COGNITIVE, SOCIOEMOTIONAL, AND NEURAL MECHANISMS ASSOCIATED WITH AGE-RELATED DIFFERENCES IN FIRST AND THIRD PERSON MORAL JUDGMENTS

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A dissertation submitted to the faculty of the

Department of Psychology and Neuroscience

in partial fulfillment of the requirements for the degree of

Doctor of Philosophy

Boston College

Morrissey College of Arts and Science

Graduate School

May 2022

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Abstract

The present research used a combination of resting-state functional connectivity and behavioral testing within and beyond the laboratory to examine how age is associated with potential cognitive and socioemotional motivational mechanisms in relation to first-person moral decision-making and third person moral judgments.

Part I investigated whether the gray matter structure and resting-state functional connectivity of the Default Mode Network were similarly related to working memory capacity and sacrificial moral decision-making in younger and older adults. Results indicated that better working memory performance was positively associated with Default Mode Network segregation in both groups, as marked by increased within-network resting-state functional connectivity, and decreased between-network connectivity. Critically, reduced bias to endorse the utilitarian option during sacrificial dilemmas involving incidental harm was associated with increased segregation of the Default Mode Network in younger adults. Similar behavioral performance in older adults, however, was associated with reduced segregation of the Default Mode Network via increased coupling with Salience Network regions. These findings suggest that Default Mode Network functional integrity may be differentially associated with age-related changes in working memory capacity and sacrificial moral decision-making.

Part II investigated whether age differences in utilitarian moral decision-making extend beyond the laboratory in non-sacrificial settings during the COVID-19 pandemic. Results indicated that older age and negative affect were associated with the purchase of extra amounts of hard to find good and medical supplies. Negative memory was additionally associated with the purchase of hard to find goods. Advancing age was also associated with reported distribution of these goods to family members, suggesting that these behaviors may have actually resulted in more utilitarian outcomes than when younger adults reported purchasing these goods. These findings suggest that advancing age may be associated with the engagement in utilitarian moral decision-making in real-world settings more than sacrificial moral decision-making literature might suggest. These results also highlight the link between emotional memory and moral decision-making in real-world settings.

Part III sought to determine whether younger adults display memory biases for mixed-valence moral scenarios about others' actions in a similar manner to the negativity biases demonstrated in the emotional memory literature. It also sought to determine whether episodic memory content could be used to predict subsequent judgments about agents' actions. Indeed participants demonstrated an immoral memory bias for motivational content that they learned about agents' actions. Additionally, memory for motivational content appeared to predict subsequent judgments of agents' actions. These findings suggest that the information recalled from episodic memory stores may be important for informing subsequent moral judgments about agents' actions. These immoral memory biases observed in younger adults highlight important avenues for future research to consider when examining age-related motivational shifts in emotional memory and moral judgment.

The findings of the present work highlight the complex interplay of cognitive and socioemotional motivational mechanisms associated with age-related effects on first-person moral decision-making and third-person moral judgments. In the context of the broader literature, the findings indirectly point to the involvement of age-related motivational mechanisms in all three studies. These findings have important implications for moral development in the second half of life.

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Acknowledgments

First, I thank my advisor, Dr. Elizabeth Kensinger, for her unwavering support over the last six years. Capturing Elizabeth's impact on my development as a scientist, researcher, mentor, and overall person would require a document at least twice the length of this dissertation. Her overwhelming optimism and commitment to scientific rigor shaped me as a scientist who is ready to take on the next research challenge, regardless of how lofty. I thank her for teaching me how to find the right questions, and for her encouragement to seek out personally meaningful work. I am grateful for her support, and desire to work alongside me as I sought to provide the broader community with access to the scientific findings about aging and cognition. Her desire to take on the interests of her students as her own provided me with invaluable insight about how to instill excitement in the next generation of scientists. Elizabeth, thanks for giving me a chance and for encouraging me to chase after this line of work.

I also thank my Dissertation Committee, Drs. Hiram Brownell, Liane Young and Angela Gutchess. Hiram, as my secondary advisor, played an integral role in the development of my statistics knowledge. From early on he pushed me to question the assumptions made by those in my field and beyond. From conversations about uncommon effect sizes to ensuring that my data was set up properly, his insight helped me to develop a critical eye for my own research and the field as a whole. I thank Liane for engaging in conversations about this inquiry into aging, memory and moral judgment. Our brainstorming sessions were invaluable as I sought to find the point of convergence between these topics. I am grateful for all of her lab meetings that I was able to attend, as they provided me with great insight into the field of moral cognition. I thank my external committee member, Angela, for all of the insight into the cognitive neuroscience of aging gained from her over the last five years. It was during her course at Brandeis University that many ideas in current dissertation were originally imagined. Beyond the present work, I am grateful for her mentorship since the early years of my graduate studies. From including me in her lab's activities and introducing me to other researchers at aging conferences, to pushing me to become a better writer, I was incredibly lucky to have such an excellent mentor at a second institution during my graduate studies.

The neuroimaging data included in the present dissertation would not have been possible without the assistance from Dr. Ross Mair and Tammy Moran at the Harvard University Center for Brain Science. I thank them both for their efforts to ensure collection of the highest quality data possible at the neuroimaging center. Relatedly, I thank Dr. Barry Schaudt and Wei Qiu in Research Services at Boston College for their dozens of emails and Zoom meetings to ensure the computing resources used to run the fMRI analyses were executed properly.

I am grateful for my overlap with past and present members of the Cognitive and Affective Neuroscience Laboratory at Boston College. Over these last six years they were a wellspring of inspiration. Specifically, I thank Dr. Jaclyn Ford for her mentorship in all areas of my research training. From coaching me through major setbacks in my first set of fMRI analyses early in graduate school, to teaching me how to manage large datasets and large teams of research assistants, she was a constant source of knowledge and encouragement over these years. I thank Dr. Tony Cunningham for his collaboration and willingness to include the research questions for Part II of the present work in his COVID19 study. He is a paragon of collaboration and open science, two qualities I hope to emulate in the future. Drs. Sarah Kark, Holly Bowen, and Eric Fields were all incredible role models with regard to conducting rigorous science. I am incredibly grateful for their endless conversations related to fMRI, statistics, and navigating graduate school, as I sought to get a foothold during the early years of my graduate training.

This work also could not have been possible without tireless efforts of the amazing team of research assistants who worked with me. I specifically thank Cortney Stedman for her recruitment efforts of the participants included in the analyses for Part I. I also thank Rachel Furlan for her coding and data cleaning for Part I. And finally, I thank Sylvia Murray for the hundreds of hours spent scoring the narrative data for Part III. This was a heroic undertaking.

I also want to thank the members of Liane Young's Morality Lab for welcoming me into their lab meetings over the last few years. Much of the work presented in this dissertation was inspired by conversations in those meetings. Specifically, I want to thank Minjae Kim. I am incredibly grateful for our conversations and collaborations that were generated to develop Part III of this dissertation. I am excited to see where this work takes us.

I want to thank the Diana Jacobs Kalman/AFAR Scholarships for Research in the Biology of Aging, for supporting my research, and making data collection for Part I possible. I also want to thank the various sources for travel funding at Boston College, including GSAS, the Provost, and the GSA.

Beyond academia, I want to thank my family. I thank my parents Cheryl and Tom for their overwhelming support. They haven't always understood what exactly it is that I do, or why I've been conducting this work over these last several years. But they've always instilled the belief that I could reach this accomplishment. For that I am incredibly grateful. I also thank my in-laws, Bill and Carolyn Kerr for the many early-morning conversations about the purpose and implications of this work. I could not have done this without the support from all four of them.

And finally, most importantly, to my at-home research team, Grace, Theo and Georgia, thanks for helping me keep my head on straight. Theo and Georgia, right now, you're not old enough to understand what I've been doing over the last couple of years since you joined your mom and me. But if you read this someday, just know that your infectious giggles kept me smiling during the hardest parts of these last few years. Grace, you have been the single greatest source of support over these last six years. You celebrated my wins, and sat with me through times of uncertainty. You brainstormed grant ideas, encouraged my strange fascination with the human mind, and helped me shutdown work at the end of the day. I am grateful for your ability to help me keep perspective of the bigger picture, and to push through the harder parts of the last six years. You are the partner I could not have imagined for myself. I'm looking forward to our years to come. Thank you.

Notes

- Portions of the contents of the general introduction and discussion were taken directly from the original submission of the following literature review written by the author:

  Daley, R. T., & Kensinger, E. A. (2021). Cognitive decline, socioemotional change, or both? How the science of aging can inform future research on sacrificial moral dilemmas. Aging, Neuropsychology, and Cognition, 1-28. https://doi.org/10.1080/13825585.2021.2019183

- The contents of Parts I-III are going to be submitted as separate manuscripts. As a result, there is some overlap in the content discussed in the introductions and discussions for each of these subsection

GENERAL INTRODUCTION

Older adults (65 years+) comprise the fastest growing population within the United States (Bureau, 2020). By exercising their right to vote, guiding the value systems of future generations, and holding political office, older adults assist in shaping the moral context of society. It is therefore imperative that we understand how older adults may differ from their younger counterparts when making first-person moral decisions and third-person moral judgments about others.

The examination and validation of moral developmental theories primarily focus on the first quarter of life, with the apex of moral reasoning and decision-making assumed to be achieved in early adulthood (Garrigan et al., 2018). Any changes thereafter are typically examined through the lens of sub-optimal processing as in the case of patients with brain lesions (Ciaramelli et al., 2007; Koenigs et al., 2007; McCormick et al., 2016a) or those who suffer from neurodegenerative disorders (Carr et al., 2015; Chiong et al., 2013; Fong et al., 2017; Ponsi et al., 2021; Strikwerda-Brown et al., 2021). Yet, even in the absence of age-related disease, performance across a range of tasks can differ between young and older adults. First-person sacrificial moral decision-making (K. Huang et al., 2021; S. Huang et al., 2021; McNair et al., 2019) and third person moral judgment (Margoni et al., 2018, 2019a; Margoni, 2020) have recently been highlighted as no exceptions to this pattern. Specifically, older adults engage in fewer utilitarian decisions than younger adults during hypothetical sacrificial moral dilemmas. That is, they are less likely to sacrifice one person to save many others. They also judge harms committed by other individuals more harshly than younger adults, regardless of the context in which these harms were committed. Only a small number of studies to date have examined age-related differences to these problems, yet there is a wealth of relevant literature in the psychology and neuroscience of aging that points to cognitive as well as socioemotional motivational mechanisms that potentially support these age-related differences.

Age-Related Cognitive Decline

Research examining responses to sacrificial moral decision-making highlights the importance of fluid cognitive abilities and the associated neural correlates (Greene et al., 2004; Jeurissen et al., 2014; Zheng et al., 2018). Theory of mind also mediates age-related differences in the moral judgment of others' behaviors (Margoni et al., 2018). As age-related differences in theory of mind are also associated with reduced fluid cognitive abilities in older adults (Bottiroli et al., 2016; Charlton et al., 2009; Rakoczy et al., 2012), providing a brief overview of age-related changes to fluid cognitive abilities in non-moral domains will inform the context of the present work.

The cognitive aging literature has produced several theories that focus on cognitive control and its relation to behavior, which may provide insight into older adult moral decision-making and judgment. First, processing speed accounts demonstrate that older adults are known to be slower when processing task-relevant content, potentially accounting for cognitive declines across many domains (Salthouse, 1996). Specifically, during economic decision-making, which has characteristics that parallel sacrificial moral dilemmas (i.e. weighing costs and outcomes), Henninger et al. (2010) demonstrate that older adults have poorer quality responses compared to younger adults on the Cambridge Gambling Task, Balloon Analogue Risk Task, and the Iowa Gambling Task. Interestingly, the poorer quality responses provided by older adults on these tasks are not consistent in relation to risk. Older adults made more risky decisions on the Cambridge Gambling Task but more risk-averse decisions on the Balloon Analogue Risk Task. Performance on these tasks were mediated by processing speed. Those who had slower processing speed made poorer quality decisions generally, and it could be suggested that they answered inconsistently (i.e. risk-averse vs. risky decision) across the tasks. In this case slower processing speed in older adults may inhibit the necessary cognitive control required to appropriately respond to moral dilemmas.

Second, working memory theories (Craik & Byrd, 1982; Park, 2000) suggest that age-related declines in working memory capacity may lead to inferior performance on tasks because older adults are less efficient at mentally manipulating or maintaining task-relevant content. In this way older adults may not be able to keep all task-relevant content in mind when deliberating over decision-making or judgment tasks, subsequently relying on affective heuristics to make a decision in the context of moral dilemmas. Relatedly, theories associated with inhibitory control (Hasher et al., 1991) suggest that older adults have difficulty ignoring task-irrelevant information. While young adults may ignore some thoughts or feelings when making their decisions, older adults may not be able to gate this affective content in the same way. If reduced inhibitory control allows for the influence of emotional content to guide older adults' decisions, this may be associated with greater reliance on emotional heuristics when responding to moral dilemmas. That is, older adults may focus more attention on their emotional experience elicited by a dilemma, as opposed to weighing the potential outcomes of their decision or the motivations of others' actions.

Although there is extensive discussion as to the interrelations among these cognitive declines with aging, their common thread highlights that older adults consistently demonstrate impairments in fluid cognitive abilities relative to younger adults. This suggests that age-related behavioral differences in first and third person moral decision-making may simply be due to reduced cognitive capacity associated with advancing age. These age-related changes in cognitive capacity that potentially explain behavioral differences in moral decision-making also appear to rely on similar brain structures identified by both the moral decision-making and aging literatures.

Early work examining the neural correlates of moral decision-making distinguished between the relative contributions of the lateral and medial prefrontal cortices (Greene, 2001, 2007; Greene et al., 2004; Jeurissen et al., 2014; Zheng et al., 2018). And more recent work has demonstrated that functional network approaches may also be beneficial to deciphering brain-behavior relationships in the context of moral decision-making. Reniers et al. (2012) demonstrated that the dorsolateral prefrontal cortex was engaged during moral decision-making relative to non-moral dilemmas, but they also identified a set of regions typically associated with the Default Mode Network (Greicius et al., 2003) that showed increased activation, during moral dilemmas. Similarly, in a meta-analysis examining the overlapping and distinct neural mechanisms supporting active moral reasoning and the passive experience of moral emotions Sevinc & Spreng (2014) also identified regions typically associated with the Default Mode Network during both types of moral processes.

Recent attempts to understand older adult changes in cognition have also begun to focus on functional network approaches. The most well understood network in relation to cognitive aging is the Default Mode Network. This network comprises at least two cortical hubs, the medial prefrontal cortex and the posterior cingulate cortex (Buckner et al., 2008; Fox et al., 2005; Raichle et al., 2001). It was originally observed while participants were at “rest” while receiving fMRI scanning (Raichle et al., 2001). This finding along with the Default Mode Network’s anticorrelation with the functional networks involved in externally focused tasks that involve attention and executive control (Cieri & Esposito, 2018), suggest that Default Mode

Network functional integrity should show positive associations with cognitive ability. When an individual is at rest, the Default Mode Network comes online, but when the individual engages in an externally oriented task such as a working memory task, the Default Mode Network should go offline as other networks are engaged to successfully complete a task.

Regions in the Default Mode Network are also particularly susceptible to age-related gray matter atrophy (Fjell et al., 2014). In parallel, the functional integrity of the Default Mode Network is known to show age-related functional dedifferentiation, or reduced network specialization (Damoiseaux, 2017). Older adults tend to show weaker within-network functional connectivity between regions in the Default Mode Network and stronger functional connectivity between the regions of the Default Mode Network and regions involved in externally oriented networks. This functional dedifferentiation between networks is associated with poorer performance on cognitive tasks in older adults (Nashiro et al., 2017). As the Default Mode Network is also associated with performance on moral decision-making tasks, discerning the relationships between this network, moral decision-making, and fluid cognitive abilities may provide key insights to moral cognition across the adult lifespan.

Age-Related Socioemotional Motivational Changes

Advancing age is also associated with well documented shifts in motivation that are thought to impact tasks that incorporate both cognitive and socioemotional components. Socioemotional Selectivity Theory (SST), the most prominent theory supporting this idea, suggests that any situation that narrows time horizons – including advancing age – is associated with an increased motivation to prioritize emotional goals (Carstensen et al., 2003) and to focus on the present moment (Lang & Carstensen, 2002) .

Extensive literature has interpreted patterns of performance on cognitive tasks in light of SST. For instance, in cognitive domains older adults are known to show better memory and attention for affective compared to neutral content. They also frequently show positivity biases in these domains relative to younger adults, either by increasing their responses to positive information or dampening their responses to negative information (Mather & Carstensen, 2005; Reed & Carstensen, 2012).

The extension of SST into social domains demonstrates that older adults not only prioritize positive relationships, but they engage in behaviors that attempt to assist social cohesion. Some point to these social behaviors as potentially resulting from age-related changes in generativity, or a desire to set up the next generation to be as successful as possible (Luong et al., 2011). Generativity versus stagnation is the major developmental stage experienced in middle adulthood, according to Erikson's (1950) developmental theory, but older adulthood is not necessarily associated with declines in generativity. Rather, there appears to be a qualitative shift, such that older adults move from what Erikson et al., (1989) refer to as, "maintaining the world" (p.74) in middle adulthood, as exemplified by productivity in the areas of work and family life, to, "care for the present, with concern for the future," (p.74). An example of this shift involves older adults refraining from giving their adult children advice in order to avoid interpersonal conflict. This behavior according to Erikson et al. (1989) reflects a form of learning over time, whereby refraining from action embodies generative concern, rather than ambivalence during social interactions.

This idea is reaffirmed in a review from Blanchard-Fields, (2007) who suggests that when social conflict arises for older adults, they are more likely to engage in passive emotion-regulation strategies in order to maintain positive relationships. For example, they may withdraw themselves from a situation as conflict arises. Again, Blanchard-Fields, (2007) suggests this is not likely due to older adults' inability to engage in active strategies, but more likely due to their expertise gained over several decades of practicing different types of strategies.

It should also be noted that part of the grand-generativity description set forth by Erikson et al. (1989) involves that, "… the individual seeks outward-looking care for others with inward-looking concern for self" (p.74). In this case, grand-generativity does not only involve concern for others, but also includes a self-preservation component. In this case, older adult propensity toward engaging in social strategies that reduce interpersonal conflict likely should not be considered selfless, but behaviors that reduce social negativity for the other person, as well as the self in the current moment. It follows, that in a motivated attempt to promote social cohesion, older adults may engage in more passive approaches than the more active approaches taken by their younger counterparts, in order to simultaneously care for others and reduce personal negative emotions. This literature generally points to motivational mechanistic explanations for potential age-related differences for first-person moral decision-making and third person moral judgments.

Finally, it should also be noted that age-related neural changes do not always track with behavior in consistent ways. In fact, some network changes may not have negative cognitive consequences in certain domains. For example, Andrews-Hanna et al. (2019) suggests that although age-related changes in the structural and functional integrity of the Default Mode Network are associated with well documented cognitive declines, certain abilities may be preserved or even enhanced with these age-related neural changes. Specifically, tasks that require internally guided mental processes may be well served by these functional changes in the Default Mode Network. As imagining hypothetical moral dilemmas requires internally guided imagery processes, these age-related changes in Default Mode Network architecture may actually serve as beneficial to older adults when responding to moral dilemmas.

Spreng & Turner (2019) propose their Default Executive Coupling Hypothesis of Aging whereby, increased functional coupling between lateral prefrontal regions and Default Mode Network regions during cognitively demanding tasks can be detrimental or beneficial to older adult performance depending upon task demands. When tasks can be correctly performed by calling on semantic knowledge stores, or past experience, older adults may benefit from the integration of these sets of regions. When tasks require fluid cognitive abilities and semantic knowledge stores are not beneficial to the task, however, increased integration of these regions will negatively impact older adult performance. It remains an open question as to whether the relationship between age-related changes in Default Mode Network integrity and moral decision-making reflect the well documented declines in fluid cognitive abilities, or whether responding to these moral dilemmas is better served by these large-scale network changes.

The Present Research

Overview

In light of the current literature, **Part I** examines how the structure and resting-state function of the Default Mode Network relate to first-person sacrificial moral decision-making and working memory in older and younger adults. Next, **Part II**, extends the examination of sacrificial moral decision-making beyond the laboratory, by asking an adult lifespan sample about their real-life non-sacrificial utilitarian moral decision-making during the COVID-19 pandemic. This study also examined the relationship between utilitarian decision-making and subjective affective experiences as well as emotional memories related to the COVID-19 pandemic, highlighting a connection between emotion, episodic memory, and first-person moral decision-making. Finally, **Part III** examines the link between episodic memory and third-person moral judgments of others' actions. This last study examined these relationships in a younger adult sample in order to establish the pattern of memory-judgment relationships to be compared to future research with older adult samples.

Methods and Logic

Part I sought to determine whether the gray matter structure and resting-state functional connectivity of the Default Mode Network were similarly related to sacrificial moral decision-making and working memory in younger and older adults. There were no age-related differences in working memory performance, but older adults endorsed fewer utilitarian decisions during sacrificial moral dilemmas that involved direct harm to another person compared to younger adults. Better working memory performance was positively associated with Default Mode Network segregation in both groups, as marked by stronger within-network resting-state functional connectivity, and decreased between-network connectivity. Critically, reduced bias to endorse the utilitarian option during sacrificial dilemmas that caused indirect, rather than direct harm to another person, was associated with increased segregation of the Default Mode Network in younger adults. However, older adults who demonstrated similar moral decision-making behavior to younger adults, demonstrated reduced segregation of the Default Mode Network via increased coupling with Salience Network regions. These findings suggest that Default Mode Network functional integrity may be differentially associated with age-related changes in working memory capacity and sacrificial moral decision-making.

Part II sought to determine whether age differences in utilitarian moral decision-making extend beyond the laboratory in non-sacrificial settings. Given that older and younger adults tend to demonstrate age-related differences in affective experience as well as emotional memory, this study also sought to determine how these factors relate to utilitarian decisions with regard the purchasing of hard to find goods and medical supplies in during the spring 2020 phase of the COVID-19 pandemic. During this study refraining from purchasing these materials was associated with the utilitarian option. Indeed older age and negative affect were associated with purchasing extra amounts of these materials. Negative memory was additionally associated with the purchase of extra amounts of hard to find goods. Advancing age was also associated with reported distribution of these goods to family members, suggesting that these behaviors may have actually resulted in more utilitarian outcomes than when younger adults reported purchasing these goods. These findings suggest that advancing age may be associated with the engagement in utilitarian moral decision-making in real-world settings more than the sacrificial moral decision-making literature would suggest. It additionally highlights links between emotional memory and moral decision-making in real-world settings.

