in Boston. Throughout this time, she developed an interest in the neuropsychology of aging and co-authored several abstracts and manuscripts on intracerebral hemorrhage and cerebral amyloid angiopathy. Over the next several years she worked as a clinical research coordinator at the University of Virginia in the Neurosurgery department. Her efforts were aimed at managing clinical trials for cervical spinal cord injury and cerebral vasospasms. Her next endeavor in the field of neuropsychology brought her to the Frontotemporal Dementia Research Center at the University of Pennsylvania in Philadelphia, Pennsylvania. Amy continued to refine her interests in neurodegenerative processes as a research coordinator and contributed as a co-author to several manuscripts on frontotemporal dementia. Also, during this time, Amy earned her Master of Science degree in Animal Science from Drexel University.

Amy entered the clinical psychology doctoral program at the University of Maine in Orono, Maine in August 2017 under the mentorship of Rebecca MacAulay, Ph.D. As a graduate student, Amy conducted research investigating risk and resilience factors of aging in community-dwelling older adults within the Cognitive Aging Resiliency Enhancement Lab. Under the mentorship of her advisor, she was first author on one manuscript, co-authored six manuscripts, nine abstracts, and five research presentations at national conferences. Amy received her Master of Arts in Psychology from the University of Maine in December 2019 and moved onto doctoral
candidacy. Amy has received five years of supervised clinical training in psychological intervention and assessment, with a particular focus in neuropsychology in outpatient settings.

Amy is currently completing her predoctoral internship at the University of Florida in the Clinical Neuropsychology track in Gainesville, Florida. Her training focuses on providing neuropsychological assessment using both fixed and flexible battery approaches in both outpatient and inpatient settings to individuals with a wide range of neurological, psychiatric, and medical concerns. She also provides evidence-based interventions to individuals suffering from insomnia and adjustment disorders. After finishing her internship and receiving her degree, Amy will complete a two-year postdoctoral fellowship in Clinical Neuropsychology at the Harvard Partners Consortium in Boston, Massachusetts to help prepare her for a career as a board-certified clinical neuropsychologist. She is a member of several professional organizations including the Society for Clinical Neuropsychology, the International Neuropsychological Society, and the National Academy of Neuropsychology. She is a candidate for the Doctor of Philosophy degree in Psychology from the University of Maine in May 2023.