Part III sought to determine whether younger adults display memory biases for mixed-valence moral scenarios about others' actions in a similar manner to the negativity biases demonstrated in the emotional memory literature. It also sought to determine whether this episodic memory content could be used to predict subsequent moral judgments about agents' actions. Indeed participants demonstrated an immoral memory bias for the first motivational content that they learned about agents' actions. Critically, memory for the first motivational content that participants learned about agents' actions predicted subsequent moral judgments, with particular emphasis on motivation conditions containing immoral motivational content. These findings suggest that negativity biases observed in the emotional memory literature may extend to the moral judgment literature. Also, the information recalled from episodic memory stores may be important for informing subsequent moral judgments about agents' actions.

1.0 AGE-RELATED DIFFERENCES IN DEFAULT MODE NETWORK RESTING-STATE FUNCTIONAL CONNECTIVITY BUT NOT GRAY MATTER VOLUME RELATE TO SACRIFICIAL MORAL DECISION-MAKING AND WORKING MEMORY PERFORMANCE

1.1 Abstract

Older adults make fewer utilitarian decisions than younger adults during sacrificial moral dilemmas, which are associated with age-related reductions in Default Mode Network resting-state functional segregation. Decreases on tasks associated with fluid cognitive abilities, such as working memory capacity, are also associated with age-related Default Mode Network changes. Relatedly, regions within this network demonstrate some of the greatest age-related gray matter atrophy. Age-related changes in structure and function of the Default Mode Network may be associated with poorer working memory capacity and reduced utilitarian moral decision-making. Alternatively, recent theories suggest that age-related changes to Default Mode Network function may be adaptive in the context of tasks that include socioemotional components. As such, reduced Default Mode Network segregation may be associated with differential outcomes in moral decision-making for younger and older adults. In the present study, there were no age-related differences in working memory capacity. Older adults were less likely than younger adults to indicate the utilitarian option when trials involved instrumental harm. Generally, increased resting-state functional connectivity segregation of the Default Mode Network was associated with better working memory performance in both groups, and reduced bias to endorse the utilitarian option during Incidental dilemmas compared to Instrumental dilemmas in younger adults. Older adults with similar moral decision-making behavior to younger adults had reduced segregation of the Default Mode Network via increased coupling with Salience Network regions. These findings suggest that Default Mode Network functional integrity may be differentially associated with age-related changes to working memory capacity and sacrificial moral decision-making.

1.2 Introduction

Within the sacrificial moral decision-making literature, the prototypical moral dilemmas presented to participants include the Trolley Problem (Foot, 1967) and the Footbridge Dilemma (Thomson, 1986). During the Trolley Problem, participants are presented with a scenario where a trolley is headed down a track toward several people. If the trolley continues down the track, it will kill all of these individuals; however, the participant has the option to push a switch that will divert the trolley onto another track. Unfortunately there is one person on this other track. Thus, the crux of this dilemma requires participants to decide whether to sacrifice one person to save many others by pushing the switch, or allow several people to die by refraining from action.

Choosing to press the switch during this dilemma is typically identified as abiding by utilitarian ethics, or attempts to maximize goodness for the greatest number of people (Mill, 1895). Deciding to refrain from pushing the switch, however, is typically identified in the literature as abiding by rule or duty-based deontological ethics (Kant, 1785). In this case, it is not permissible to kill one person, even if it would save many others. The decisions and outcomes of the Trolley Problem are paralleled in the Footbridge Dilemma, with the exception that rather than deciding whether to push a switch, participants have the option to push a person off of a footbridge in front of the trolley, to save many others down the track.

Despite the same outcomes (i.e. deciding whether to sacrifice one person to save many others), most individuals indicate that they would push the switch, but not push the person (Greene, 2013). This may be explained by the higher emotionality associated with the idea of directly causing harm to someone by pushing them off a bridge, rather than indirectly causing harm to someone by pushing a switch. According to the Dual-Process Theory of Moral Judgment, in order to engage in sacrificing one person to save many others during the more emotional Footbridge Dilemma, participants must override their initial emotional response (Greene et al., 2004) by engaging cognitive control resources and their associated neural correlates (Greene & Young, 2020). These theorized cognitive control mechanisms may provide insight into age-related differences in performance during these dilemmas.

It has recently been demonstrated that older adults engage in fewer utilitarian moral decisions than younger adults during sacrificial moral dilemmas (K. Huang et al., 2021; S. Huang et al., 2021; McNair et al., 2019). In one case, these age-related differences were partially mediated by older adults' tendency to report higher negative affective experience in response to the dilemmas (McNair et al., 2019). In the context of the Dual-Process Theory of Moral Judgment, it is possible that older adults may not have the capacity to engage cognitive control over their initial emotional response to the dilemma, potentially leading them to refrain from action. Interestingly, the findings from McNair et al., (2019) indicated no interaction between age and problem type (e.g. Trolley vs. Footbridge dilemma), suggesting that even during the less emotional Trolley-type problems, the idea of sacrificing one person to save many others may be problematic for older adults. As McNair et al. (2019) did not measure cognitive ability independent from the moral decision-making task, it is difficult to speculate about the involvement of decreased cognitive control abilities in their older adult sample.

Further support for the finding that older adults engage in fewer utilitarian decisions during sacrificial moral dilemmas comes from S. Huang et al.(2021), who found that older adults made fewer utilitarian decisions than younger adults, but only when the deontological option was more intuitive than the utilitarian option. Discussion on the intuitive-unintuitive distinction in the context of hypothetical sacrificial moral dilemmas is beyond the scope of the current study, but it is important to note that S. Huang et al. (2021) highlight that the Footbridge Dilemma reflects a scenario where the deontological option is more intuitive. As such the behavioral findings from S. Huang et al. (2021) appear to replicate the findings from McNair et al. (2019) specifically for the more emotional Footbridge-type dilemmas.

Insight into these behavioral findings were extended by the finding that age-related differences in response to these dilemmas were partially mediated by alterations to the intrinsic function of the Default Mode Network (S. Huang et al., 2021). Specifically, older adult propensity to engage in fewer utilitarian decisions than younger adults was partially accounted for by reduced resting-state functional connectivity segregation of the Default Mode Network from other large-scale networks. Unlike McNair et al. (2019), this study also collected cognitive data from their samples, highlighting that the older adult sample indeed had poorer fluid cognitive abilities than their younger adult sample. This is consistent with widespread findings that older adults tend to have poorer fluid cognitive abilities such as poorer working memory, which may impact decision-making processes (Hartshorne & Germine, 2015; Park, 2000). Similar to McNair et al. (2019), however, beyond using these cognitive scores to characterize their sample, S. Huang et al. (2021), did not examine age-related Default Mode Network alterations in relation to these differences. This raises the question of whether age-related changes to the Default Mode Network are related to changes in fluid cognitive abilities and first-person sacrificial moral decision-making in similar ways.

Older adults tend to demonstrate poorer performance than younger adults on tasks that engage working memory capacity alone. Yet, tasks that contain social and emotional content in many cases can lead to preserved performance across the adult lifespan (Duarte & Kensinger, 2019). These age-related differences in working memory capacity are associated with poorer functional connectivity within the Default Mode Network, and specifically long-range connections between its two primary hubs, the medial prefrontal cortex and the posterior cingulate cortex (Sambataro et al., 2010). Although age-related decreases in working memory capacity and Default Mode Network functional integrity may appear to parallel the age-related differences in sacrificial moral decision-making, recent theory complicates this speculation.

Andrews-Hanna et al. (2019) suggest that although the age-related alterations to the Default Mode Network are associated with poorer performance on cognitive tasks, these alterations may actually support adaptive functioning on tasks that contain social or emotional content. Recent advances in the fields of social and affective neuroscience demonstrate that age-related declines in cognition and Default Mode Network function may not always extend to socioemotional domains, especially when tasks involve internal deliberation, or can be successfully completed by tapping into knowledge stores (Spreng & Turner, 2019, 2021).

Given that sacrificial moral dilemmas contain both working memory (i.e. weighing costs) and socioemotional (i.e. negative emotions associated with sacrificing people) components, it is possible that age-related alterations to the Default Mode Network, may be differentially associated with working memory capacity and responses to sacrificial moral decision-making. Determining an answer to this problem will further assist in understanding the complex nature of age-related changes to brain-behavior relationships within this network. Also, although age-related changes to Default Mode Network resting-state functional connectivity may show different relationships with working memory performance and sacrificial moral decision-making, there remains at least one more gap in the literature.

The primary focus of this introduction has been the relationship between age-related changes to Default Mode Network *function* and behavior, but the regions within this network also show some of the greatest age-related *structural* changes. Specifically, regions within the

Default Mode Network show some of the most accelerated age-related gray matter volumetric declines compared to the rest of the cortex (Fjell et al., 2014). In this case, gray matter volume of these regions may also help to explain some of the age-related variance in working memory capacity and moral decision-making. Examining behavior on these tasks in relation to Default Mode Network physical structure and resting-state function will provide insight into whether older and younger adults simply engage this network differently, or whether the function of this network in older adults is additionally constrained by declines in gray matter volume of the medial prefrontal cortex and the posterior cingulate cortex.

Given these age-related differences in working memory capacity, sacrificial moral decision-making and Default Mode Network gray matter volume and resting-state functional connectivity the present study sought to elucidate three aims. The first aim sought to determine how strongly the gray matter volume of the medial prefrontal cortex and posterior cingulate cortex (core nodes of the Default Mode Network) differentially predict performance on working memory or sacrificial moral decision-making in younger and older adults. Hypothesis 1 predicted interactions between age group and gray matter volume with either of these regions on performance in both tasks. This hypothesis is supported by the idea that structural metrics among older adults reflect the relative preservation versus atrophy of regions with aging. If supported, this hypothesis should lead to strong relationships between gray matter volume and performance on both tasks in older adults; however, these relationships should be weaker among younger adults, in whom structural variability does not reflect atrophy, giving rise to the hypothesized interactions.

The second aim sought to assess whether the variability in behavioral performance on each of these tasks could be predicted by resting-state functional connectivity over and above gray matter volume. With regard to working memory capacity, Hypothesis 2a predicted stronger resting-state functional connectivity between the medial prefrontal cortex and posterior cingulate cortex would be associated with better performance in both groups. Although the gray matter structural metrics should not show meaningful relationships with behavioral performance in younger adults as indicated in Hypothesis 1, past work demonstrates that increased Default Mode Network functional connectivity is associated with better working memory performance in younger adults (Sambataro et al., 2010).

The moral decision-making outcomes could take one of two forms in Aim 2. First, Hypothesis 2b.1 predicted that increased resting-state functional connectivity between the medial prefrontal cortex and posterior cingulate cortex would be associated with better working memory capacity and increased utilitarian decision-making in both younger and older adults over and above gray matter volume. These findings would suggest that sacrificial moral decision-making tracks with Default Mode Network resting-state functional connectivity in similar ways to working memory capacity. In this case, older adult propensity to respond with fewer utilitarian responses to sacrificial moral dilemmas may reflect associations with cognitive decline.

Alternatively, Hypothesis 2b.2 suggested that increased resting-state functional connectivity in the DMN would be associated with better working memory capacity in both groups, and *increased* utilitarian decision-making in younger adults, but *decreased* utilitarian decision-making in older adults, over and above gray matter volume. These findings would indicate that older adult propensity to respond with fewer utilitarian responses may reflect processes other than cognitive decline and the degradation of the Default Mode Network's intrinsic function.

Finally, the third aim sought to determine how age-related changes to resting-state functional connectivity within the Default Mode Network (segregation), and between the core nodes of Default Mode Network and externally oriented networks are associated with moral decision-making and working memory performance. The finding that resting-state functional connectivity segregation of the Default Mode Network mediates the relationships between advancing age and increased deontological-intuitive decisions (S. Huang et al., 2021) was not published until after this study was pre-registered (OSF Preregistration Link: https://osf.io/krm7c) and data were collected. In the pre-registration for this study, functional coherence of the Default Mode Network was defined as higher resting-state functional connectivity between the medial prefrontal cortex and the posterior cingulate cortex. The primary goal of this study was to examine how age-related structural and functional deterioration of the two major hubs of the Default Mode Network relates to working memory and sacrificial moral decision-making. In an attempt to understand how these functional hubs relate to other regions within the Default Mode Network and other large-scale networks in an unconstrained manner, in light of the findings from S. Huang et al. (2021), we also examined associations between individual differences in performance on these tasks and separate whole-brain seed-based resting-state functional connectivity analyses. The medial prefrontal cortex and posterior cingulate cortex were used as separate seed regions in these analyses. Although this methodological approach examines resting-state functional connectivity *within* the Default Mode Network, and *between* core regions of the Default Mode Network and regions outside of this network, similar logic of Hypothesis 2b.1 and 2b.2 apply to the hypotheses of this aim.

First, Hypothesis 3a suggested that increased resting-state functional connectivity between Default Mode Network regions, and decreased connectivity between Default Mode

Network regions and regions outside of the Default Mode Network, will be associated with better working memory capacity and increased utilitarian decision-making in both younger and older adults. This finding would suggest that reduced segregation of the Default Mode Network would be associated with poorer working memory performance and fewer utilitarian responses. This finding would extend previous work demonstrating that reduced segregation of the Default Mode Network is associated with less utilitarian decision-making in older adults (S. Huang et al., 2021), by demonstrating that this reduced segregation is also associated with poorer working memory capacity in the same sample of participants.

Alternatively, Hypothesis 3b suggested that increased resting-state functional connectivity between Default Mode Network regions, and decreased connectivity between Default Mode Network regions and regions outside of the Default Mode Network will be associated with better working memory capacity in both groups, and increased utilitarian decision-making in younger adults, but decreased utilitarian decision-making in older adults. This finding, would point to the possibility that age-related changes to Default Mode Network segregation may be associated with adaptive functioning during tasks that contain socioemotional content (Andrews-Hanna et al., 2019).

To address these aims, participants in the current study were presented with a series of sacrificial moral dilemmas and a working memory task via an online survey. Structural gray matter volume and resting-state functional scans were collected in a separate session.

1.3 Methods

Participants

Participants for this study included 39 younger adults (24 Female, M_{age} = 25.95 , SD_{age} = 5.01) and 34 older adults (26 Female, M_{age} = 70.65 , SD_{age} = 7.02) from an ongoing study investigating the relationships between the age-related cognitive and motivational mechanisms associated with sacrificial moral decision-making. Upon enrolling in the study, two younger adults (1 female, 1 male) withdrew prior to completing the task resulting in a 37 participant younger adult sample (23 female, $M_{age} = 25.84$, $SD_{age} = 4.92$).[1] All participants were healthy, right handed, native English speakers, with normal or corrected to normal vision. All participants were cognitively healthy and reported no history of a neurological or psychiatric disorder. All participants were screened for MRI contraindications prior to participating in the MRI session. Prior to participating all participants successfully completed a MRI contraindication screening, and provided written consent on a Boston College IRB approved informed consent form.

Behavioral Tasks

Outside the MRI scanner participants were sent an online survey via the Qualtrics XM platform. Following the collection of participant informed consent and demographics, this online survey contained the questionnaires listed in the order below.

Moral Decision-Making Task

Participants were presented with 75 sacrificial moral dilemmas (5 practice trials; 70 task trials) from the Lotto et al. (2014) stimulus set. These dilemmas included variants of the Trolley Problem. These will be referred to as Incidental dilemmas, for the remainder of the manuscript because by choosing to push the switch participants would be causing incidental, or indirect harm to another person. The dilemmas also included variants of the Footbridge Dilemma. These will be referred to as Instrumental dilemmas for the remainder of the manuscript because choosing to push the person off the bridge involves direct or instrumental harm. This stimulus set

[1] The sample size will vary for different analyses depending on the availability or useability of behavioral data, structural gray matter volume data, or resting-state functional connectivity data. Sample sizes will be specified as necessary.

also divides dilemmas by a Self/Other factor. Half of the scenarios were in the "Self" condition, where the dilemma involved sacrificing one person to save the self among many others. And half of the scenarios were in the "Other" condition, where the dilemma involved sacrificing one person to save many others alone. This factor was not discussed in the introduction because previous literature did not find any age group interactions with this factor (McNair et al., 2019). In order to replicate the conditions used in previous literature, this factor was included in the present design. Finally, there were 15 filler dilemmas presented to participants. These filler dilemmas were not broken down by the Instrumental/Incidental factor or Self/Other factor. As a result filler dilemmas were not processed and will not be included in the analyses detailed in the current manuscript.

The 70 task trials were broken into two blocks of 35 dilemmas each (7 dilemmas per condition: Incidental-Self; Incidental-Other; Instrumental-Self, Instrumental-Other; Filler). Trials were randomly presented within each block.

Participants were presented with each trial on five different screens. The first screen contained the dilemma setup. The second screen included the proposed resolution, along with the following question: "*Would you do this proposed action?*" (*Yes; No*). It should be noted that the presentation of the proposed resolution along with the "Yes/No" question on the same screen is a divergence from previous studies. Previous work examining age differences on this task presented the proposed resolution and decision on two separate screens. The decision in the present study to present the proposed resolution and decision on the same page, was to reduce working memory confounds associated with the task. Participants in this case would not be required to keep the proposed action in mind while deciding whether or not to make an endorsement. The third screen contained the following question: "*How morally acceptable did* *you find the action proposed in the scenario you just read?*" (*1- not at all acceptable; 7 completely acceptable*). Screen three included the following question: "*How effortful did you find it to make a decision about the proposed action in the scenario that you just read*" (1 - *easy/minimal effort*; 7 - *difficult/very effortful*). On screens four and five, participants were asked to make valence and arousal ratings using the Self-Assessment Manikin on a 1-9 point rating scale (Bradley & Lang, 1994).

All five of these questions are listed here in order to demonstrate the procedure by which participants completed the task. Examination of subjective effort, valence, and arousal are beyond the scope of the proposed analyses, and the original pre-registration for this study. As such, the only moral decision-making questions that will be discussed for the remainder of this manuscript are the following: 1) "*Would you do this proposed action?*" (Yes/No); 2) "*How morally acceptable did you find the action proposed in the scenario you just read*?" (*1- not at all acceptable; 7 completely acceptable*). It should also be noted that although the moral acceptability ratings were not discussed in the introduction, the findings from McNair et al. (2019) demonstrate similar outcomes for proposed utilitarian action (i.e. "Yes/No") responses and moral acceptability ratings of proposed action. Older adults rated proposed utilitarian actions as less morally acceptable than younger adults across all dilemma types, and this was partially accounted for by their experience of greater negative affect in response to the dilemmas.

Additional Moral Dilemma Questions

Next, participants were presented with several post-hoc motivation questions for their responses to the moral dilemma questions, along with three moral dilemmas related to the COVID-19 pandemic. Again, these questions are part of larger study, and participant responses to these questions are beyond the scope of this manuscript. As a result, they will not be discussed further, but are presented here to place the analyses included in this manuscript in context.

Working Memory Task

As part of the original pre-registration for this study, participants were next presented with an N-back task. Due to participant confusion with the presentation of this task in an online format, results from this task were discarded due to uncertainty of whether poor performance reflected worse working memory abilities, or a misunderstanding of how to correctly complete the task.[2] As a result, all participants were re-contacted and asked to complete an adapted online version of the Digit Span Forward (total possible score: 16) and Digit Span Backward (total possible score: 14) tasks from the Wechsler Adult Intelligence Scale-IV (Wechsler, 2008). Although Digit Span Forward and Digit Span Backward data were collected from as many participants as possible, not all participants completed this task. Sample sizes for analyses using these tasks will be indicated as necessary.

Additional Questionnaires

Following the presentation of the N-back task in the original online survey, participants were then presented with the Future Time Perspective scale (Lang & Carstensen, 2002), the Emotion Regulation Questionnaire (Gross & John, 2003), one additional emotion regulation questionnaire, and the Ethical Position Questionnaire (Forsyth, 1980). All participants were then presented with Mental Health Resources (a standard procedure in the Cognitive and Affective Neuroscience Laboratory, given the emotional nature of the questions posed in our experimental designs), an attention check, and post-task quality assurance questions. These additional

[2] Many participants reached out via phone or email to indicate that they were concerned that they did not complete this task correctly, or they were generally confused by the instructions.

questionnaires were used to address questions for the larger study, and are again beyond the scope of the present manuscript. As such, they will not be discussed further.

Analyses

Behavioral

Moral Decision-Making

Proportion Utilitarian. For the question, "*Would you do this proposed action?*", the utilitarian response was always, "Yes". As such, for each participant, a "Proportion Utilitarian" score was calculated by taking the number of "Yes" responses divided by the total number of questions included in the analyses. A 2(Incidental/Instrumental) * 2(Self/Other) * 2(Age Group) repeated measures ANOVA on Proportion Utilitarian score was used to evaluate age group differences in sacrificial moral decision-making. The Incidental/Instrumental factor and Self/Other factor were within-subject factors, and the Age Group factor was a between subjects factor. Any significant effects were further investigated using follow-up *t*-tests.

Acceptability Ratings. For the question, "*How morally acceptable did you find the action proposed in the scenario you just read*?" (*1- not at all acceptable; 7 completely acceptable*), an "Acceptability Rating" score was computed for each participant by taking the average acceptability rating across trials. Similar to the Proportion Utilitarian scores, Acceptability Ratings were subjected to a 2(Incidental/Instrumental) * 2(Self/Other) * 2(Age Group) repeated measures ANOVA. The Incidental/Instrumental Factor and Self/Other factor were within-subject factors, and the Age Group factor was a between subjects factor. Any significant effects were further investigated using follow-up *t*-tests.

Working Memory Capacity. To evaluate age-related differences in working memory capacity, Independent samples t-tests on raw scores were computed for Digit Span Forward and Digit Span Backward tasks, with Age Group as the independent variable for each test.

Neural

All structural and functional MRI data were collected as part of two larger projects broadly examining the neural correlates of emotional memory. These data were collected approximately within two years of participants completing the online questionnaires. All functional data used in the current manuscript reflect resting-state scans that were collected prior to the task completed in a given scanning session. Using resting-state scans prior to a task collected in the MRI scanner is important to ensure that any resting-state analyses conducted within this manuscript do not reflect any post-hoc memory consolidation processes elicited by the task that participants completed during their scanning session.

Brain Image Acquisition. All structural and resting-state brain data were collected on a Siemens Magnetom^{fit} scanner using a 32-channel head coil. Structural brain images were acquired by collecting whole-brain anatomical images with a single-shot interleaved multi-slice T1-weighted structural scan (3D MEMPRAGE, Sagittal Slices = 176, TR = 2530 ms, Slice Thickness = 1 mm, Voxel Size = 1 mm^3, Field of View [FOV] = 256 mm, Flip Angle = 7 degrees). All resting-state images were collected using an interleaved multi-slice EPI sequence (Slices = 64, TR = 650 ms, Slice Thickness = 2.3 mm, Voxel Size = 2.3 mm^3, Multiband Acceleration Factor = 8, Flip Angle = 52 degrees).

Structural Image Gray Matter Preprocessing. Structural metrics for each participant's gray matter volume were obtained using FreeSurfer software (Reuter et al., 2012). Cortical reconstruction and volumetric segmentation were conducted using FreeSurfer v.6.0.0 (Fischl, 2012; Fischl et al., 2002; Fischl & Dale, 2000) and the Desikan-Killiany-Tourville (DKT) protocol for parcellation (Klein & Tourville, 2012). Volume was computed for each region in the DKT atlas.

Next, in order to control for variability in individual subject intracranial volume, a residual normalization correction procedure was applied to each region in the DKT atlas, as previously observed in the literature (Voevodskaya et al., 2014). As a result, when discussing the volume of a given region of interest moving forward, it should be assumed that this measure is the residual normalization corrected volume. Also, in order to reduce the number of linear regression models run to address Aims 1 and 2, given that the medial prefrontal cortex and posterior cingulate cortex are cortical midline regions, left and right hemisphere volumes were averaged together for each participant. These averaged volumes were then subjected to further analyses.

Finally, it is important to note that within the DKT atlas, the medial orbitofrontal cortex was the best representation of a medial prefrontal cortex cluster. As such, when discussing the volume of the medial prefrontal cortex, it is important to keep in mind that this will be referring to the medial orbitofrontal cortex region in the DKT atlas. Also, the posterior cingulate cortex region of interest defined in the functional connectivity analyses (discussed below) appears to overlap two regions in the DKT atlas, namely the posterior cingulate cortex, and the isthmus cingulate cortex. As such, all analyses examining gray matter volume in relation to behavior were originally run using the posterior cingulate cortex volume. A separate set of analyses were also run with the isthmus cingulate cortex replacing the posterior cingulate cortex when examining relationships between behavior and gray matter volume.

Resting-State Preprocessing and Subject-Level Analyses. Resting-state functional connectivity scans were preprocessed and denoised using the CONN Toolbox v.20b (Whitfield-Gabrieli & Nieto-Castanon, 2012; http://www.nitrc.org/projects/conn; RRID:SCR_009550), implemented in the MATLAB R2020a toolbox SPM12. Scans were preprocessed using the CONN toolbox's Default Preprocessing Pipeline, however, slice-time correction was removed from the pipeline. As such, resting-state fMRI scans were realigned and unwrapped, centered, segmented, normalized to MNI space, smoothed with an 8mm Gaussian smoothing kernel and resampled to 2mm isotropic voxels. The first 8 scans for each participant were removed in order to account for scanner equilibration. Functional outliers scans were identified for scrubbing using the intermediate setting within the CONN toolbox, which includes a global-signal z-value threshold = 5 *SD*, and a subject-motion threshold = 0.9 mm.

Next, all preprocessed scans were subjected to CONN's denoising step in order to remove potential confounding effects that could impact the BOLD signal. Denoising included the linear regression of confounding effects, subsequently implemented the following parameters. The anatomical component-based noise correction procedure (aCompCor; Behzadi et al., 2007), was used to remove subject-level noise related to white matter (16 confound dimensions) and CSF (16 confound dimensions). Estimated subject-motion parameters (12 confound dimensions and their first order derivatives) were used to account for participant motion. Scrubbing parameters included the number of noise components identified by functional outlier detection for each subject during preprocessing, to remove the impact of these scans on the BOLD signal in the preprocessed data. Finally, following the regression of these confounding effects, all scans were linearly detrended and subjected to band-pass filtering [0.008 0.09 Hz] in order to focus the BOLD signal on slow-frequency fluctuations typically observed in resting-state functional connectivity analyses (Hallquist et al., 2013).

Prior to addressing the brain-behavior analyses associated with Aims 2 and 3, resting-state functional connectivity data were subjected to two separate analyses. For Aim 2, individual participant ROI-to-ROI resting-state functional connectivity analyses were conducted using the medial prefrontal cortex (MNI: 1, 55, -3) and posterior cingulate cortex (MNI: 1, -61, 38) as the two regions of interest (Figure 1). Each seed ROI was constructed as a sphere (12 mm diameter). These seed ROIs were chosen from CONN's Default Mode Network medial prefrontal cortex and posterior cingulate cortex ROIs which were constructed based on the findings from Fox et al. (2005). This analysis produced a Fisher r-to-Z transformed parameter estimate of resting-state functional connectivity between the medial prefrontal cortex and posterior cingulate cortex (mPFC-to-PCC_conn) for each subject.

For Aim 3, a whole-brain seed-to-voxel resting-state functional connectivity analysis was conducted using the medial prefrontal cortex seed. This analysis produced statistical maps of Fisher r-to-Z transformed parameter estimates of functional connectivity between the medial prefrontal cortex and the rest of the brain. Given the importance of both the medial prefrontal cortex and posterior cingulate cortex in the context of the Default Mode Network, the steps to create these whole-brain functional connectivity maps were repeated using the posterior cingulate cortex as a seed region. These individual participant level maps were then used to create group-level analyses to assess Aim 3, as described in the following sections.

Brain-Behavior Analyses

Aim 1 Analyses. To address AIM 1, multiple linear regression was used to determine how age-related differences in gray matter volume of the core nodes of the Default Mode

Network (i.e. the medial prefrontal cortex and posterior cingulate cortex) relate to moral decision-making and working memory performance. First, two separate models were created for the moral decision-making outcomes. Gray matter volume of the medial prefrontal cortex and the posterior cingulate cortex (and separately, isthmus cingulate cortex) along with age group were used to predict Proportion Utilitarian scores (Model 1.1) and Acceptability Ratings (Model 1.2), as outlined below.[3]

Model 1.1: prop_util = b1(mPFC_vol) + b2(PCC_vol) + b3(age_group) + b4(mPFC_vol) (age_group) + b5(PCC_vol) * (age_group) + b6(mPFC_vol) * (PCC_vol) + b7(mPFC_vol)*(PCC_vol)*(age_group).*

Model 1.2: acceptability = b1(mPFC_vol) + b2(PCC_vol) + b3(age_group) + b4(mPFC_vol) (age_group) + b5(PCC_vol) * (age_group) + b6(mPFC_vol) * (PCC_vol) + b7(mPFC_vol)*(PCC_vol)*(age_group).*

Digit Span Forward scores and Digit Span Backward scores were used as the dependent variables for Model 1.3 and 1.4 respectively. Both of these models had the same predictor variables as Models 1.1 and 1.2.

Model 1.3: digit_forward = b1(mPFC_vol) + b2(PCC_vol) + b3(age_group) + b4(mPFC_vol) (age_group) + b5(PCC_vol) * (age_group) + b6(mPFC_vol)*(PCC_vol)*(age_group)*

Model 1.4: digit_back = b1(mPFC_vol) + b2(PCC_vol) + b3(age_group) + b4(mPFC_vol) (age_group) + b5(PCC_vol) * (age_group) + b6(mPFC_vol) * (PCC_vol) + b7(mPFC_vol)*(PCC_vol)*(age_group)*

[3] The dependent variables for Models 1.1 and 1.2 were actually Proportion Utilitarian Instrumental Bias score and Acceptability Rating Self Bias score. These scores are defined in the results section based upon the observed age interactions in the repeated measures ANOVAs. Further explanation of how these variables were computed are also listed in the results.

AIM 2 Analyses. To determine whether the variability in behavioral performance on these tasks could be predicted by resting-state functional connectivity between the core nodes of the Default Mode Network over and above gray matter volume, multiple linear regression was used to assess the same dependent variables used in Models 1.1-1.4. Both gray matter volume of the medial prefrontal cortex and posterior cingulate cortex, as well as their functional connectivity metrics (i.e. mPFC-to-PCC_conn) were used in the same model. For example, Model 2.1.1 was fit to predict Proportion Utilitarian responses using the gray matter volume metrics. This model was then updated with resting-state functional connectivity (Model 2.1.2). The difference in variance explained between Model 2.1.1 and Model 2.1.2, was used to provide insight into whether resting-state functional connectivity or gray matter volume explained more of the variability in behavioral performance on the task. This analysis approach was used for Acceptability Ratings (Model 2.2.1 and Model 2.2.2), Digit Span Forward (Model 2.3.1 and Model 2.3.2) and Digit Span Backward (Model 2.4.1 and Model 2.4.2). It is important to note that all four of these models were run separately for each age group to determine how individual variability within each group relates to the behavioral outcomes.

Model 2.1.1: prop_util = b1(mPFC_vol) + b2(PCC_vol)
Model 2.1.2: prop_util = b1(mPFC_vol) + b2(PCC_vol) + b3(mPFC-to-PCC_conn)

Model 2.2.1: acceptability = b1(mPFC_vol) + b2(PCC_vol)
Model 2.2.2: acceptability = b1(mPFC_vol) + b2(PCC_vol) + b3(mPFC-to-PCC_conn)

Model 2.3.1: digit_forward = b1(mPFC_vol) + b2(PCC_vol)
Model 2.3.2: digit_forward = b1(mPFC_vol) + b2(PCC_vol) + b3(mPFC-to-PCC_conn)

Model 2.4.1: digit_back = b1(mPFC_vol) + b2(PCC_vol)
Model 2.4.2: digit_back = b1(mPFC_vol) + b2(PCC_vol) + b3(mPFC-to-PCC_conn)

Also, although the models for Acceptability Ratings and Digit Span Backward are included to address Aims 1 and 2, evaluation of these models are included in Appendix A rather than the results section. Models examining Acceptability Ratings are reported in the Appendix A due to a Self/Other by Age Group interaction in behavioral performance, as described in the results section below. Although this behavioral performance relationship to age is theoretically plausible (see: Daley & Kensinger, 2021), the present study did not have specific hypotheses related to Default Mode Network structure or functional relationships with these behavioral outcomes. Regarding the Digit Span Backward models, these models did not provide further insight beyond the models evaluating Digit Span Forward. As a result, they are included in Appendix A for reference.

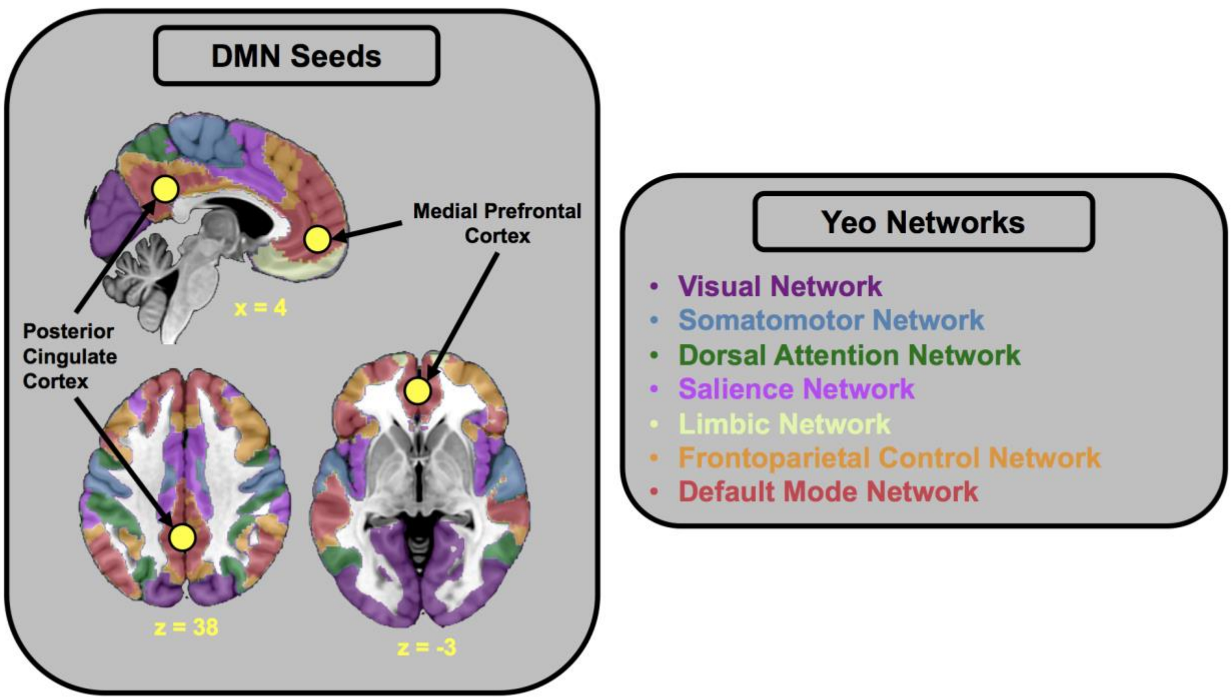

Figure 1. Default Mode Network regions of interest and Yeo networks. The medial prefrontal cortex (MNI: 1, 55, -3) and posterior cingulate cortex (MNI: 1, -61, 38) seed regions are indicated by the yellow circles. These yellow circles represent the spherical regions of interest (12 mm) in the CONN Toolbox's (v20b) canonical Default Mode Network seed regions. The seven networks overlaid on the

brain rendering are the resting-state cortical parcellations in nonlinear MNI152 space identified by Yeo et al (2011). These networks were overlaid using the liberal network mask (https://surfer.nmr.mgh.harvard.edu/fswiki/CorticalParcellation_Yeo2011).

Aim 3 Analyses. Next, in order to evaluate how resting-state functional connectivity within the Default Mode Network, as well as connectivity with regions outside of this network relate to behavioral performance on moral decision-making and working memory performance in younger and older adults, separate whole-brain seed-to-voxel resting-state functional connectivity analyses were conducted using the medial prefrontal cortex and posterior cingulate cortex as seed regions in separate analyses. Separate one-way ANCOVAs were used to model these relationships as indicated by the following general formula:

$$Seed \sim OA\_beh + YA\_beh + OA + YA$$

In this formula the OA_beh and YA_beh terms were computed by first taking the average score from the entire sample for a given behavioral metric (e.g. Proportion Utilitarian). Individual participant behavioral metrics were then mean-centered using the average score from the entire sample. Once these mean-centered scores were obtained, the OA_beh term was created by including only the older adult participant mean-centered scores in the term. The same was done for the YA_beh score, by only including the younger adult participant mean-centered scores. The last two terms in the model include dummy scored terms, with the OA term setting older adults as 1 and younger adults as 0. The YA term sets younger adults as 1 and older adults as 0.

To evaluate this model, an omnibus *F*-test was first computed, which identified any significant clusters that showed resting state functional connectivity with the seed region in relation to the terms in the model. The results of this *F*-test were evaluated using CONN's standard settings for cluster-based inferences, with a cluster threshold set to $p < .05$ (cluster-size p-FDR corrected), and voxel threshold of $p < .001$. After obtaining the results of this *F*-test, four follow-up *t*-tests were conducted in SPM12: 1) Younger Adult Behavior > Baseline; 2) Older Adult Behavior > Baseline; 3) Younger Adult Behavior > Older Adult Behavior; 4) Older Adult Behavior > Younger Adult Behavior.

Significant clusters identified by the first of these follow-up *t*-tests (Younger Adult Behavior > Baseline) are interpreted as regions that show stronger positive functional connectivity with the seed region for younger adults, but not older adults, at higher behavioral scores. The same logic follows for the second *t*-test, with the exception that significant clusters are associated with older adult, but not young adult, performance. These two *t*-tests provided insight into how age-related differences in the regions functionally connected to the seed region relate to behavioral performance in each group.

Clusters identified by follow-up *t*-test three (Younger Adult Behavior > Older Adult Behavior) are those regions functionally connected to the seed region in both groups, but where younger adults show more positive resting-state functional connectivity than older adults at higher behavioral scores. Again, the logic for follow-up *t*-test three extends to *t*-test four, with the exception that significant clusters are associated with stronger positive functional connectivity for older adults compared to younger adults at higher behavioral performance.

All follow-up *t*-tests were masked by the results from the omnibus *F*-test prior to evaluating significant clusters. This ensured that the regions identified in these post-hoc tests were constrained by the original *F*-test. It should be noted that these follow-up *t*-tests were examined at $p < .005$ (uncorrected), and a Monte Carlo Simulation (Slotnick, 2017; Slotnick et al., 2003) was used to determine that a voxel extent of $k = 54$ corrected for multiple comparisons at $p < .05$. This correction approach is consistent with previous work using similar scanning parameters during resting-state scan acquisition (Kark & Kensinger, 2019; for more examples using this correction approach see: Daley, Bowen, Fields, Gutchess, et al., 2020; Daley, Bowen, Fields, Parisi, et al., 2020; Thakral et al., 2015, 2020). For visualization purposes, the REX toolbox (Duff et al., 2007) was used to extract subject-level parameter estimates of resting-state functional connectivity within significant clusters identified by a given *t*-test to be plotted against behavior. Visual rendering of statistical brain maps were created using MRIcroGL (Rorden & Brett, 2000).

In order to identify the network that a given cluster was contained within, the statistical maps identified by each follow-up *t*-test were overlaid on the 7 networks identified by Yeo et al. (2011) in MRIcroGL (Rorden & Brett, 2000). Each cluster was then visually inspected to determine its associated network. If a given cluster overlapped more than one network, the network containing the majority of the cluster's voxels was chosen as a label. As such, it is possible that the peak coordinate of a given cluster may occur within one network, but the majority of the cluster may exist within a second network. In this case, the second network would be used as the label for the cluster. Networks identified for each cluster are indicated under the "Network" column in relevant tables in the results section. As a visual guide, the networks used in the present analyses are depicted in Figure 1 along with the seed regions used to address Aims 2 and 3.

These steps outlined above were used to examine seed-to-voxel analyses in relation to Proportion Utilitarian (Prop_Util) scores and Digit Span Forward scores (DF). Acceptability ratings were not evaluated in these models because there was a significant Age Group * Self/Other interaction that was primarily driven by differences between the levels of this factor in older adults alone, as indicated in the results section below. There were no significant differences between younger and older adults in either condition. Digit Span Forward was chosen as the working memory metric to address Aim 3, because the Digit Span Backward performance was negatively skewed when age group was ignored, rendering concerns about ceiling effects. As a result, four models were used to evaluate Aim 3:

Model 3.1: *Medial Prefrontal Cortex Seed ~ OA_Prop_Util + YA_Prop_Util + OA + YA*

Model 3.2: *Posterior Cingulate Cortex Seed ~ OA_Prop_Util + YA_Prop_Util + OA + YA*

Model 3.3: *Medial Prefrontal Cortex Seed ~ OA_DF + YA_DF + OA + YA*

Model 3.4: *Posterior Cingulate Cortex Seed ~ OA_DF + YA_DF + OA + YA*

1.4 Results

Behavior

Moral Decision-Making

Older adults endorse fewer utilitarian responses during instrumental dilemmas than younger adults. The 2 (Incidental/Instrumental) * 2 (Self/Other) * 2 (Age Group) repeated measures ANOVA on Proportion Utilitarian scores revealed a significant main effect of Incidental/Instrumental, $F(1, 69) = 225.97$, $p < .001$, $\eta_p^2 = .77$. This main effect was qualified by an Incidental/Instrumental * Age Group interaction, $F(1, 69) = 9.32$, $p = .003$, $\eta_p^2 = .12$. A Welch's independent samples *t*-test revealed that during Instrumental dilemmas, younger adults ($M = .28$, $SD = .27$) were significantly more likely to indicate "Yes" to the proposed utilitarian action than older adults ($M = .15$, $SD = .14$), $t(54.81) = 2.61$, $p = .01$, $d = .61$. Yet, there were no significant differences between younger adults ($M = .61$, $SD = .25$) and older adults ($M = .65$, $SD = .24$) for Incidental dilemmas, $t(68.81) = .67$, $p = .50$, $d = .16$. Both Incidental dilemmas were endorsed to a greater extent than Instrumental dilemmas in younger adults, $t(36) = 7.92$, $p < .001$, $d = 1.30$, and older adults, $t(33) = 14.07$, $p < .001$, $d = 2.41$.

There was no main effect of Self/Other, $F(1, 69) = .41$, $p = .52$, $\eta_p^2 = .006$. Self/Other did not interact with Age Group, $F(1, 69) = 1.68$, $p = .20$, $\eta_p^2 = .02$, or Incidental/Instrumental, $F(1, 69) = .07$, $p = .79$, $\eta_p^2 = .001$. There was no significant three-way interaction, $F(1,69) = .01$, $p = .93$, $\eta_p^2 < .001$. Critically, there was no main effect of Age Group, $F(1, 69) = .92$, $p = .34$, $\eta_p^2 = .01$.

Given that there was no main effect of Age Group, but a significant Incidental/Instrumental by Age Group interaction, all subsequent analyses examining brain-behavior relationships used a Proportion Utilitarian Instrumental Bias score (Figure 2). This composite score was computed by subtracting Proportion Utilitarian (Incidental) from Proportion Utilitarian (Instrumental) scores. In this case, scores approaching 1 reflect higher endorsement of the utilitarian option during Instrumental dilemmas compared Incidental dilemmas, a score of 0 indicates no difference between the conditions, and scores approaching -1 reflect higher endorsement of the utilitarian option during Incidental dilemmas compared to Instrumental dilemmas. Younger adults ($M = -.33$, $SD = .25$) reported significantly higher Proportion Instrumental Bias scores than older adults ($M = -.50$, $SD = .21$), $t(68.11) = 3.11$, $p = .003$, $d = .73$.[4] This finding can be interpreted as older adults being more biased toward endorsing the

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[4] The significant Instrumental/Incidental by Age Group interaction replicated in all subsamples examined in this manuscript. The independent samples *t*-test comparing younger adults and older adults on Instrumental dilemmas also replicated with in all participant subsamples with the exception of the participants who were included in the working memory analyses to address Aim 2, $t(36.97) = 1.88$, $p = .07$, $d = .54$, as well as the those who were used in the working memory analyses to address AIM 3, $t(41.54) = 1.77$, $p = .09$, $d = .48$. Importantly, despite these marginally significant findings, the subsample included to address working memory analyses in Aim 2 demonstrated significant age differences in the Proportion Utilitarian Instrumental Bias score, $t(46.13) = 2.28$, $p = .03$, $d = .63$, and the subsample included to address working memory analyses in Aim 3 demonstrated marginally significant differences on this metric, $t(49.51) = 1.91$, $p = .06$, $d = .52$.

utilitarian option during Incidental dilemmas than Instrumental dilemmas, as compared to younger adults, who are less likely to show a difference between these conditions.

Older adults rate proposed utilitarian resolutions in the Self condition as less morally acceptable than the Other condition. The 2 (Incidental/Instrumental) * 2 (Self/Other) * 2 (Age Group) repeated measures ANOVA on Acceptability Ratings revealed a significant main effect of Instrumental/Incidental, $F(1, 69) = 107.68$, $p < .001$, $\eta_p^2 = .61$, with participants rating proposed resolutions in the Incidental dilemmas ($M = 3.05$, $SD = 1.16$) as more morally acceptable than the Instrumental dilemmas ($M = 2.15$, $SD = 1.05$). There was also a significant main effect of Self/Other that $F(1, 69) = 9.54$, $p = .003$, $\eta_p^2 = .12$, which was qualified by a Self/Other * Age Group interaction $F(1, 69) = 13.91$, $p < .001$, $\eta_p^2 = .17$. A paired sample's t-test revealed that older adults rated the Other condition ($M = 2.68$, $SD = 1.16$) as more morally acceptable than the Self condition ($M = 2.34$, $SD = 1.05$), $t(33) = 5.70$, $p < .001$, $d = .98$. There were no significant differences between the Self ($M = 2.70$, $SD = 1.02$) and Other conditions ($M = 2.67$, $SD = 1.04$) in younger adults, $t(36) = .34$, $p = .74$, $d = .06$. There were also no significant differences in the Self condition between younger and older adults, $t(68.14) = 1.46$, $p = .15$, $d = .35$. This was also the case for the Other condition, $t(66.59) = .04$, $p = .97$, $d = .01$.

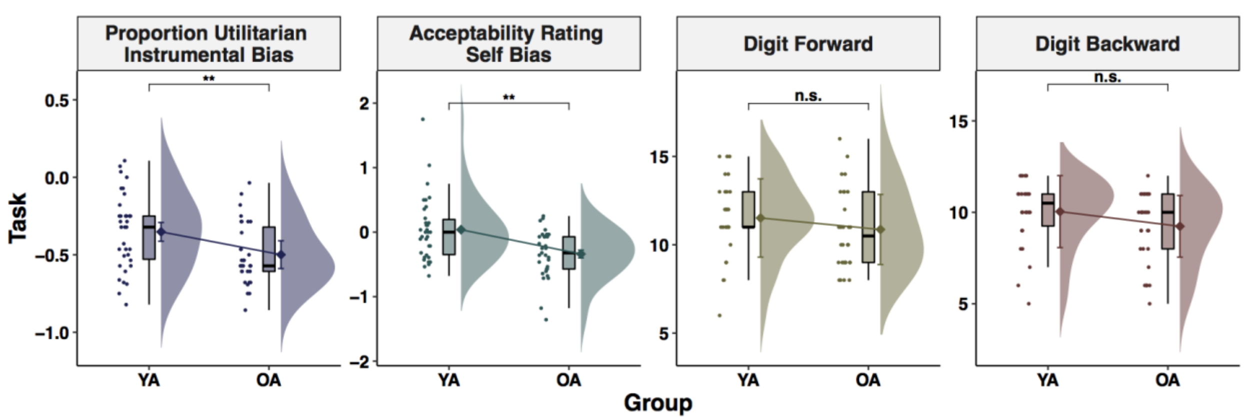

Figure 2. Age by condition interactions in moral decision-making despite age-invariant working memory performance. For Proportion Utilitarian Instrumental Bias scores, scores closer

to 0 indicate no difference in utilitarian decisions between Instrumental and Incidental conditions. Scores closer to -1 are associated with higher endorsement of utilitarian decisions during Incidental dilemmas to a greater extent than Instrumental dilemmas. For Acceptability Rating Self Bias Scores, positive scores indicate that proposed utilitarian actions during the Self compared to the Other condition are more acceptable, a score of 0 indicates no difference between the conditions, and negative scores indicate utilitarian decisions during the Other condition are more acceptable than the Self condition. Digit Forward and Digit Backward scores reflect raw scores. OA = older adult; n.s. = not significant; YA = younger adult.

Instrumental/Incidental did not interact with Self/Other, $F(1, 69) = .82$, $p = .37$, $\eta_p^2 = .01$, or Age Group, $F(1, 69) = 1.90$, $p = .17$, $\eta_p^2 = .03$. There was no 3-way interaction between Instrumental/Incidental, Self/Other and Age Group, $F(1, 69) = 1.45$, $p = .23$, $\eta_p^2 = 02$. Finally, there was no significant main effect of Age Group, $F(1, 69) = .49$, $p = .48$, $\eta_p^2 = .01$.

Given that there was no main effect of Age Group, but a significant Age Group by Self/Other interaction, all subsequent analyses examining brain-behavior relationships used an Acceptability Rating Self Bias score that was computed in the following manner: Acceptability Rating [Self] - Acceptability Rating [Other] (Figure 2). In this case positive scores reflect higher Acceptability Ratings for the Self condition compared to the Other condition, a score of 0 indicates no difference between the two conditions, and negative scores reflect higher Acceptability Ratings for the Other condition than the Self condition. There was a significant difference between younger ($M = .03$, $SD = .49$) and older adults ($M = -.34$, $SD = .35$) on Acceptability Self Bias scores, $t(65.37) = 3.69$, $p < .001$, $d = .87$. Finally, given that there were no hypotheses related to the Self/Other factor, and that previous research did not demonstrate any age-related interactions with this factor (McNair et al., 2019), all analyses associated with brain-behavior relationships for the Acceptability Self Bias scores are listed in Appendix A.

Working Memory Capacity

Younger adults (n = 28; M = 11.82, SD = 2.02) and older adults (n = 33; M = 10.94, SD = 2.19) showed no significant differences in Digit Span Forward performance (Figure 2), $t(58.58) = 1.63$, $p = .11$, d = 42. There were also no significant differences in Digit Span Backward performance between younger adults (M = 9.89, SD = 2.08), and older adults (M = 9.06, SD = 2.08), $t(57.37) = 1.56$, $p = .12$, $d = .40$. These findings replicated in all subsamples of participants used in each aim.

Brain Metrics

As expected, younger adults had significantly larger medial prefrontal cortex volume (M = 5382.56 mm^3, SD = 539.71 mm^3), than older adults (M = 4840.68 mm^3, SD = 332.12 mm^3), $t(57.02) = 5.07$, $p < .001$, $d = 1.2$. This was also the case for the posterior cingulate cortex ($M_{Younger\ Adults}$ = 3290.05 mm^3, $SD_{Younger\ Adults}$ = 335.91 mm^3; $M_{Older\ Adults}$ = 2805.8 mm^3, $SD_{Older\ Adults}$ = 335.14 mm^3), $t(65.78) = 5.95$, $p < .001$, $d = 1.44$, and the isthmus cingulate cortex ($M_{Younger\ Adults}$ = 2624.23 mm^3, $SD_{Younger\ Adults}$ = 342.09 mm^3; $M_{Older\ Adults}$ = 2196.72 mm^3, $SD_{Older\ Adults}$ = 226.24 mm^3), $t(59.3) = 6.11$, $p < .001$, $d = 1.47$. Younger adults also demonstrated significantly stronger resting-state functional connectivity between the medial prefrontal cortex and posterior cingulate cortex (M = .26 , SD = .18), than older adults (M = .15, SD = .16), $t(61.89) = 2.36$, $p = .02$, $d = .59$.

Brain-Behavior Relationships

Gray Matter Volume

Gray matter volume of the core nodes of the Default Mode Network does not predict Proportion Utilitarian Instrumental Bias in younger or older adults. To determine how gray matter volume of the core nodes of the Default Mode Network relate to age-related differences in Proportion Utilitarian Instrumental Bias, Model 1.1.1 was estimated with main effects terms for

Age Group ($n_{Younger\ Adults}$ = 35; $n_{Older\ Adults}$ = 33), medial prefrontal cortex volume and posterior cingulate volume (Table 1). This model provided a significantly better overall fit than the intercept-only model, $\chi(3) = 4.54$, $p = .006$ (Table 1). The inclusion Age Group by region of interest interactions (Model 1.1.2), $\chi(2) = .70$, $p = .50$, or a 3-way interaction between Age Group, medial prefrontal cortex, and posterior cingulate cortex volume (Model 1.1.3), $\chi(2) = .88$, $p = .42$, did not improve overall model fit. The results from Model 1.1.1 indicate that none of the independent variables predicted Proportion Utilitarian Instrumental Bias. The model including isthmus cingulate cortex volume instead of posterior cingulate cortex volume also did not significantly predict Proportion Utilitarian Instrumental Bias scores (Appendix A, Table S1). Finally, models examining the relationship between gray matter structure and Acceptability Rating Self Bias scores (Model 1.2) are reported in Appendix A (Table S2, S3, and Figure S1).

Table 1.
Proportion Utilitarian Instrumental Bias and Gray Matter Volume Model

	Model 1.1.1	Model 1.1.2	Model 1.1.3
(Intercept)	-0.398 ***	-0.422 ***	-0.427 ***
	[-0.453, -0.344]	[-0.496, -0.347]	[-0.503, -0.350]
Age Group	0.058	0.061	0.071 +
	[-0.014, 0.129]	[-0.014, 0.136]	[-0.006, 0.147]
mPFC Vol.	0.000	0.000	0.000
	[-0.000, 0.000]	[-0.000, 0.000]	[-0.000, 0.000]
PCC Vol.	0.000	0.000	-0.000
	[-0.000, 0.000]	[-0.000, 0.000]	[-0.000, 0.000]
Age Group x mPFC Vol.		-0.000	0.000

		[-0.000, 0.000]	[-0.000, 0.000]
Age Group x PCC Vol.		0.000	0.000
		[-0.000, 0.000]	[-0.000, 0.000]
mPFC Vol. x PCC Vol.			-0.000
			[-0.000, 0.000]
Age Group x mPFC Vol. x PCC Vol.			0.000
			[-0.000, 0.000]
Num.Obs.	68	68	68
R2	0.177	0.196	0.219
R2 Adj.	0.139	0.131	0.127
AIC	-3.9	-1.4	0.7
BIC	7.2	14.2	20.6
Log.Lik.	6.926	7.687	8.674
F	4.602	3.016	2.399

Note: Dependent Variable = Proportion Utilitarian Instrumental Bias score. Age Group is deviation coded (YA = 1, OA = -1). Brackets indicate estimate 95% CI. All other independent variables are mean-centered. p < 0.1 = + p < 0.05 = *, p < 0.01 = **, p < 0.001 = ***.

Gray matter volume of the core nodes of the Default Mode Network does not predict Digit Span Forward in younger or older adults. To determine how gray matter volume of the core nodes of the Default Mode Network relate to Digit Span Forward performance, Model 1.3.1 was estimated with main effects terms for Age Group ($n_{Younger\ Adults}$ = 26; $n_{Older\ Adults}$ = 32), medial prefrontal cortex volume and posterior cingulate volume (Table 2). This model did not provide a better overall model fit than the intercept-only model, $\chi(3) = 1.27$, $p = .29$. Updating Model 1.3.1 with terms examining 2-way interactions between Age Group and each region of interest (Model 1.3.2), $\chi(2) = 1.21$, $p = .31$, or a model examining a 3-way interaction between Age Group, medial prefrontal cortex volume, and posterior cingulate cortex volume (Model 1.3.3), $\chi(2) = .53$, $p = .59$, also did not provide a better overall model fit. These findings indicate that similar to Proportion Utilitarian Instrumental Bias performance, none of the independent variables in this model were significant predictors of working memory performance. The model including isthmus cingulate cortex volume instead of posterior cingulate cortex volume also did not significantly predict Digit Span Forward scores (Appendix A, Table S3). Similar results were produced for models examining Digit Span Backwards (Model 1.4; Appendix A, Table S4 and S5).

Table 2.
Digit Span Forward and Gray Matter Volume

	Model 1.3.1	Model 1.3.2	Model 1.3.3
(Intercept)	11.30 ***	11.75 ***	11.92 ***
	[10.73, 11.86]	[10.92, 12.57]	[10.98, 12.86]
Age Group	0.05	0.22	0.42
	[-0.74, 0.84]	[-0.60, 1.04]	[-0.52, 1.35]
mPFC Vol.	-0.00	-0.00	-0.00
	[-0.00, 0.00]	[-0.00, 0.00]	[-0.00, 0.00]
PCC Vol.	0.00	0.00	-0.00
	[-0.00, 0.00]	[-0.00, 0.00]	[-0.00, 0.00]
Age Group x mPFC Vol.		-0.00	-0.00

		[-0.00, 0.00]	[-0.00, 0.00]
Age Group x PCC Vol.		-0.00	-0.00
		[-0.00, 0.00]	[-0.00, 0.00]
mPFC Vol. x PCC Vol.			0.00
			[-0.00, 0.00]
Age Group x mPFC Vol. x ICC Vol.			0.00
			[-0.00, 0.00]
Num.Obs.	58	58	58
R2	0.066	0.109	0.127
R2 Adj.	0.015	0.023	0.005
AIC	257.6	258.9	261.7
BIC	267.9	273.4	280.3
Log.Lik.	-123.813	-122.464	-121.856
F	1.282	1.271	1.043

Note: Dependent variable = Digit Span Forward Score. Age Group is deviation coded (YA = 1, OA = -1). All other independent variables are mean-centered. Brackets indicate estimate 95% CI. p < 0.1 = + p < 0.05 = *, p < 0.01 = **, p < 0.001 = ***.

ROI-to-ROI Resting-State Functional Connectivity

Resting-state functional connectivity between the core nodes of the Default Mode Network does not predict Proportion Utilitarian Instrumental Bias in younger or older adults. To determine whether resting-state functional connectivity between the medial prefrontal cortex and posterior cingulate cortex could predict Proportion Utilitarian Instrumental Bias in younger and older adults, medial prefrontal cortex volume, posterior cingulate cortex volume, and parameter estimates of resting-state functional connectivity between these two regions were included in separate models for younger (*n* = 33; Table 3), and older adults (*n* = 31; Table 4). Neither the model containing just the gray matter volume terms (Model 2.1.1), $\chi(2) = 1.20$, $p = .32$, nor the updated model containing the parameter estimate of medial prefrontal cortex to posterior cingulate cortex resting-state functional connectivity (Model 2.1.2), $\chi(1) = .48$, $p = .49$ significantly improved overall model fit than the intercept-only model in younger adults. Neither of these models improved overall model fit than the intercept-only model in older adults either (Model 2.1.1[Older Adults]: $\chi(2) = 1.76$, $p = .19$; Model 2.1.2 [Older Adults]; $\chi(1) = 1.39$, $p = .25$). The model including isthmus cingulate cortex volume instead of posterior cingulate cortex volume also did not significantly predict Proportion Utilitarian Instrumental Bias scores (Appendix A, Table S6 and S7). Generally, these findings indicate that alongside gray matter volume, resting-state functional connectivity between the medial prefrontal cortex and posterior cingulate cortex does not predict Proportion Utilitarian Instrumental Bias in younger or older adults in the present sample. Finally, models examining the relationship between these predictors and Acceptability Rating Self Bias scores (Model 2.2) are reported in Appendix A (Table S8 - S11).

Table 3.
Proportion Utilitarian Instrumental Score, Gray Matter Volume and Resting-State Functional Connectivity (Younger Adults)

	Model 2.1.1	Model 2.1.2
(Intercept)	-1.06 *	-0.88
	[-2.04, -0.07]	[-2.00, 0.23]
mPFC Vol.	0.00	0.00

	[-0.00, 0.00]	[-0.00, 0.00]
PCC Vol.	0.00	0.00
	[-0.00, 0.00]	[-0.00, 0.00]
mPFC-to-PCC RSFC		-0.17
		[-0.68, 0.34]
Num.Obs.	33	33
R2	0.075	0.090
R2 Adj.	0.013	-0.004
AIC	2.9	4.4
BIC	8.9	11.8
Log.Lik.	2.552	2.823
F	1.217	0.957

Note: Dependent variable = Proportion Utilitarian Instrumental Bias score. Brackets indicate estimate 95% CI. p < 0.1 = + p < 0.05 = *, p < 0.01 = **, p < 0.001 = ***.

Table 4.
Proportion Utilitarian Instrumental Score, Gray Matter Volume and Resting-State Functional Connectivity (Older Adults)

	Model 2.1.1	Model 2.1.2
(Intercept)	-1.14 +	-1.12 +
	[-2.34, 0.07]	[-2.32, 0.08]
mPFC Vol.	0.00 +	0.00 +
	[-0.00, 0.00]	[-0.00, 0.00]
PCC Vol.	-0.00	-0.00

	[-0.00, 0.00]	[-0.00, 0.00]
mPFC-to-PCC RSFC		-0.25
		[-0.70, 0.19]
Num.Obs.	31	31
R2	0.110	0.154
R2 Adj.	0.047	0.060
AIC	-8.4	-7.9
BIC	-2.6	-0.8
Log.Lik.	8.189	8.970
F	1.736	1.638

Note: Dependent variable = Proportion Utilitarian Instrumental Bias score. Brackets indicate estimate 95% CI. p < 0.1 = + p < 0.05 = *, p < 0.01 = **, p < 0.001 = ***.

Resting-state functional connectivity between the core nodes of the Default Mode Network does not predict Digit Span Forward scores in younger or older adults. To determine whether resting-state functional connectivity between the medial prefrontal cortex and posterior cingulate cortex could predict Digit Span Forward performance in younger and older adults, medial prefrontal cortex volume, posterior cingulate cortex volume, and parameter estimates of resting-state functional connectivity between these two regions were included in separate models for younger adults (*n* = 24; Table 5), and older adults (*n* = 30, Table 6). Neither the model containing just the gray matter volume terms (Model 2.3.1), $\chi(2) = .19$, *p* = .82, nor the updated model containing the parameter estimate of medial prefrontal cortex to posterior cingulate cortex resting-state functional connectivity (Model 2.3.2), $\chi(1) = 1.24$, *p* = .28, significantly improved overall model fit than the intercept-only model in younger adults. Neither of these models improved overall model fit than the intercept-only model in older adults either (Model 2.3.1[Older Adults]: $\chi(2) = 1.57$, $p = .23$; Model 2.3.2[Older Adults]: $\chi(1) = .45$, $p = .51$). The model including the isthmus cingulate cortex volume instead of posterior cingulate cortex volume also did not significantly predict Digit Span Forward scores (Appendix A, Table S12 and S13). Similar results were produced for models examining Digit Span Backwards (Model 2.4; Appendix A, Table S14-S17). Generally, these findings indicate that alongside gray matter volume, resting-state functional connectivity between the medial prefrontal cortex and posterior cingulate cortex does not predict Digit Span Forward in younger or older adults in the present sample.

Table 5.
Digit Span Forward, Gray Matter Volume and Resting-State Functional Connectivity (Younger Adults)

	Model 2.3.1	Model 2.3.2
(Intercept)	15.88 *	16.59 *
	[0.88, 30.89]	[1.56, 31.61]
mPFC Vol.	-0.00	-0.00
	[-0.00, 0.00]	[-0.00, 0.00]
PCC Vol.	-0.00	-0.00
	[-0.00, 0.00]	[-0.01, 0.00]
mPFC-to-PCC RSFC		3.17
		[-2.77, 9.11]
Num.Obs.	24	24
R2	0.018	0.075

R2 Adj.	-0.076	-0.064
AIC	106.8	107.4
BIC	111.5	113.3
Log.Lik.	-49.410	-48.687
F	0.188	0.541

Note: Dependent variable = Digit Span Forward. Brackets indicate estimate 95% CI. p < 0.1 = + p < 0.05 = *, p < 0.01 = **, p < 0.001 = ***.

Table 6:
Digit Span Forward, Gray Matter Volume and Resting-State Functional Connectivity (Older Adults)

	Model 2.3.1	Model 2.3.2
(Intercept)	2.57	2.36
	[-11.33, 16.48]	[-11.74, 16.45]
mPFC	0.00	0.00
	[-0.00, 0.00]	[-0.00, 0.00]
PCC	0.00	0.00
	[-0.00, 0.00]	[-0.00, 0.00]
mPFC-to-PCC RSFC		1.67
		[-3.45, 6.78]
Num.Obs.	30	30
R2	0.106	0.121
R2 Adj.	0.040	0.020
AIC	137.6	139.0

BIC	143.2	146.0
Log.Lik.	-64.776	-64.520
F	1.598	1.193

Note: Dependent variable = Digit Span Forward. Brackets indicate estimate 95% CI. p < 0.1 = + p < 0.05 = *, p < 0.01 = **, p < 0.001 = ***.

Seed-to-Voxel Whole Brain Resting-State Functional Connectivity

Proportion Utilitarian Instrumental Bias (Medial Prefrontal Cortex Seed). Significant clusters identified by the Proportion Utilitarian Instrumental Bias one-way ANCOVA omnibus *F*-test are depicted in Figure 3. The results of this *F*-test were used as a mask for all subsequent *t*-test contrasts examining age-related differences in behavioral performance on resting-state functional connectivity. It is important to note that significant clusters identified by this *F*-test are agnostic to the direction of connectivity (i.e. positive or negative) with the medial prefrontal cortex. A *F*-contrast was created for each model to mask relevant *t*-tests, similar to the present model. However, the results of these models will not be depicted in subsequent sections.

***Contrast*: *Younger Adults Proportion Utilitarian Instrumental Bias > Baseline*.** Examination of the regions that show stronger positive functional connectivity with the medial prefrontal cortex at higher Proportion Utilitarian Instrumental Bias scores in younger adults, but not older adults, included the right hippocampus and right temporal pole, two Default Mode Network regions (Table 7). A portion of the left temporal pole, left inferior temporal gyrus, and right orbitofrontal cortex, all regions associated with the Limbic Network were also identified. Finally, somewhat surprisingly the medial prefrontal cortex also showed increased functional connectivity with one dorsolateral prefrontal cortex cluster, a region identified within the Frontoparietal Control Network.

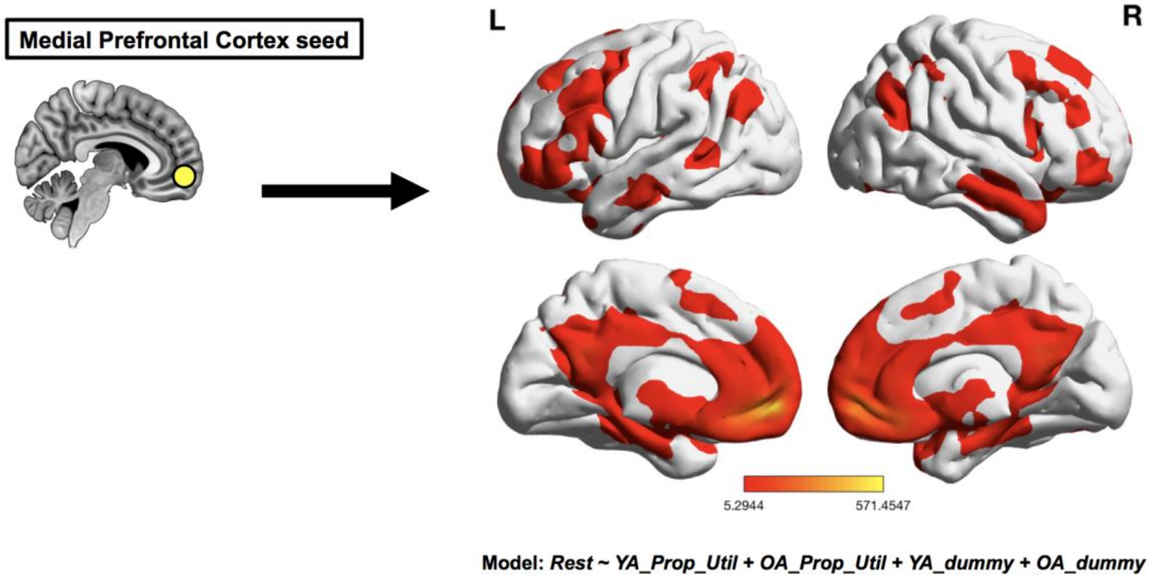

Figure 3. Regions functionally connected to the medial prefrontal cortex for Proportion Utilitarian Instrumental Bias Model. The highlighted regions demonstrated significant resting state functional connectivity with the medial prefrontal cortex for the omnibus *F*-test for the Proportion Utilitarian Bias Model (Model 3.1). The results of this *F*-test were used as a mask for follow-up *t*-tests. mPFC = medial prefrontal cortex; OA = older adult; YA = younger adult.

Contrast: Older Adults Proportion Utilitarian Instrumental Bias > Baseline. Examination of the regions that show stronger positive functional connectivity with the medial prefrontal cortex at higher Proportion Utilitarian Instrumental Bias scores in older adults, but not younger adults, includes the right insula, a core hub of the Salience Network. Other Salience Network regions included the supplementary motor area, and the right superior temporal pole. There were also Frontoparietal Control Network regions identified, including the right orbitofrontal cortex and right precentral gyrus. Finally, the right middle occipital gyrus, a Visual network region was identified. These findings indicate that older adults who were less likely to differently respond to Instrumental and Incidental dilemmas, had reduced segregation of the medial prefrontal cortex from regions in networks outside of the Default Mode Network.

Table 7.

Regions demonstrating stronger positive resting-state functional connectivity with the medial prefrontal cortex at higher levels of Proportion Utilitarian Instrumental Bias scores in younger or older adults

Contrast	Hemisphere	Region	BA	XYZ (MNI)	Cluster Extent	Network
YA > Baseline	R	Hippocampus	NA	24, -12, -14	154	DMN
				28, -20, -8		
				30, -4, -24		
	R	Temp. Pole	38	56, 4, -30	56	DMN
	L	dlPFC	9	-40, 20, 32	60	FCPN
	L	Inf. Temp. Gyrus	20	-44, -6, -42	248	Limbic
	L	Orbitofrontal Cortex	11	-12, 54, -28	89	Limbic
	R	Temp. Pole	38	30, 24, -42	108	Limbic
				48, 22, -32		
OA > Baseline	R	Orbitofrontal Cortex	11	16, 34, -12	86	FCPN
	R	Precentral Gyrus	6	48, 4, 50	78	FCPN
				38, -4, 50		
	R	Sup. Motor Area	6	6, 6, 54	250	SN
				-2, -10, 52		
	L	Sup. Temp. Pole	22	-56, 14, -6	76	SN
	R	Insula	13	38, 12, 2	251	SN
			44	40, 8, 10		
			44	42, 12, 20		
	L	Mid. Occip. Gyrus	18	-18, -88, -6	113	Visual
	L	Calcarine Cortex		-10, -100, -4		
	R	Cerebellum	NA	4, -46, -16	251	NA
				8, -34, -16		
	L	Cerebellum	NA	-22, -64, -56	80	NA
				-28, -58, -46		
	L			-14, -70, -54		
	L	Cerebellum	NA	-28, -70, -22	98	NA
				-34, -90, -24		
				-32, -80, -22		

Note: The regions identified by the YA > Baseline contrast are regions demonstrating stronger positive resting state functional connectivity with the medial prefrontal cortex in younger adults, but not older adults at higher levels of Proportion Utilitarian Instrumental Bias scores. The regions identified by the OA > Baseline contrast are regions demonstrating stronger positive resting state functional connectivity with the medial prefrontal cortex in older adults, but not younger adults, at higher levels of Proportion Utilitarian Instrumental Bias scores. dlPFC = dorsolateral prefrontal cortex; DMN = Default Mode Network; FCPN = Frontoparietal Control Network, SN = Salience Network.

Contrast: Younger Adults Proportion Utilitarian Instrumental Bias > Older Adults Proportion Utilitarian Instrumental Bias. Regions functionally connected to the medial prefrontal cortex in both groups, but where younger adults showed stronger positive functional connectivity than older adults at higher Proportion Utilitarian Instrumental Bias scores primarily include regions within the Default Mode Network, including the right dorsomedial prefrontal cortex, the right parahippocampal gyrus, and the left middle frontal gyrus (Figure 4, Table 8). The interactions in the right dorsomedial prefrontal cortex and right parahippocampal gyrus clusters interestingly appear to be driven by behavioral differences in older adult performance. That is, older adults who have stronger negative Proportion Utilitarian Instrumental Biases appear to show stronger positive functional connectivity between the medial prefrontal cortex and these regions, whereas older adults with weaker Proportion Utilitarian Instrumental Biases (i.e. scores approaching 0) demonstrated relatively weaker functional connectivity between these regions. Younger adults on the other hand, demonstrate very little variability in functional connectivity strength between these regions across the range of Proportion Utilitarian Instrumental Bias scores.

These age-related relationships are similarly observed in the right middle frontal gyrus, a Frontoparietal Control Network region, with the exception that stronger negative functional connectivity between these regions is associated with reduced Proportion Utilitarian Instrumental

Bias in older adults. Again, younger adults demonstrate very little variability in functional connectivity between these regions across the range of behavioral performance.

Finally, stronger positive functional connectivity between the medial prefrontal cortex, and the two Limbic Network regions, was associated with opposite outcomes in older and younger adults with regard to positive functional connectivity. Stronger connectivity in younger adults was associated with higher Proportion Utilitarian Instrumental Bias scores (i.e. approaching a score of 0), but lower, or more negative scores in older adults.

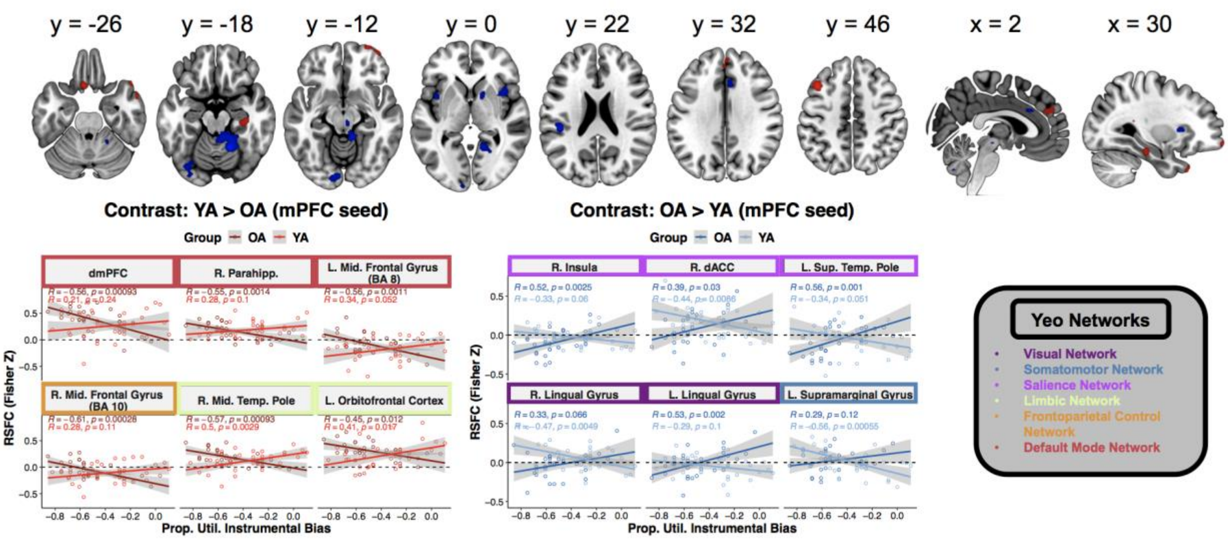

Figure 4. Default Mode Network segregation with medial prefrontal cortex associated with weaker Proportion Utilitarian Instrumental Bias scores in younger adults and stronger negative bias in older adults. The red clusters and scatter plots are regions where younger adults show stronger positive functional connectivity with the medial prefrontal cortex compared to older adults at higher levels of Proportion Utilitarian Instrumental Bias. The blue clusters and associated plots are regions where older adults show stronger positive functional connectivity with the medial prefrontal cortex compared to younger adults at higher levels of Proportion Utilitarian Instrumental Bias. These results were masked with the results from the omnibus F-test in Figure 3. Scores are uncentered for the sake of visualization. Scores closer to 0 on the x-axis reflect reduced bias. Scores closer to -1 indicate higher endorsement of the utilitarian option during incidental dilemmas compared to instrumental dilemmas. dACC = dorsal anterior cingulate cortex; dmPFC = dorsomedial prefrontal cortex; mPFC = medial prefrontal cortex.

Contrast: Older Adults Proportion Utilitarian Instrumental Bias > Younger Adults Proportion Utilitarian Instrumental Bias. Regions functionally connected to the medial prefrontal cortex in both groups, but where older adults showed stronger positive functional connectivity than you adults at higher levels of Proportion Utilitarian Instrumental Bias scores primarily include regions within the Salience Network, including the right insula, the right dorsal anterior cingulate, and the left superior temporal pole (Figure 4, Table 8). Again, older adults appear to be driving the interactions within the right insula and the left superior temporal pole, such that stronger positive functional connectivity between the medial prefrontal cortex and these regions is associated with higher Proportion Utilitarian Instrumental Biases scores, and more negative scores this in metric in older adults are associated with stronger negative functional connectivity. Younger adults, however, are showing relatively little change in functional connectivity across the range of scores, with weaker functional connectivity than older adults in general. The interaction in the dorsal anterior cingulate, another major hub of the Salience Network, appears to be driven by both groups, however, the two age groups appear to show the largest differences in functional connectivity at more negative Proportion Utilitarian Instrumental Bias scores. Specifically, at lower, or more negative Proportion Utilitarian Instrumental scores, younger adults show more positive functional connectivity between the medial prefrontal cortex and the dorsal anterior cingulate than older adults.

With regard to non-Salience Network regions, younger adults appear to be driving the interaction in the left lingual gyrus, such that stronger positive functional connectivity is associated with more negative Proportion Utilitarian Instrumental Bias scores. The opposite pattern occurs in the right lingual gyrus such that older adults appear to primarily be driving the interaction by showing stronger positive functional connectivity at higher Proportion Utilitarian Instrumental Bias scores.

Finally, younger adults also appear to be driving the interaction in the Somatomotor Network region identified, such that the medial prefrontal cortex shows stronger positive connectivity with the supramarginal gyrus at more negative Proportion Utilitarian Instrumental Bias scores. Older adults show very little functional connectivity fluctuation between this region and the medial prefrontal cortex across the range of Proportion Utilitarian Instrumental Bias scores.

Table 8.
Regions demonstrating age group by Proportion Utilitarian Instrumental Bias interactions in resting-state functional connectivity with the medial prefrontal cortex

Contrast	Hemisphere	Region	BA	XYZ (MNI)	Cluster Extent	Network
YA > OA	L	Mid. Front. Gyrus	8	-40, 18, 46	133	DMN
	R	Parahippocampal Gyrus	36	34, -24, -20	68	DMN
	R	dmPFC	9	0, 44, 30	56	DMN
				2, 52, 30		
	R	Mid. Front Gyrus	10	42, 62, -8	86	FCPN
	R			30, 66, -12		
	R	Mid. Temp. Pole	38	34, 26, -40	243	Limbic
				48, 22, -32		
				42, 26, -36		
	L	Orbitofrontal Cortex	11	-6, 20, -24	60	Limbic
OA > YA	L	Sup. Temp. Pole	38	-56, 14, -6	159	SN
	L	Insula	13	-46, 12, -10		
	L	Insula	13	-40, 6, 0		
	R	dACC	32	6, 24, 30	90	SN
	R	Insula	13	40, 12, 2	173	SN
				32, 16, 6		
	L	Supramarginal Gyrus	40	-44, -32, 24	81	Somatomotor
	R	Lingual Gyrus	19	16, -54, 0	80	Visual
			18	24, -60, 2		
	L	Lingual Gyrus	18	-8, -88, -14	172	Visual

L	Calcarine Cortex	18	-10, -100, -4		
L	Lingual Gyrus	18	-16, -90, -8		
R	Cerebellum	NA	16, -54, -18	457	NA
			10, -42, -12		
			20, -46, -20		NA
L	Cerebellum	NA	-34, -90, -24	203	
			-32, -82, -22		NA
			-28, -70, -22		
R	Cerebellum	NA	12, -54, -60	255	NA
			10, -58, -40		
			6, -66, -44		
R	Pallidum	NA	14, 6, -4	113	NA

Note: The regions identified by the YA > OA contrast are regions where younger adults show stronger positive functional connectivity with the medial prefrontal cortex than older adults at higher levels of Proportion Utilitarian Instrumental Bias scores. The regions identified by the OA > YA contrast are regions where older adults show stronger positive functional connectivity with the medial prefrontal cortex than younger adults at higher levels of this score. dACC = dorsal anterior cingulate cortex; dmPFC = dorsomedial prefrontal cortex DMN = Default Mode Network; FCPN = frontoparietal control network; SN = Salience Network; OA = older adult; YA = younger adult

Proportion Utilitarian Instrumental Bias (Medial Prefrontal Cortex Seed) Summary.

Together these findings indicate that the higher Proportion Utilitarian Instrumental Bias scores in younger adults are associated with higher Default Mode Network segregation, as demonstrated by increased positive functional connectivity between the medial prefrontal cortex and other Default Mode Network regions. At similar levels of behavioral performance, however, older adults showed *reduced* segregation of the Default Mode Network via stronger positive functional connectivity between the medial prefrontal cortex and Salience Network and Frontoparietal Control Network regions.

Of the Default Mode Network regions that demonstrated Age Group by Proportion Utilitarian Instrumental Bias interactions, older adults appeared to be the primary drivers of these relationships, with stronger positive functional connectivity between these regions and the medial prefrontal cortex being associated with more negative Proportion Utilitarian Instrumental Bias scores.

Interactions between the medial prefrontal cortex and the two major hubs of the Salience Network, however, provided less consistent age-related results. Indeed, older adults again appear to be driving the interaction in the right insula, with stronger positive functional connectivity being associated with higher Proportion Utilitarian Instrumental Bias scores. In the dorsal anterior cingulate cortex, the other major hub of the Salience network, stronger positive functional connectivity was associated with higher Proportion Utilitarian Instrumental Bias scores in older adults but lower, or more negative scores in younger adults. These results suggest that reduced segregation between the Default Mode Network and the Salience Network, as indicated by increased functional connectivity between the medial prefrontal cortex and Salience Network regions, is associated with different behavioral performance in the two age groups.

Proportion Utilitarian Instrumental Bias (Posterior Cingulate Cortex Seed).

***Contrast*: *Younger Adults Proportion Utilitarian Instrumental Bias > Baseline*.** Examination of the regions that show stronger positive functional connectivity with the posterior cingulate cortex at higher Proportion Utilitarian Instrumental Bias scores in younger adults, but not older adults, included regions outside the Default Mode Network (Table 9).

Table 9.

Regions demonstrating stronger positive resting-state functional connectivity with the posterior cingulate cortex at higher levels of Proportion Utilitarian Instrumental Bias scores in younger adults

Contrast	Hemisphere	Region	BA	XYZ (MNI)	Cluster Extent	Network
YA > Baseline	R	Sup. Parietal Lobule	7	40, -50, 60	404	DAN
	R	Supramarginal Gyrus	40	54, -30, 54		
	L	dlPFC	9	-38, 20, 28	56	FCPN
	L	Inf. Temp. Gyrus	20	-54, -2, -44	147	Limbic
	L			-40, 0, -42		

L	Mid. Occipital Gyrus	18	-22, -102, -2 -28, -102, 4 -18, -94, -4	178	Visual
R	Caudate	NA	12, 16, -2 6, 14, 6	84	NA
OA > Baseline					
		No Significant Clusters			

Note: The regions identified by the YA > Baseline contrast are regions demonstrating significantly stronger positive resting state functional connectivity with the posterior cingulate cortex in younger adults, but not older adults at higher levels of Proportion Utilitarian Instrumental Bias scores. dlPFC = dorsolateral prefrontal cortex; DAN = Dorsal Attention Network; FCPN = Frontoparietal Control Network; OA = older adults; YA = younger adults.

***Contrast*: *Older Adults Proportion Utilitarian Instrumental Bias > Baseline*.** There were no significant clusters that showed stronger positive functional connectivity with the posterior cingulate cortex at higher Proportion Utilitarian Instrumental Bias scores in older adults, but not younger adults.

***Contrast: Younger Adults Proportion Utilitarian Instrumental Bias > Older Adults Proportion Utilitarian Instrumental Bias*.** There were no significant clusters identified that were functionally connected to the posterior cingulate cortex in both groups, but where younger adults showed stronger positive functional connectivity than older adults at higher Proportion Utilitarian Instrumental Bias.

***Contrast: Older Adults Proportion Utilitarian Instrumental Bias > Younger Adults Proportion Utilitarian Instrumental Bias*.** Regions functionally connected to the posterior cingulate cortex in both groups, but where older adults showed stronger positive functional connectivity than younger adults at higher Proportion Utilitarian Instrumental Bias scores include the right precuneus and the left insula (Table 10, Figure 5). Interestingly, stronger decoupling or negative functional connectivity between the posterior cingulate cortex and the left insula appears to be associated with higher Proportion Utilitarian Instrumental Bias scores in younger adults, but more negative scores in older adults. With regard to the precuneus, both older and younger adults showed positive functional connectivity between this region and the posterior cingulate. Stronger functional connectivity, however, was associated with higher Proportion Utilitarian Instrumental Scores in older adults, but more negative scores in younger adults.

Table 10.
Regions demonstrating age group by Proportion Utilitarian Instrumental Bias interactions in resting-state functional connectivity with the posterior cingulate cortex

Contrast	Hemisphere	Region	BA	XYZ (MNI)	Cluster Extent	Network
YA > OA						
			No Significant Clusters			
OA > YA						
	R	Precuneus	31	4, -44, 46	151	SN
	L	Insula	13	-40, 0, 6	180	SN
				-32, -12, 8		
				-34, 0, 12		
	R	Cerebellum	NA	18, -62, -20	122	NA
				10, -64, -12		NA

Note: The regions identified by the OA > YA contrast are regions where older adults show stronger positive functional connectivity with the posterior cingulate than younger adults at higher levels of this score. SN = Salience Network; OA = older adult; YA = younger adult

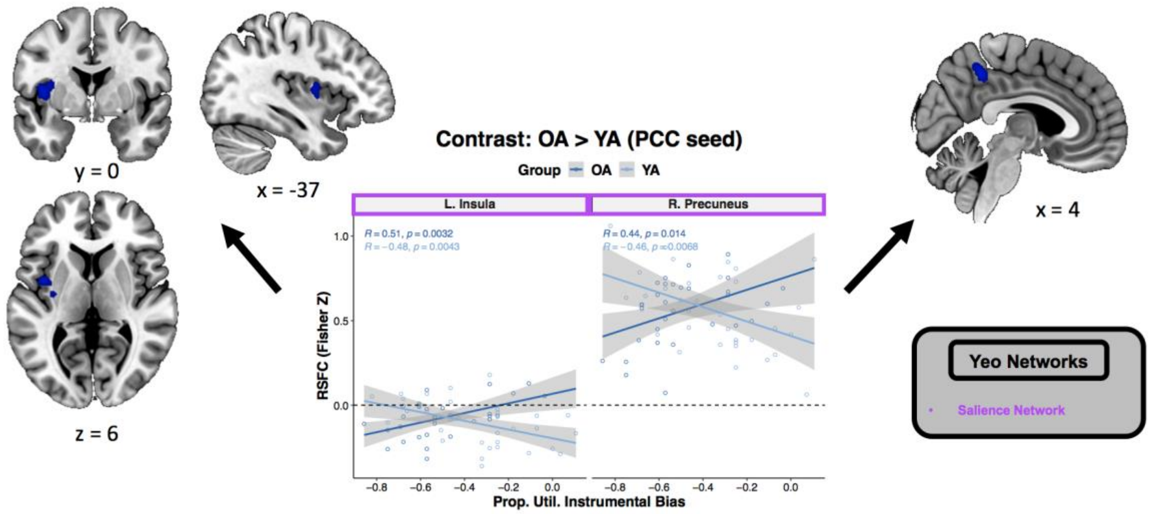

Figure 5. Reduced Salience Network coupling with the posterior cingulate cortex is associated with higher Proportion Utilitarian Instrumental bias scores in younger adults and more negative scores in older adults. The clusters and scatter plots are regions where older adults show stronger positive functional connectivity with the posterior cingulate cortex compared to younger adults at higher levels of Proportion Utilitarian Instrumental Bias. These results were masked with the results from the omnibus F-test in Figure 3. Scores are uncentered for the sake of visualization. Scores closer to 0 on the x-axis reflect reduced proportion utilitarian instrumental bias. Scores closer to -1 indicate higher endorsement of the utilitarian option during incidental dilemmas compared to instrumental dilemmas.

Proportion Utilitarian Instrumental Bias (Posterior Cingulate Cortex Seed) Summary. The primary findings from this set of analyses demonstrates that younger adults show positive functional connectivity between the posterior cingulate cortex and regions outside the Default Mode Network at higher Proportion Utilitarian Instrumental Bias scores. Of the regions common to younger and older adults, however, stronger positive functional connectivity between the posterior cingulate and Salience Network regions is associated with higher Proportion Utilitarian Instrumental Bias scores in older adults, but more negative scores in younger adults.

Digit Span Forward (Medial Prefrontal Cortex Seed).

***Contrast*: *Younger Adults Digit Span Forward > Baseline*.** Examination of the regions that show stronger positive functional connectivity with the medial prefrontal cortex at higher Digit Span Forward scores in younger adults, but not older adults, included a right calcarine cortex cluster that extended into the left middle occipital gyrus, and a right calcarine cortex cluster that extended into the right lingual gyrus (Table 11). Both of these clusters are located within the Visual Network.

***Contrast*: *Older Adults Digit Span Forward > Baseline*.** Examination of the regions that show stronger positive functional connectivity with the medial prefrontal cortex at higher Digit Span Forward scores in older adults, but not younger adults, included the right hippocampus, a Default Mode Network cluster.

Table 11

Regions demonstrating stronger positive resting state functional connectivity with the medial prefrontal cortex at higher Digit Span Forward scores in younger or older adults

Contrast	Hemispher e	Region	BA	XYZ (MNI)	Cluster Extent	Network
YA > Baseline	R	Calcarine Cortex	17	16, -94, 4	756	Visual
			17	2, -80, 4		
	L	Mid. Occipital Gyrus	18	-14, -94, 2		
	R	Calcarine Cortex	17	18, -66, 6	205	Visual
	R	Lingual Gyrus	18	14, -46, 4		
			17	16, -76, 8		
OA > Baseline						
	R	Hippocampus	NA	28, -14, -10	97	DMN
				30, -22, -6		

Note: The regions identified by the YA > Baseline contrast are regions demonstrating stronger positive resting state functional connectivity with the medial prefrontal cortex in younger adults, but not older adults at higher Digit Span Forward scores. The regions identified by the OA > Baseline contrast are regions demonstrating stronger positive resting state functional connectivity with the medial prefrontal cortex in older adults, but not younger adults, at higher Digit Span Forward scores. DMN = Default Mode Network

Contrast: Younger Adults Digit Span Forward > Older Adults Digit Span Forward. Regions functionally connected to the medial prefrontal cortex in both groups, but where younger adults showed stronger positive functional connectivity than older adults at higher Digit Span Forward scores included one ventromedial prefrontal cortex cluster and a calcarine cortex cluster (Table 12, Figure 6A). These are associated with the Default Mode Network and Visual Network respectively.

Contrast: Older Adults Digit Span Forward > Younger Adults Digit Span Forward. Regions functionally connected to the medial prefrontal cortex in both groups, but where older adults showed stronger positive functional connectivity than younger adults at higher Digit Span Forward scores included the right hippocampus, left angular gyrus, and right middle temporal pole. All of these regions are Default Mode Network regions. Of note, the strongest relationship between Digit Span Forward scores in older adults and positive functional connectivity with the medial prefrontal cortex occurred in the right hippocampus.

Digit Span Forward (Medial Prefrontal Cortex Seed) Summary. Generally, there were very few regions that showed stronger positive functional connectivity with the medial prefrontal cortex at higher Digit Span Forward scores in younger adults, but not older adults, and vice versa. Of the regions common to both groups, it appears as though better performance on Digit Span Forward was generally associated with more widespread resting-state functional connectivity between Default Mode Network regions and the medial prefrontal cortex in older adults.

Table 12.
Regions demonstrating age group by Digit Span Forward interactions in resting-state functional connectivity with the medial prefrontal cortex

Contrast	Hemisphere	Region	BA	XYZ (MNI)	Cluster Extent	Network
YA > OA	R	vmPFC	10	6, 66, -6	85	DMN
	R	Calcarine Cortex	18	14, -98, 6	664	Visual
				20, -100, 16		
				4, -78, 0		
OA > YA						
	R	Mid. Temp. Pole	38	50, 18, -38	74	DMN
				52, 20, -30		
				44, 26, -34		
	R	Hippocampus	NA	28, -14, -8	58	DMN
				32, -8, -12		
	L	Angular Gyrus	39	-38, -82, 40	58	DMN
	L	Cerebellum	NA	-28, -78, -50	65	NA

Note: The regions identified by the YA > OA contrast are regions where younger adults show stronger positive functional connectivity with the medial prefrontal cortex than older adults at higher Digit Span Forward scores. The regions identified by the OA > YA contrast are regions where older adults show stronger positive functional connectivity with the medial prefrontal cortex than younger adults at higher levels of this score. DMN = Default Mode Network; OA = older adult; vmPFC = ventromedial prefrontal cortex; YA = younger adult

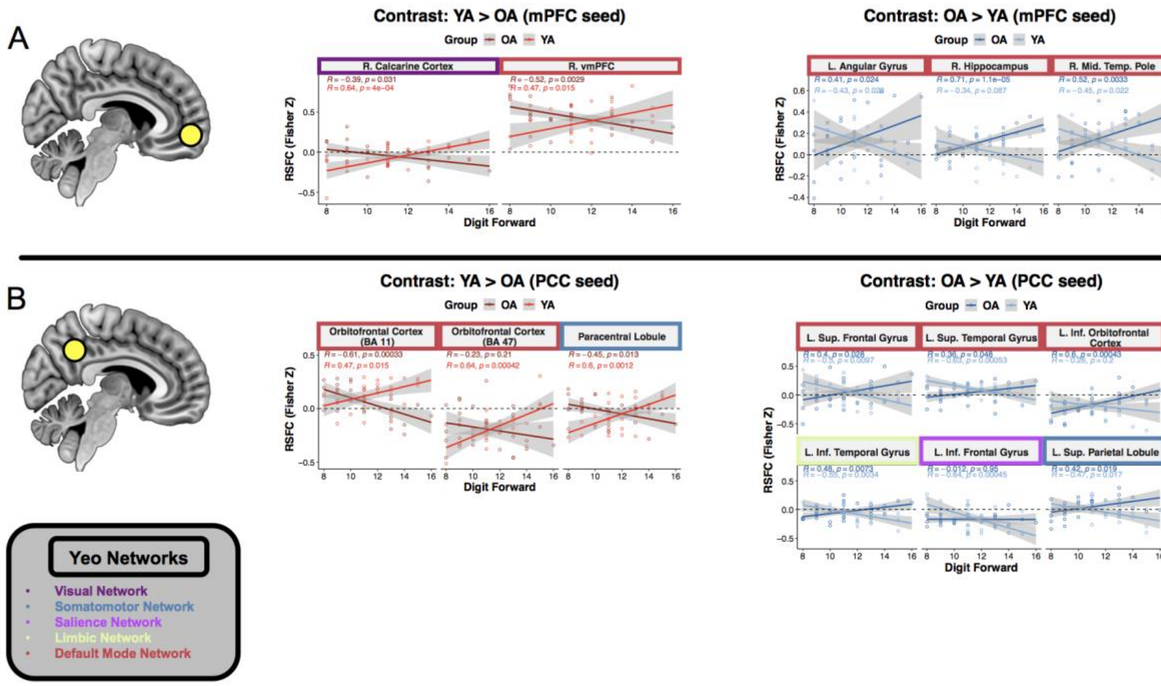

Figure 6. Widespread within Default Mode Network positive resting-state functional connectivity is associated with better Digit Span Forward performance in older adults. The red clusters and scatter plots are regions where younger adults show stronger positive functional connectivity with the specified seed region in each panel compared to older adults at higher Digit Span Forward scores. The blue clusters and associated plots are regions where older adults show stronger positive functional connectivity with each seed region compared to younger adults at higher Digit Span Forward scores. A) Medial prefrontal cortex seed analyses; B) Posterior cingulate cortex seed analyses.

Digit Span Forward (Posterior Cingulate Cortex Seed).

***Contrast*: *Younger Adults Digit Span Forward > Baseline*.** Examination of the regions that show stronger positive functional connectivity with the posterior cingulate cortex at higher Digit Span Forward scores in younger adults, but not older adults, included a left middle frontal gyrus cluster located within the Default Mode Network, and a left supplementary motor area cluster and a right precentral gyrus cluster (Table 13). Both of these latter regions are associated with the Somatomotor Network.

Contrast: Older Adults Digit Span Forward > Baseline. Examination of the regions that show stronger positive functional connectivity with the posterior cingulate cortex at higher Digit Span Forward scores in older, but not younger adults included the left inferior orbitofrontal cortex, a Default Mode Network Region, and the left fusiform (BA 37), a Visual Network Region. There were also several cerebellum clusters identified.

Table 13.
Regions demonstrating stronger positive resting-state functional connectivity with the posterior cingulate cortex at higher Digit Span Forward scores in younger or older adults

Contrast	Hemisphere	Region	BA	XYZ (MNI)	Cluster Extent	Network
YA > Baseline	L	Middle Frontal Gyrus	8	-24, 36, 54	141	DMN
	L	Supplementary Motor Area	6	-12, -26, 64	143	Somatomotor
	R	Precentral Gyrus	6	16, -18, 62	226	Somatomotor
		Supplementary Motor Area		12, -24, 66		
		Supplementary Motor Area		0, -32, 66		
OA > Baseline	L	Inferior Orbitofrontal Cortex	47	-54, 38, -8	71	DMN
				-56, 34, 2		
	L	Fusiform	37	-32, -68, -8	79	Visual
	R	Cerebellum	NA	34, -42, -52	163	NA
	L	Cerebellum	NA	-40, -54, -26	60	NA
	L			-40, -42, -30		
	R	Cerebellum	NA	52, -50, -34	211	NA
				44, -54, -28		
				40, -48, -32		
	L	Cerebellum	NA	-22, -78, -44	82	NA
	L	Cerebellum		-34, -72, -34		

Note: The regions identified by the YA > Baseline contrast are regions demonstrating stronger positive resting state functional connectivity with the posterior cingulate cortex in younger adults, but not older adults at higher Digit Span Forward scores. The regions identified by the OA > Baseline contrast are regions demonstrating stronger positive resting state functional connectivity with the posterior cingulate cortex in older adults, but not younger adults, at higher Digit Span Forward scores. DMN = Default Mode Network

Contrast: Younger Adults Digit Span Forward > Older Adults Digit Span Forward.

Regions functionally connected to the posterior cingulate cortex in both groups, but where younger adults showed stronger positive functional connectivity than older adults at higher Digit Span Forward scores included two orbitofrontal cortex clusters (Table 14, Figure 6B). Both of these regions are associated with the Default Mode Network. A paracentral lobule cluster, typically associated with the Somatomotor Network, was also identified.

Contrast: Older Adults Digit Span Forward > Younger Adults Digit Span Forward.

Regions functionally connected to the posterior cingulate cortex in both groups, but where older adults showed stronger positive functional connectivity than younger adults at higher Digit Span Forward scores included three Default Mode Network regions, the left superior frontal gyrus, the left superior temporal gyrus, and the left inferior orbitofrontal cortex (Table 14, Figure 6B). Several regions outside of the Default Mode Network were identified including the left inferior temporal gyrus (Limbic Network), left inferior frontal gyrus (Salience Network), and left superior parietal lobule (Somatomotor Network). Again, one cerebellum cluster was also identified.

Table 14.

Regions demonstrating age group by Digit Span Forward interactions in resting-state functional connectivity with the posterior cingulate cortex

Contrast	Hemisphere	Region	BA	XYZ (MNI)	Cluster Extent	Network
YA > OA	L	Orbitofrontal Cortex	11	-10, 32, -14	254	DMN
	R	ACC	32	6, 30, -6		

	L	Orbitofrontal Cortex	47	-34, 38, -8	59	DMN
	L			-24, 38, -8		
	L	Paracentral Lobule	4	-12, -26, 64	613	Somatomotor
				10, -26, 68		
	R	Supplementary Motor Area	6	10, -20, 58		
OA > YA						
	L	Superior Frontal Gyrus	10	-30, 60, 24	73	DMN
	L	Superior Temporal Gyrus	22	-52, -4, -12	96	DMN
		Middle Temporal Gyrus	21	-66, -14, -12		
	L	Inferior Orbitofrontal Cortex	47	-54, 36, -8	56	DMN
			47	-54, 34, 0		
	L	Inferior Temporal Gyrus	20	-52, -4, -44	222	Limbic
	L	Temporal Pole	38	-38, 0, -40		
				-36, 8, -46		
	L	Inferior Frontal Gyrus	44	-50, 12, 0	111	SN
	L	Inferior Orbitofrontal Cortex	44	-46, 6, 4		
	L	Superior Parietal Lobule	7	-30, -50, 60	60	Somatomotor
	R	Cerebellum	NA	32, -46, -48	365	NA
				40, -46, -32		

Note: The regions identified by the YA > OA contrast are regions where younger adults show stronger positive functional connectivity with the posterior cingulate cortex than older adults at higher Digit Span Forward scores. The regions identified by the OA > YA contrast are regions where older adults show stronger positive functional connectivity with the posterior cingulate cortex than younger adults at higher levels of this score. ACC = anterior cingulate cortex; DMN = Default Mode Network; OA = older adult; SN = Salience Network; YA = younger adult

Digit Span Forward (Posterior Cingulate Cortex Seed) Summary. Overall, the posterior cingulate cortex primarily showed stronger positive functional connectivity with other Default Mode Network regions at higher Digit Span Forward scores. In younger adults, higher Digit Span Forward scores were primarily associated with long-range functional connections between the posterior cingulate cortex and frontal Default Mode Network regions. In older adults, these functional connections with the posterior cingulate cortex were primarily associated with lateral temporal and frontal Default Mode Network regions. Also, somewhat surprisingly reduced segregation of the posterior cingulate cortex from regions outside the Default Mode Network was also associated with better Digit Span Forward performance in older adults, and poorer performance in younger adults.

1.5 Discussion

The findings from this study provide three key insights with regard to the relationship between aging and sacrificial moral decision-making. First, younger and older adults who have similar working memory capacity may only differ in their tendency to endorse the Utilitarian response during Instrumental moral dilemmas, or dilemmas where participants have to decide whether to cause direct harm to another person in order to save several others. Second, gray matter volume of the core nodes of the Default Mode Network do not appear to be associated with either working memory capacity or moral decision-making in older or younger adults. And finally, although increased resting-state functional connectivity between regions within the Default Mode Network was generally associated with increased working memory performance in both younger and old adults, reduced segregation of this network, via increased coupling primarily with Salience Network regions, was associated with a reduced bias to indicate the utilitarian response during Incidental compared to Instrumental dilemmas in older adults, but an increased bias in younger adults. Put another way, the functional segregation of the Default Mode Network was associated with *similar* working memory capacity outcomes in younger and older adults, but desegregation of this network was associated with *different* moral decision-making outcomes in these groups.

In the absence of working memory differences older adults provide fewer utilitarian responses to Instrumental dilemmas than younger adults.

With regard to behavioral performance, the present findings importantly highlight that even when younger and older adults have similar working memory performance on average, older adults continue to make fewer utilitarian decisions during Instrumental dilemmas than younger adults. Indeed this finding diverges from McNair et al. (2019), who found that older adults endorsed fewer utilitarian decisions across both Incidental and Instrumental dilemmas, using a subset of the dilemmas presented in the current study. Critically, however, they did not collect any measures assessing fluid cognitive abilities, rendering it difficult to determine whether their findings are indeed associated with age-related declines in cognitive ability. Also, the stimuli used in the current study included all trials normed by Lotto et al. (2014), as compared to McNair et al. (2019) who used the sub-set of trials that typically receive the most varied responses from participants. Although one possible critique is that age-related effects may have been diminished in the present study due to the inclusion of these additional trials, if older adults make decisions to sacrificial moral dilemmas primarily based upon heuristics or stored knowledge (Spreng & Turner, 2021), rather than taking aspects of the dilemma into account, it would be expected that older adults should still refrain from endorsing the utilitarian option even in these less controversial dilemmas. However, even in the absence of a main effect of Age Group in the present study, the age-related differences during Instrumental dilemmas point to consistency with other work in this area.

S. Huang et al. (2021), also found that older adults were less likely to engage the utilitarian response during sacrificial moral dilemmas. As they highlight, this effect was primarily observed during the presentation of Deontological Intuitive dilemmas, which parallel the Instrumental dilemmas presented in the current study, as well as those presented by McNair et al., (2019). Unlike McNair et al. (2019), S. Huang et al. (2021) did collect a battery of cognitive testing, highlighting that the older adults included in their study did indeed have poorer fluid cognitive abilities than the younger adult participants. Despite these age-related differences in cognitive profile, however, given that S. Huang et al. (2021) utilized Deontological Intuitive dilemmas that were similar to Instrumental dilemmas, but not Incidental dilemmas, yet again, it is unclear how age-related differences in cognitive profile relate to the range of moral dilemmas typically observed in the literature.

The findings from the present study, although not providing insight into age-related *differences* in cognitive profile, demonstrate that younger and older adults who have *similar* working memory capacity on average, demonstrate different decisions specifically during Instrumental, but not Incidental dilemmas. Although the present study could not have predicted that the sample would have age-invariant working memory capacity, these moral decision findings provide important insights to complement the findings from the few studies in this nascent sub-literature.

The finding that older adults were less likely than younger adults to indicate the utilitarian response specifically during Instrumental dilemmas, despite age-invariant working memory performance, points to the possibility of a mechanistic explanation beyond age-related cognitive declines. These moral decision-making differences may be due to age-related motivation shifts to reduce interpersonal conflict via direct harm to others. This is in contrast to dual-process theories that would point to age differences during these dilemmas as potentially reflecting poorer cognitive control over emotions during these more emotionally salient dilemmas (Greene et al., 2004). Although speculative, looking beyond age-related cognitive decline, a possible mechanistic explanation for these age-related differences may be found in the emotion regulation literature.

As older adulthood is marked by an increased tendency to prioritize emotional regulatory goals (Carstensen et al., 2003), it is possible that avoidance of Instrumental but not Incidental harm may be associated with attempts to reduce direct, although hypothetical, interpersonal conflict in older adults. The present paradigm is defined along utilitarian versus non-utilitarian outcomes, but another way to consider these findings is in the context of the literature demonstrating these age differences in socioemotional regulatory goals. Older adults often attempt to engage in emotional regulation strategies that increase positive affective experiences (Livingstone & Isaacowitz, 2021), rather than strategies to reduce negative affective experiences. These latter approaches often reflect avoidance-type strategies such as situation selection. In the context of interpersonal conflict, however, older adults are more likely to engage in these avoidance strategies to a greater extent than younger adults, which may be more effective in producing positive interpersonal outcomes (Blanchard-Fields, 2007).

As highlighted by both S. Huang et al. (2021) and McNair et al. (2019), these hypothetical sacrificial moral dilemmas only allow for negative interpersonal consequences. It may be the case that older adults in an attempt to minimize interpersonal conflict avoid causing direct harm to the individual by engaging in the non-utilitarian decision. Relatedly, older adulthood is marked by reduced social network size (Bruine de Bruin et al., 2020; Cornwell et al., 2008), but this reduction is often a result of selective pruning (English & Carstensen, 2014). Older adults are more interested in maintaining emotionally meaningful social circles, whereas younger adults tend to maintain larger circles, with more peripheral connections (Lang & Carstensen, 2002). As a result, it is possible that older and younger adults are simply approaching this task with different social and emotional goal states in mind. That is, younger adults may be more interested in maximizing the number of individuals that they are reducing harm for, regardless of dilemma type, whereas, the problem type may be associated with separable approaches for older adults. In the context of causing direct harm, in order to maximize interpersonal emotional goals, older adults may view refraining from the utilitarian decision as the more viable way to achieve these goals. Of course, this discussion on socioemotional motivations is speculative, but it highlights an important idea that in the absence of age-related cognitive decline, differences in moral decision-making may not reflect a desire to maintain deontological ethical approaches by older adults, but rather differences in social and emotional motivational goal states. Future work should design paradigms to probe these motivational approaches as possible mechanisms for age-related differences in sacrificial moral decision-making.

Older adults also rated utilitarian options during the Self dilemmas as less morally acceptable than the Other dilemmas.

The finding that older adults rated proposed utilitarian decisions as less acceptable during dilemmas in the Self condition than the Other condition also diverges from previous research. McNair et al. 2019 did not find any significant differences between these conditions. As we have argued elsewhere (Daley & Kensinger, 2021), age-related interactions with self-relevance during moral decision-making might be consistent age-related increases in older adult tendency reduce self-related biases compared to younger adults (Sui & Humphreys, 2017). In this case, rating the utilitarian behavior in the Other condition as more morally acceptable than the Self condition, may simply reflect this reduction in self bias in older adults. This bias may reflect some form of generative concern, or a desire to set up future generations for success in older compared to younger adults (Erikson et al., 1989; Lodi-Smith et al., 2021; Schoklitsch & Baumann, 2012). One limitation with this speculation is that older adults, but not younger adults, demonstrated significant differences between these conditions. Future work would need to replicate this finding in a larger sample, in order to consider this claim. Also, the present study did not ask participants to compare the relative acceptability of the Self and Other conditions, further complicating claims about an Other bias for moral acceptability ratings in older adults. Given that this effect was not present in previous literature, and that we did not have hypotheses related to Default Mode Network structure and function along Self-Other distinctions, brain-behavior relationships for acceptability ratings will not be discussed further.

Gray matter volume and resting-state functional connectivity between the core nodes of the Default Mode Network do not predict working memory or moral decision-making in younger or older adults.

The gray matter volume of the medial prefrontal cortex and posterior cingulate, core nodes of the Default Mode Network, were significantly larger in younger adults compared to older adults. This finding is consistent with previous work demonstrating significant age-related atrophy of regions identified within this network (Fjell et al., 2014). Relatedly, younger adults demonstrated significantly stronger resting-state functional connectivity between these two hubs of the Default Mode Network compared to older adults. Again, this finding is consistent with previous work demonstrating age-related degradation of long-range functional connections of these core hubs (Sala-Llonch et al., 2015). Despite these consistent findings with previous literature, the gray matter structure and resting-state functional connectivity between these two hubs of the Default Mode Network were not significant predictors of working memory capacity or moral decision-making, subsequently failing to provide support for any of the hypotheses related to Aim 1 or 2.

It may be the case that age-related changes to gray matter volume or resting-state functional connectivity between the core hubs of this network are not important for performance on these tasks. With regard to gray matter structure, it may be the case that gray matter volume is not the appropriate metric by which to examine relationships with performance on these tasks. For example, fractal dimensionality, a method that is sensitive to the shape of a given region in addition to volume (Madan, 2021; Madan & Kensinger, 2016), may be a better measure of age-related brain-behavior relationships in relation to these tasks than gray matter volume alone. Also, although age-related reduction in the functional segregation of the Default Mode Network is associated with both working memory and moral decision-making outcomes (S. Huang et al., 2021; Sambataro et al., 2010), it may be the case that the gray matter changes of less prominent Default Mode Network regions, or regions identified in externally oriented networks, such as the dorsolateral prefrontal cortex, may be important for performance on these tasks. As indicated in the next section, despite the observed long-range reductions in functional connectivity between the medial prefrontal cortex and posterior cingulate cortex, in the present sample, it may be the case that specific resting-state functional connections between these two hubs are not important for performance on these tasks.

Segregation Default Mode Network appears to be differentially related to moral decision-making and working memory capacity in older but not younger adults.

The seed-to-voxel whole-brain resting-state functional connectivity analyses generally provide support for Hypothesis 3b. Segregation of the Default Mode Network as indicated by increased within-network and reduced between-network resting-state functional connectivity was associated with better working memory capacity in both groups, but differential moral decision-making outcomes in these groups. Specifically, increased functional connectivity between the core hubs of the Default Mode Network and Salience Network regions was associated with a reduced Proportion Utilitarian Instrumental Bias in older adults. Older adults who performed more similarly to younger adults on the moral decision-making task, by being equally likely to indicate the utilitarian option during Instrumental and Incidental dilemmas, had *stronger* Default Mode Network to Salience Network coupling. These findings are generally consistent with the working memory literature, but provide novel insights into the moral decision-making literature.

Age-related decreases in functional segregation of the Default Mode Network are typically associated with poorer working memory capacity (Keller et al., 2015; Sambataro et al., 2010). The present study similarly demonstrated that increased functional segregation of this network was generally associated with better working memory performance in both groups. It should be noted that younger adults also demonstrated resting-state functional connectivity between the medial prefrontal cortex and Visual Network regions at higher levels of working memory capacity. Given that older and younger adults performed similarly on this task, it may be the case that reduced segregation of the Default Mode Network from Visual Network regions, along with more network-wide increases of within-network connectivity in the older adult participants contributed to these age-invariant behavioral findings.

Previous work examining how age-related differences in moral decision-making during dilemmas akin to Instrumental dilemmas, revealed that older adult tendency to refrain from the utilitarian option was associated with reduced segregation of the Default Mode Network from the rest of the brain, and increased coupling with the Dorsal Attention Network (S. Huang et al., 2021). Findings from the present study demonstrate the opposite relationship with age, such that increased segregation of Default Mode Network was associated with a stronger bias toward indicating the Utilitarian option for Incidental, but not Instrumental dilemmas, in older adults, but relatively little difference between conditions for younger adults. Moreover, increased resting-state functional connectivity between the Default Mode Network and the Salience Network in older adults was associated with moral decision-making behavior more similar to younger adults. This Default Mode Network to Salience Network coupling in relation to moral decision-making is not unprecedented. Chiong et al. (2013) found that compared to individuals with behavioral variant frontotemporal dementia, cognitively healthy older adults tend to demonstrate stronger Default Mode Network interactions with the Salience Network during moral reasoning about Instrumental dilemmas (Chiong et al., 2013). Although this previous finding does not reflect resting-state functional connectivity interactions, it does implicate interactions between these two networks in relation to moral decision-making in healthy older adults.

Although the present findings may at first appear to contradict the findings from S. Huang et al., (2021), they may actually provide complementary accounts of how age differences in moral decision-making relate to the intrinsic function of the Default Mode Network. S. Huang et al. (2021) demonstrated these age-related differences in a sample of younger and older adults who had significantly different fluid cognitive abilities. The age-invariant working memory performance in the present study sample suggests that the age-related comparisons examining the relationship between moral decision-making and Default Mode Network resting-state functional connectivity, may actually reflect relationships that are less impacted by fluid cognitive abilities than in previous work. Due to concerns related to power, however, we did not examine three-way interactions between age, moral decision-making and working memory capacity in relation to resting-state functional connectivity in the whole-brain analyses. In order to make stronger claims about these relationships future work should seek to model these variables together with larger samples.

Comparing the age-related moral decision-making and working memory relationships with resting-state functional connectivity within the present study, indicates that although Default Mode Network segregation may be important for working memory capacity across the lifespan, the benefits of this network remaining decoupled from other networks may not generalize to the moral domain. Given that older adults who performed *less* similarly younger adults on the moral decision-making task showed reduced Default Mode Network to Salience Network coupling compared to older adults who performed *more* similarly to younger adults, it is possible that age-related differences in moral decision-making may actually be associated with motivational changes (Daley & Kensinger, 2021), as opposed to declines in cognitive control and associated functional networks. If working memory performance and moral decision-making were similarly impacted by intrinsic Default Mode Network function, reduced segregation of this network should be associated with both poorer working memory performance and a stronger bias toward indicating yes for Incidental dilemmas compared to Instrumental dilemmas in both groups. Given that reduced segregation in older adults was actually associated with a *reduced* bias in moral decision-making, this pattern of results may reflect adaptive network changes in older adults. This would be consistent with recent theories suggesting that age-related changes to Default Mode Network function may actually be adaptive depending upon the task being examined (Andrews-Hanna et al., 2019; Spreng & Turner, 2019, 2021). However, this perspective assumes that age-related differences in moral decision-making during sacrificial moral dilemmas are due to some form of age-related decline in cognitive ability and the associated functional networks. Given the possibility of different age-related socioemotional motivational approaches to these dilemmas as highlighted above, it is possible that refraining from the utilitarian option during the Instrumental dilemmas to a greater extent than Incidental dilemmas actually reflects healthy cognitive functioning in older adults. Based upon the findings from the present study, however as well as the rest of the literature, this still remains an open question.

Finally, although the findings of the present study importantly demonstrate age-related differences in moral decision-making and its relation to large scale networks even in the absence of working memory differences, future work should seek to develop moral decision-making tasks that modulate cognitive control difficulty in order to engage a moral decision. Using such a task would provide insight as to whether the cognitive control abilities required to complete morally-neutral tasks are actually necessary in the moral domain. Indeed previous work has used divided attention designs to reduce cognitive control resources during Instrumental dilemmas (Greene et al., 2008). One concern with this approach is that it provides a better measure of task-switching efficiency, rather than testing moral decision-making ability. Using a paradigm that modulates the difficulty of a unitary task may provide greater insight into these age-related brain-behavior relationships.

Limitations

The largest limitation of the present study is the sample size. The current study sample is not small by typical standards for fMRI research examining univariate relationships. Recent debate, however, estimates hundreds to thousands of participants may be necessary to obtain reproducible effects in studies examining how individual differences in brain structure or resting-state functional connectivity relate to behavior (Cecchetti & Handjaras, 2022; Marek et al., 2022). This debate raises concerns about the null results associated with Aim 1 and 2 in the present study. It is possible that the sample in the current study did not allow for the appropriate power to detect relationships between gray matter structure or resting-state functional connectivity between the medial prefrontal cortex and posterior cingulate in relation to working memory capacity or moral decision-making. Relatedly, these power concerns raise the possibility that the findings in Aim 3 simply reflect noise. This concern is somewhat mitigated given that the Aim 3 findings are generally consistent with previous research examining brain-behavior relationships with regard to both working memory performance and moral decision-making. Also, given that the present study maintained specific hypotheses related to these brain-behavior relationships, this helps to reduce some of these sample-related concerns. One possible way to avoid these concerns in future work involves the examination of brain activity *during* the moral decision-making task in older and younger adults. This could provide insight as to whether older and younger adults are engaging similar neural processes when making moral decisions, while simultaneously avoiding power concerns associated with the brain metrics used in the current study.

Another possible limitation is that the decision to engage or not engage in the utilitarian option was presented on the same screen as the proposed resolution. This deviates from methods employed by previous studies. This methodological approach was intentional, as it was intended to reduce possible working memory confounds induced by the task. However, by taking this approach, the task may have diminished age-related effects previously observed by McNair et al. (2019).

Relatedly, the use of one working memory task, although helpful for modeling working memory relationships with resting-state functional connectivity may not be sufficient to determine age-related working memory abilities. This raises the possibility that the working memory task employed in the current study was not difficult or sensitive enough to observe age-related differences. Despite these concerns however, ceiling effects on this task were not observed in either group. This points to the possibility that this task was not too easy for participants. Future work should examine more cognitive testing to determine how broader age-related cognitive profiles relate to moral decision-making performance.

Finally, the investigation of the present brain-behavior relationships provide insight into how working memory and moral decision-making relate to the intrinsic function of the Default Mode Network, but it remains unclear if or how younger and older adults differ in their recruitment of this network during actual moral decision-making. Indeed, activity within this network is observed during moral decision-making in younger adults (Greene & Young, 2020) and older adults (Chiong et al., 2013) separately, but direct age comparisons have yet to be examined in the literature.

Conclusion

The present study extended previous findings related to aging and moral decision-making research by demonstrating that older adults endorse fewer utilitarian moral decisions during Instrumental dilemmas, even when they do not differ in working memory from their younger counterparts. Stronger working memory capacity in both groups was associated with increased resting-state functional connectivity within the Default Mode Network. And finally, older adults who performed more similarly to younger adults with regard to sacrificial moral decision-making, also demonstrated increased Default Mode Network to Salience Network resting-state functional connectivity. These findings suggest that mechanisms beyond cognitive and neural decline may account for age-related differences in sacrificial moral decision-making.

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2.0 MORAL DECISION-MAKING DURING THE COVID-19 PANDEMIC: ASSOCIATIONS WITH AGE, NEGATIVE AFFECT, AND NEGATIVE MEMORY

2.1 Abstract

The COVID-19 pandemic provided the opportunity to determine whether age-related differences in utilitarian moral decision-making during sacrificial moral dilemmas extend to non-sacrificial dilemmas in real-world settings. As affect and emotional memory are associated with moral and prosocial behaviors, we also sought to understand how these were associated with moral behaviors during the 2020 spring phase of the COVID-19 pandemic in the United States. Older age, higher negative affect, and greater reports of reflecting on negative aspects of the pandemic were associated with higher reported purchase of hard to find goods, while older age and higher negative affect alone were associated with higher reported purchase of hard to find medical supplies. Older age was associated with what appeared at first to be non-utilitarian moral behaviors with regard to the purchasing of these supplies. However they also reported distributing these goods to family members rather than engaging in hoarding behaviors. These findings suggest that advancing age may be associated with engagement in utilitarian moral decision-making in real-world settings more than the sacrificial moral decision-making literature would suggest.

2.2 Introduction

The COVID-19 pandemic provided the opportunity to observe utilitarian moral decision-making analogous to the Trolley Problem (Foot, 1967) in real world settings. During the Trolley Problem, a trolley is speeding down the track toward five people and the individual faced with the dilemma has the option to push a switch that would divert the trolley onto another track. Unfortunately, there is one other person on the diverted track. As a result, the individual faced with the dilemma has to choose whether to press a switch, subsequently sacrificing one person to save five others, or refrain from action, allowing the five to be sacrificed. Pushing the switch during this dilemma is referred to as the utilitarian response. Utilitarian ethics are based in consequentialism, such that the morality of a behavior is judged by its outcome, or how well it maximizes good for the greatest number of people (Mill, 1895). Sacrificing one person to save many others, in the case of the Trolley Problem reflects utilitarian response because "goodness" is maximized for five people, albeit at the expense of one other person.

Older adults engage in non-utilitarian decision-making during sacrificial moral dilemmas to a greater extent than younger adults and this is partially accounted for by their experience of greater negative affect in response to the dilemmas (McNair et al., 2019). Interestingly, older adults make these non-utilitarian decisions in the case of the Trolley Problem, as well as the more emotional Footbridge Dilemma. In the Footbridge Dilemma the individual decides whether to physically push one person off a bridge in front of a trolley to save five others, or refrain from doing so (Thomson, 1986). This age-related finding suggests that even during the less emotionally salient dilemmas (i.e. the Trolley Problem) older adults will still refrain from the utilitarian option. Further support for this finding highlights that age-related differences in utilitarian moral decision-making occurs primarily when the non-utilitarian option is "intuitive" or immediately compelling as compared to the utilitarian option, as in the case of the Trolley Problem and Footbridge Dilemma (S. Huang et al., 2021).

Extensions of these hypothetical moral dilemmas were also examined in the context of the COVID-19 pandemic. K. Huang et al. (2021) presented adults across the lifespan with a hypothetical sacrificial moral dilemma related to the allocation of scarce resources (i.e. ventilators) during the COVID-19 pandemic. Without any experimental intervention, middle-aged and older adults were more likely to engage in non-utilitarian decision-making compared to younger adults. These findings extend age-related differences in utilitarian decision-making beyond older adulthood into middle age, suggesting that the utilitarian response to sacrificial moral dilemmas, although common in younger adults, may not generalize with advancing age.

During the spring 2020 phase of the COVID-19 pandemic in the United States, citizens were exposed to widespread news coverage highlighting the shortage of hard to find goods (e.g. toilet paper) and medical supplies (e.g. masks), as well as reported hoarding of these materials. This scenario implicitly provided U.S. citizens, across the adult lifespan, with a moral dilemma analogous to the Trolley Problem; they could either engage in utilitarian behavior, by refraining from purchasing extra amounts of these goods (i.e., allowing many others to access these materials), or they could engage in the non-utilitarian behavior by purchasing extra amounts of these goods for themselves (i.e., contributing to the shortage at the expense of the broader community). This scenario provided the unique opportunity to examine age-related differences in utilitarian moral decision-making beyond hypothetical dilemmas.

One critique of sacrificial moral dilemmas involves their generalizability to real-life decision-making (Bauman et al., 2014). Indeed the COVID-19 pandemic has placed many healthcare professionals in these exact scenarios in relation to hospital resources (Savulescu et al., 2020; Supady et al., 2021), however most adults will not find themselves making decisions with immediate life-or-death consequences. Although K. Huang et al. (2021) importantly highlight age-related differences in tendencies toward utilitarian decision-making during hypothetical scenarios that involve COVID-19 resource allocation, and potential ways to mitigate non-utilitarian behaviors, it remains unclear how age relates to *non-hypothetical* decision-making behavior that has moral implications during the COVID-19 pandemic.

During the spring 2020 phase of the COVID-19 pandemic in the United States, we asked participants to report on two such behaviors: purchasing extra amounts of hard to find goods (e.g., toilet paper) and hard to find medical supplies (e.g., masks). Our first aim was to understand how age relates to utilitarian decision-making for each of these behaviors (Preregistration: https://osf.io/rgx6b). Given previous work demonstrating that older and middle-aged adults engage in fewer utilitarian decisions than younger adults during hypothetical sacrificial moral dilemmas (K. Huang et al., 2021; S. Huang et al., 2021; McNair et al., 2019), we hypothesized that advancing age would be associated with the endorsement of non-utilitarian decisions for these real-world moral dilemmas. Further, increasing age is one factor associated with "high-risk" groups during the COVID-19 pandemic (Yanez et al., 2020), raising the possibility that it could be associated with self-preservation through the engagement of non-utilitarian decisions with regard to purchasing hard to find goods and medical supplies. This finding would be consistent with the findings from K. Huang et al. (2021), but extend age-related differences beyond the hypothetical domain. We distinguished this outcome from an alternate possibility, that advancing age would be associated with the endorsement of *more* utilitarian decisions for moral dilemmas during the COVID-19 pandemic (i.e. refraining from purchasing extra amounts of hard to find goods and medical supplies). This finding could potentially be explained by the idea that during non-lethal moral dilemmas in real-life settings the utilitarian option becomes viable in light of the middle to late life motivational shifts that are associated with increased generativity or the desire to set the stage for following generations (Daley & Kensinger, 2021; Erikson, 1950; Schoklitsch & Baumann, 2012).

Our second aim was to understand how individual differences in positive and negative affect across the adult lifespan relate to moral decision-making in these real-world dilemmas. Our prior studies revealed that older adults reported higher positive affect, and lower negative affect, during this early phase of the COVID-19 pandemic (Cunningham, Fields, Garcia, et al., 2021; Rodriguez-Seijas et al., 2020). Relatedly, some research suggests that positive mood inductions are associated with non-utilitarian decision-making during moral dilemmas (Strohminger et al., 2011; but see: Valdesolo & DeSteno, 2006); this could suggest that the positive affective experience associated with advancing age in the current sample would push participants toward non-utilitarian decisions (Daley & Kensinger, 2021). Yet other work demonstrates that higher subjective negative affect primarily accounts for older adult's non-utilitarian decisions during hypothetical moral dilemmas (McNair et al., 2019). Thus, alternatively, there could be an effect of negative affect on decisions or an age-by-affect interaction.

Our third aim involved determining how individual differences in emotional *memories* for the spring phase of the COVID-19 pandemic relate to moral decision-making in real world dilemmas (Preregistration addendum DOI: https://osf.io/w5c8j). Previous work links the recall of positive memories of helping behaviors during a negative public event with increased likelihood to engage in prosocial behaviors (Ford, Gaesser, et al., 2018). Similarly, higher vividness of episodic simulation for engaging in imagined harms was associated with the increased likelihood of committing actual harms in the future (Morris et al., 2022). As memory and episodic simulation contain overlapping cognitive and neural mechanisms (Schacter & Addis, 2020), together, these findings point to differential outcomes of emotional valence during episodic processes on subsequent moral decisions.

Given the aforementioned role of emotion in moral decision-making, along with recent examination of the connection between memory and moral decision-making (Stanley et al., 2021), another possibility arises, in that emotional memories from the COVID-19 pandemic may also be related to the behaviors endorsed during the dilemmas outlined in the present study. When considering the purchase of scarce goods and medical supplies, we hypothesized that individuals who reported recalling the community working together would show less purchasing of such supplies, while individuals who reported recalling more fears of illness spreading would show more purchasing of such supplies. Also recent work with individuals who have medial temporal lobe damage highlights the importance of episodic cognitive processes in moral decision-making (McCormick et al., 2016; Verfaellie et al., 2021). Given the well observed memory impairments observed with advancing age, we also explored whether the nature of this memory-behavior relation differed with age.

Finally, rather than only relying on behaviors engaged in relation to these dilemmas to determine whether they are (non)utilitarian, it is possible to gain insight into their outcomes by probing the motivations for choosing to engage or not engage in these behaviors. There is some critique of this approach during hypothetical moral dilemmas, suggesting that post-hoc descriptions of moral reasoning may not reflect reasoning prior to making a particular decision, but rather, rationalization after fast-acting affective responses (Haidt, 2001; but see: Pizarro & Bloom, 2003). The current assessments asked about behaviors that took place over relatively long periods of time, allowing for the possibility that consciously-accessible motivations guided behavior. For example, in laboratory settings, participants are often asked to respond to dilemmas as soon as they read them, leading to the possibility that fast-acting emotional responses may influence decision-making behavior in the same moment. Although learning about material shortages in the news may lead to initial emotional responses, people may also have had the opportunity to deliberate over their decision to purchase these goods over longer durations of time (i.e. minutes, hours, days). As such, reported motivations for purchasing these materials (or refraining from doing so), likely does not reflect the theorized fast-acting emotional responses as influencing (non)utilitarian decision-making in the laboratory.

Characterizing what participants believe their behavioral motivations were during post-hoc motivation reporting may provide insight into whether a behavior actually had (non)utilitarian outcomes. It is important to note that although antecedent intentions are not important for judging whether behaviors are utilitarian in nature (as judging the morality of these behaviors is based solely on outcomes), purchasing these hard to find goods or medical supplies is just one step of the behavior. Knowledge of the ultimate use of the items may allow for greater insight into these decisions. For example, if an individual is purchasing these goods and medical supplies in order to distribute them to others, this act could be viewed as more utilitarian than purchasing these goods simply to hoard for personal use. Without the knowledge of these motivations, it would be difficult to determine whether a behavior is utilitarian with regard to the questions in the current study. Given the exploratory nature of this last aim, we did not provide hypotheses beyond the possibility that older adults would explain their actions via a more prosocial and utilitarian lens, regardless of their decision. Again, this would potentially be explained by their motivation toward generativity.

2.3 Methods

Participants

Our final study sample included *N* = 507 participants (Female = 419; Table 1), whose ages ranged from 18 to 90 years old (*M* = 40.19, *SD* = 17.87; Table 2) and who primarily reported being non-Hispanic (94.3%) and white (84.2%).

Table 1

Demographics (Full Sample)

Variable	Category	n (total = 507)	%
Race	African American	12	2.4
	American Indian / Alaska Native	1	0.2
	Asian	50	9.9
	Latinx	8	1.6
	More than one race	6	1.2
	Prefer Not to Say	2	0.4
	Unknown	1	0.2
	White	427	84.2
Ethnicity	Ethnicity Unreported	5	1.0
	Hispanic	24	4.7
	Not Hispanic	478	94.3
Biological Sex	Female	419	82.6
	Male	88	17.4

Income	$0 - $25,000	28	5.5
	$25,001 - $50,000	83	16.4
	$50,001 - $75,000	84	16.6
	$75,001 - $100,000	91	17.9
	$100,001 - $150,000	104	20.5
	$150,001 - $250,000	63	12.4
	$250,000+	54	10.7

Table 2.

Independent Variable Summary Statistics (Full Sample)

	Mean	SD	Min	Max	1	2	3	4	5
1. Age	40.19	17.87	18.00	90.00	1	.	.	.	.
2. PANAS_PA	23.31	9.28	10.00	50.00	.36	1	.	.	.
3. PANAS_NA	15.67	6.08	10.00	43.00	-.05	-.14	1	.	.
4. Housing	1.70	1.44	0.00	8.00	-.30	-.06	.07	1	.
5. Dependents	0.34	0.79	0.00	6.00	.13	.02	.07	.39	1

Note: The last five columns indicate Pearson r correlation coefficients. N = 507.

The current manuscript includes data from the openly available Boston College COVID-19 Sleep and Well-Being Dataset (https://osf.io/gpxwa/), which included periods of daily survey of mood and sleep, and larger one-time assessments (for full description of data collection see: Cunningham, Fields, & Kensinger, 2021). The relevant moral dilemma questionnaires were first sent to N = 1518 participants on June 29, 2020, and responses received by the end of August

2020 were included in the present analyses. As the time course and impact of the COVID-19 pandemic across the globe potentially varied from country to country, to reduce heterogeneity in our sample, we only included participants within the United States. We chose not to include participant responses from Canada, as the subset of questions included in the study reflect issues that occurred within the United States and may not have been generalizable to other countries, even if those countries were close in geographical proximity. Finally, some participants skipped questions as none of the survey questions required a response to proceed. As such, in order to be included in the current analysis participants must have answered both moral dilemma questions, but not the post-hoc motivation questions.

Participants were compensated with raffle entries to receive a gift card or make a charitable donation. All participants completed an informed consent form approved by the Boston College Institutional Review Board.

Materials

Dilemma Questions

Participants were asked to respond to two "Yes/No" dilemmas associated with living during the COVID-19 pandemic as indicated in Table 3. Following each response, participants were then asked to rank order a list of potential motivations for why they engaged or did not engage in the behavior associated with each dilemma (Figure S1 – S2). Participants ranked motivations in order of importance with lower numbers indicating higher importance.

Table 3.
Dilemma Questions

Dilemma	Scenario	Question

Goods Scarcity	Since the new coronavirus (COVID19) started to spread, certain resources have become scarcer than usual due to fear that resources might run out. Specifically, toilet paper and hand sanitizer are becoming more difficult to find.	Since the spread of the new coronavirus (COVID19) have you purchased extra amounts of toilet paper and hand sanitizer?
Medical Scarcity	Since the coronavirus (COVID19) started to spread, certain medical supplies have become scarcer than usual due to fear that these resources might run out. Specifically, medical masks and gloves are becoming more difficult to find.	Since the spread of the new coronavirus (COVID19) have you purchased medical masks or gloves?

Positive and Negative Affect Schedule

Participants completed the Positive and Negative Affect Schedule (PANAS; Watson et al., 1988) during the daily surveys sent throughout the study. The present analyses focus on each participant's positive (PANAS_PA) and negative (PANAS_NA) sub-scores that were collected closest to their response to the moral dilemma questionnaire. The PANAS scores with the closest timestamp to the date that the morality questions were collected for each participant were included in analyses. The average interval between PANAS collection and collection of the moral dilemma questionnaire was 15.93 days (*S.D.* = 16.89). PANAS scores included in these analyses could have been collected before or after the morality questions. As a result, the absolute value of the duration between these two timepoints was taken for each participant prior to computing the average duration for the entire sample.

Emotional Memory Questions

During an earlier one-time assessment (launched June 16, 2020), participants responded to six emotional memory questions asking about the early months of the COVID-19 pandemic. Possible responses ranged from *"0 – Strongly Disagree*" to "*4 – Strongly Agree*" for each question. In order to investigate the relationship between emotional memory for the early phase of the pandemic and moral decisions, we used a subset of these emotional memory questions as independent variables. Negative memory (*"When I think about the past 2-3 months: I remember my fears related to the spread of the illness*) along with positive memory (*"When I think about the past 2-3 months: I remember the community working together under difficult circumstances*") were used separately as negative and positive emotional memory independent variables in a subset of the analyses listed below.

Procedure

Data Collection

Although the primary aims and analyses for this study focus on the moral dilemma questionnaires of the Boston College COVID-19 Study, given that the PANAS and emotional memory data were collected at different timepoints it is important to provide a brief overview of the timeline for the larger study. The Boston College COVID-19 Study began sending out daily survey questionnaires on March 21, 2020 and continued through May 20, 2020. At that time, the frequency of these assessments was reduced to 2-3 times per week from May 21 – June 23, 2020. New participants that enrolled during the period between June 23, 2020 and the collection of these relevant surveys were also sent 3 consecutive days of daily surveys to collect a baseline at the point they joined the study. Although PANAS data was collected 2-3 times per week for this entire duration, in the present study we used the PANAS data that was closest in time to each participant's response to the moral dilemma questionnaire, which ranged from March 27, 2020 – October 5, 2020. The emotional memory questions were asked during an assessment launched on June 16, 2020, and ended on July 15, 2020. The moral decision questions were administered between June 29, 2020 and August 26, 2020.

Analyses

In order to assess whether age and subjective emotional experience relate to moral decision-making during the COVID-19 pandemic, two separate binomial logistic regression models were fit with responses to each moral dilemma as the dependent variables, and age, PANAS_NA, and PANAS_PA as independent variables. Additionally, in order to determine whether emotional memory is associated with moral decision-making behavior, negative memory and positive memory terms were added to the models examining the purchase of hard to find goods and medical supplies. It should be noted that participants were required to respond to the emotional memory questions in order to be included in this subset of analyses. As a result, the sample sizes for each one of these models are smaller than the original sample, but are specified with the discussion of each model (see Tables S1-S3 for sub-sample demographics and summary statistics).

Next, these models were updated with income, education, housing (i.e. the number of individuals living with the participant when they responded to the survey), and dependents (i.e. the number of dependents the participant was responsible for when they responded to the survey) in order to control for variables related to socioeconomic status. The only control variable that significantly improved overall model fit for all models was housing. As a result, models containing this variable are reported in the body of the manuscript. However, tables containing all of the control models that were tested are included in Appendix B (Section B.3) under the heading “Control Analyses”.

Following the moral decision analyses, we conducted exploratory analyses examining whether age was associated with the rank-order of post-hoc motivations for either engaging or not engaging in behaviors associated with each moral decision. For example, using data from the participants who indicated “yes” to the purchase of extra amounts of hard to find goods question we fit a series of separate linear regressions with the rank ordered motivations as dependent variables and age as the independent variable. Findings from these analyses help to clarify whether people of different ages in our sample were engaging in similar behaviors for the same or different reasons.

To address concerns about multicollinearity between our independent variables, the variance inflation factor (VIF) was calculated for each independent variable within each model. All independent variables in each model had VIF < 1.4, diminishing concerns of multicollinearity.

Unless otherwise specified, all independent variables were mean-centered. All analyses were computed using R (v4.0.5) in RStudio (v1.3.1056). All binomial logistic regression models were fit using the *glm* function and linear regression models were fit using the *lm* function from the *stats* (v4.0.5) package.

2.4 Results

Purchase of Hard to Find Goods

Behavior

To evaluate the relationship between age, positive and negative affect, and the reported purchase of extra hard to find goods ($N_{Yes} = 150$, $N_{No} = 357$) during the COVID-19 pandemic, a model was fit using age, PANAS_PA, and PANAS_NA as independent variables (Table 4, Goods Model 1.1). This model fit significantly better than the null model, $X^2(3) = 26.32$, $p <$ .001. Although we initially had hypotheses related to the interaction between age and affect, comparing Goods Model 1.1 and a model (Goods Model 1.2) with two additional interaction terms (i.e. age * PANAS_NA and age * PANAS_PA) revealed that the inclusion of these interaction terms did not provide a better fit, $X^2(2) = .84$, $p = .66$. Goods Model 1.1 was then updated with housing, which provided a significantly better overall model fit $X^2(1) = 8.07$, $p =$ .004. As such, Goods Model 1.1 (Control: Housing) was chosen for further interpretation (Figure 1).

This model demonstrated a significant effect of age (OR = 1.03, 95% CI [1.02, 1.04]), suggesting that, when controlling for positive and negative affect, as well as housing, for every year that age increased, there was a 3% increase in the chance that an individual purchased extra hard to find goods in the early phase of the pandemic. Similarly, there was a significant effect of negative affect (PANAS_NA, OR = 1.05, 95% CI [1.02, 1.09]), suggesting that, when controlling for positive affect, age, and housing, for every one point increase on the PANAS_NA subscale, there was a 5.6% increase in the chance that an individual reported purchasing extra hard to find goods in the early phase of the pandemic. There was no effect of positive affect (OR = .99, 95% CI [0.97, 1.01]). Finally, there was a significant effect of housing (Housing, OR = 1.23, 95% CI [1.07, 1.42]), suggesting that, when controlling for age, positive affect, and negative affect, for every one person increase in the number of people reported as living with participants at the time of the survey, there was a 23% increase in the chance that the individual reported purchasing hard to find goods in the early phase of the pandemic.

Table 4.

Goods Scarcity Model

	Goods Model 1.1	Goods Model 1.1 (Control: Housing)	Goods Model 1.2
(Intercept)	-0.91 ***	-1.28 ***	-0.89 ***
	[-1.11, -0.71]	[-1.62, -0.95]	[-1.11, -0.69]
Age	0.02 ***	0.03 ***	0.02 ***
	[0.01, 0.03]	[0.02, 0.04]	[0.01, 0.03]
PANAS_PA	-0.01	-0.01	-0.01
	[-0.03, 0.01]	[-0.04, 0.01]	[-0.03, 0.02]
PANAS_NA	0.05 ***	0.05 **	0.05 **
	[0.02, 0.09]	[0.02, 0.08]	[0.02, 0.08]
Housing		0.21 **	
		[0.06, 0.35]	
Age × PANAS_PA			-0.00
			[-0.00, 0.00]
Age × PANAS_NA			0.00
			[-0.00, 0.00]
N	507	507	507
AIC	597.5	591.4	600.7
BIC	614.4	612.6	626.0
Log.Lik.	-294.746	-290.710	-294.329
McFadden's Pseudo R2	0.043	0.056	0.044

Note: Age, PANAS_PA, and PANAS_NA are mean centered. 95% confidence intervals are indicated in brackets. $p < 0.05$ = *, $p < 0.01$ = **, $p < 0.001$ = ***.

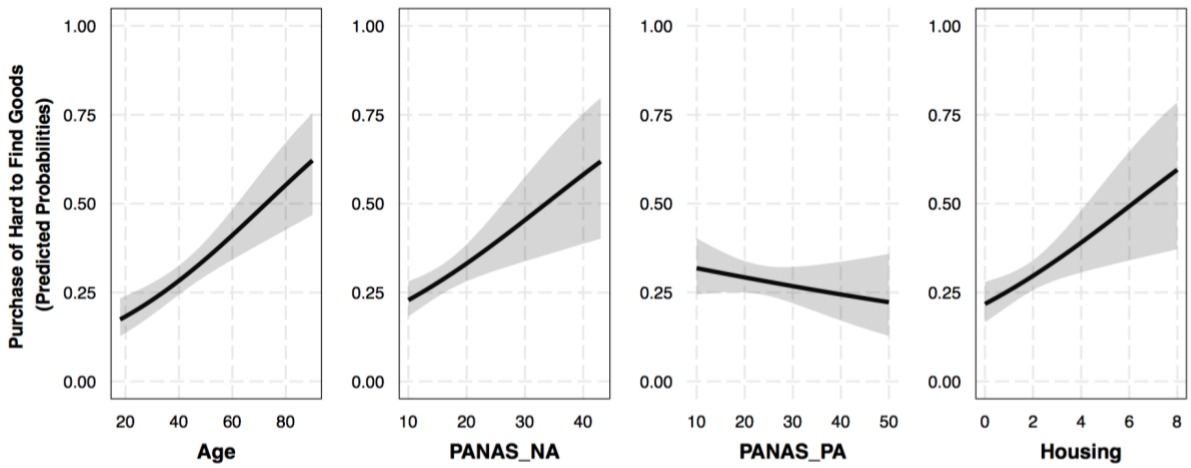

Figure 1. Purchase of extra hard to find goods relates significantly to age and negative affect (Controlling for housing). Each plot represents the effect of a given independent variable controlling for the other independent variables in Goods Model 1.1 (Control: Housing). Independent variables that produced significant effects have black borders. All variables were mean-centered in this model with the exception of housing, but for visualization purposes all variables are plotted with uncentered values. N = 507.

Next we sought to determine whether the reported purchase of extra amounts of hard to find goods additionally relates to positive and negative emotional memories for the early phase of the COVID-19 pandemic. Given that positive affect (PANAS_PA) did not demonstrate a significant relationship with the reported purchase of extra amounts of hard to find goods, this term was not included in the models for these additional analyses.[5] To examine the relationship between emotional memory and the reported purchase of extra amounts of hard to find goods we added a negative memory term and a positive memory term to our model (Goods Model 2.3,

[5] The results of Goods Models 1.1 and 1.2 replicated significant effects of age and negative affect, but no significant interaction between age and negative affect (PANAS_NA) in the subsample of memory participants as indicated in Table 5, for Goods Models 2.1 and 2.2 respectively.

Table 5). This model was created using a subset of participants (N_{Sample} = 441, N_{Yes} = 128, N_{No} = 313, Table S2, Appendix B) who completed the emotional memory questions, and provided significantly better fit than the model containing only age and negative affect as independent variables, $X^2(2) = 8.84$, $p = .01$. Similar to positive and negative affect, we suspected the possibility of age by emotional memory interactions. As such, we additionally compared this model to a model with two additional interaction terms between age and the emotional memory variables (Goods Model 2.4). This model did not provide a better fit than Goods Model 2.3, $X^2(2) = .69$, $p = .71$. Finally, Goods Model 2.3 was updated with housing as an independent variable. This model provided a better overall model fit than Goods Model 2.3, $X^2(2) = 5.8$, $p = .02$, leading to the use of Goods Model 2.3 (Control: Housing) for further interpretation (Figure 2).

Table 5.
Goods Scarcity Model (Memory Sample)

	Goods Model 2.1	Goods Model 2.2	Goods Model 2.3	Goods Model 2.3 (Control: Housing)	Goods Model 2.4
(Intercept)	-0.93***	-0.91***	-0.95***	-1.28***	-0.98***
	[-1.14, -0.72]	[-1.13, -0.70]	[-1.17, -0.74]	[-1.64, -0.93]	[-1.21, -0.76]
Age	0.02**	0.02**	0.02***	0.03***	0.02**
	[0.01, 0.03]	[0.01, 0.03]	[0.01, 0.03]	[0.01, 0.04]	[0.01, 0.03]
PANAS_NA	0.05**	0.05*	0.04*	0.04*	0.04*
	[0.01, 0.08]	[0.01, 0.08]	[0.00, 0.07]	[0.00, 0.07]	[0.00, 0.08]
Age × PANAS_NA		0.00			

		[-0.00, 0.00]			
Negative Memory			0.39**	0.39**	0.41**
			[0.13, 0.67]	[0.13, 0.66]	[0.14, 0.70]
Positive Memory			-0.04	-0.05	-0.03
			[-0.27, 0.21]	[-0.29, 0.19]	[-0.27, 0.21]
Housing				0.19*	
				[0.03, 0.34]	
Age x Negative Memory					-0.00
					[-0.02, 0.01]
Age x Positive Memory					0.00
					[-0.01, 0.02]
N	441	441	441	441	441
AIC	520.7	521.6	515.8	512.0	519.2
BIC	533.0	537.9	536.3	536.6	547.8
Log.Lik.	-257.343	-256.794	-252.923	-250.025	-252.579
McFadden's Pseudo R2	0.031	0.033	0.048	0.059	0.049

Note: All independent variables are mean centered with the exception of Housing. 95% confidence intervals are indicated in brackets. $p < 0.05$ = *, $p < 0.01$ = **, $p < 0.001$ = ***.

Consistent with the model examined in the full sample, this Goods Model 2.3 (Control: Housing) produced a significant effect of age (*OR* = 1.03, 95% *CI* [1.01, 1.04]), negative affect (PANAS_NA, *OR* = 1.04, 95% *CI* [1.00, 1.08]), and housing (*OR* = 1.20, 95% *CI* [1.04, 1.4]). Interestingly, there was also a significant effect of negative memory (*OR* = 1.47, 95% *CI* [1.12, 1.92]), suggesting that controlling for age, negative affect, positive memories, and housing, for every one unit increase in our negative memory question, there was a 47% increase in the likelihood that an individual reported purchasing extra amounts of hard to find goods during the early phase of the COVID-19 pandemic. There was no significant effect of positive memory (*OR* = .95, 95% *CI* [.75, 1.21]).

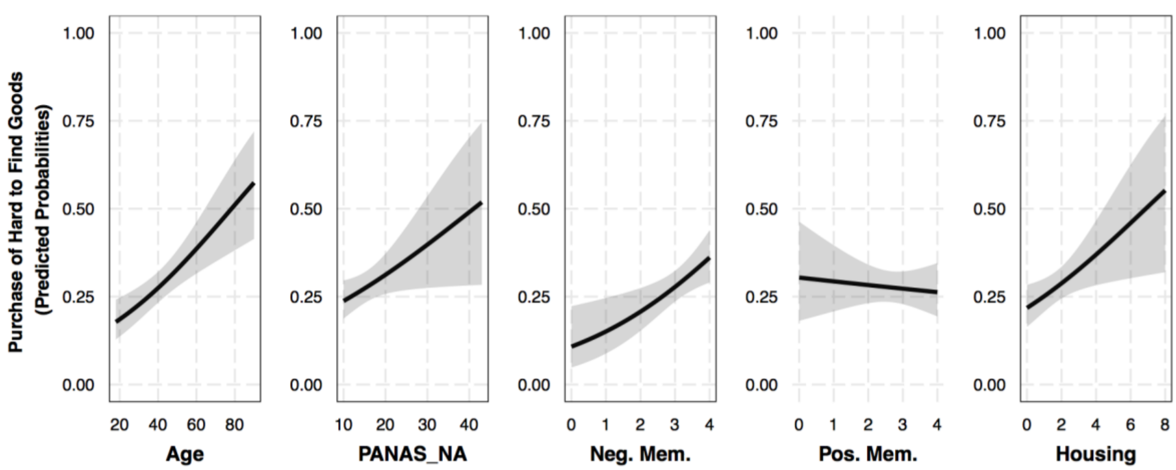

Figure 2. Purchase of extra hard to find goods is also significantly related to negative memory (Controlling for housing). Each plot represents the effect of a given independent variable controlling for the other independent variables in Goods Model 2.3 (controlling for housing). Independent variables that produced significant effects have black borders. All variables were mean-centered in this model with the exception of housing, but for visualization purposes all variables are plotted with uncentered values. N = 441.

Hard to Find Goods Motivation

Even with these age differences in the reported purchase of extra amounts of hard to find goods during the pandemic, the possibility arises that individuals may be motivated to purchase or refrain from purchasing extra amounts of hard to find goods for different reasons. We next examined whether age could predict the ranking of post-hoc motivations for those participants who indicated "Yes" to the goods purchase question. We additionally ran analyses on participants' post-hoc motivations who indicated "No" to the goods purchase question. Again, participants were not required to answer all questions presented in this section. As such there are different numbers of participants associated with each regression model and bin size distributions in Figure S1 (Appendix B) . Also, given the number of models that were fit, only significant findings will be discussed below, but the full output from all models can be found in Table S4 (Appendix B) for those participants who indicated "Yes", and Table S5 (Appendix B) for those participants who indicated "No".

With regard to those participants who indicated "Yes" to the goods purchase question, we found a significant negative effect of age in predicting the rank order of Motivation 5 (*'I had an increased need due to more people at home throughout the day'*), $F(1, 129) = 8.85$, $p = .004$, $R^2 = .06$. As participants were asked to rank motivations in order from lowest to highest, this negative effect of age suggests that advancing age was associated with greater motivation to purchase goods due to increased need for these goods due to more people at home throughout the day during the pandemic. There was also a marginal positive effect of age in predicting the rank order of Motivation 8 (*'I was shopping for a community resource [i.e. food pantry].'*), $F(1, 128) = 3.4$, $p = .07$, $R^2 = .03$, suggesting that advancing age was associated with lower motivation to shop for a community resource.

Interestingly, for those participants who indicated "No" to the goods purchase question, we found a significant positive effect of age when predicting the rank order of Motivation 3 ('*I didn't realize that people were buying extra toilet paper and hand sanitizer*'), $F(1, 345) = 3.92$, p

= .05, R^2 = .01, suggesting that younger individuals refrained from purchasing extra amounts of hard to find goods because they were less aware that others were doing so.

Summary

Together, these findings point not only to increased age and negative affect, but greater focus on negative memories, particularly in relation to fears about illness spread, as playing a role in the reported purchase of extra amounts of hard to find goods during the early phase of the COVID-19 pandemic. With regard to age, for those individuals who indicated purchasing extra amounts of hard to find goods, it appears that advancing age was associated with an increased need due to the number of family members at home throughout the day. For those individuals who indicated that they did not purchase these extra amounts of hard to find goods, it appears as though younger age was associated, not with a desire to refrain from contributing to shortages of these supplies, but with a lack of awareness that people were buying excessive amounts of these goods in the first place.

Purchase of Hard to Find Medical Supplies

Behavior

To evaluate the relationship between age, positive and negative affect, and the purchase of extra amounts of hard to find medical supplies (N_{Yes} = 173, N_{No} = 334) during the COVID-19 pandemic, a model was fit using age, PANAS_PA, and PANAS_NA as independent variables (Medical Model 1.1, Table 6). This model fit significantly better than the null model, $X^2(3)$ = 13.89, p = .003. Similar to the purchase of hard to find goods models, we suspected that age may interact with affect. As a result, we fit Medical Model 1.2 with two additional interaction terms (i.e. age * PANAS_NA and age * PANAS_PA), but this model did not provide a better fit than Medical Model 1.1, $X^2(2)$ = 3.03, p = .22. As a result, Medical Model 1.1 was updated to control for housing. This new model provided a better overall model fit than Medical Model 1.1, $X^2(1) = 24.1$, $p < .001$. As such, Medical Model 1.1 (Control: Housing) was chosen for interpretation (Figure 3).

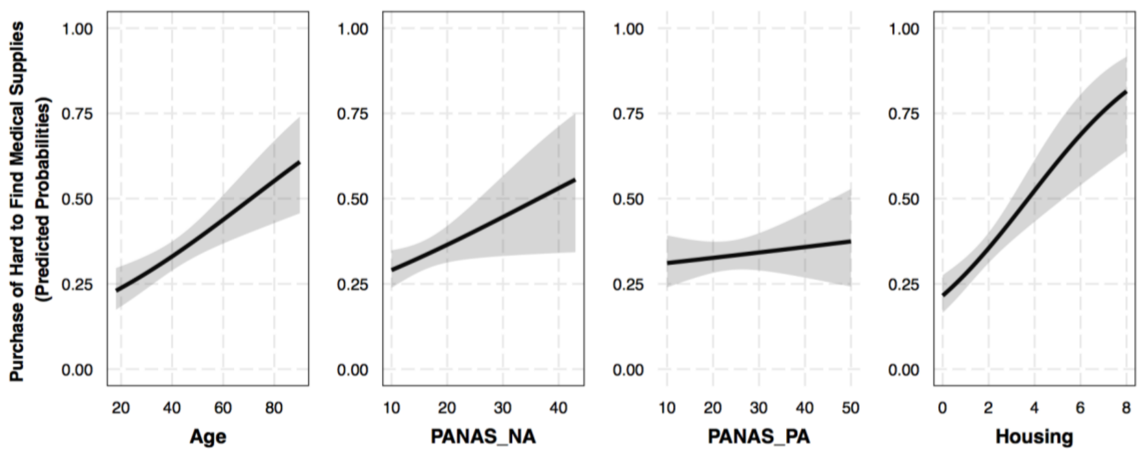

Figure 3. Purchase of hard to find medical supplies is also significantly related to age and negative affect (Controlling for housing). Each plot represents the effect of a given independent variable controlling for the other independent variables in Medical Model 1.1 (Control: Housing). Independent variables that produced significant effects have black borders. All variables were mean-centered in this model with the exception of housing, but for visualization purposes all variables are plotted with uncentered values. N = 507.

Consistent with the findings from the hard to find goods models, this model produced a significant positive effect of age (*OR* = 1.02, 95% *CI* [1.01, 1.04]), suggesting that for every year age increased, there was a 2% increase in the probability that an individual reported purchasing hard to find medical supplies. There was also a main effect of negative affect (*OR* = 1.03, 95% *CI* [1.00, 1.07], suggesting that for every one-point increase on the PANAS_NA subscale, there was a 3% increase in the probability that an individual reported purchasing hard to find medical supplies. There was also a significant effect of housing (*OR* = 1.41, 95% *CI* [1.23, 1.63], suggesting that, for every one person increase in the number of people reported as living with participants at the time of the survey, there was a 41% increase in the chance that the individual reported purchasing hard to find medical supplies in the early phase of the pandemic. Again, there was no effect of positive affect (PANAS_PA; *OR* = 1.01, 95% *CI* [.99, 1.03]).

Next we sought to determine whether the reported purchase of hard to find medical supplies additionally relates to positive and negative emotional memories for the early phase of the COVID-19 pandemic in a subset of participants (N_{Sample} = 441, N_{Yes} = 154, N_{No} =287) who completed Round 2 data collection. Neither positive nor negative memory were significantly associated with the purchase of hard to find medical supplies. As a result, this analysis will not be discussed further but can be found in the supplementary materials (Table S6, Appendix B).

Table 6.
Medical Supply Scarcity Model (Full Sample)

	Medical Model 1.1	Medical Model 1.1 (Control: Housing)	Medical Model 1.2
(Intercept)	-0.67***	-1.29***	-0.66***
	[-0.86, -0.49]	[-1.63, -0.97]	[-0.86, -0.46]
Age	0.01*	0.02***	0.01*
	[0.00, 0.02]	[0.01, 0.03]	[0.00, 0.02]
PANAS_PA	0.01	0.01	0.01
	[-0.01, 0.03]	[-0.02, 0.03]	[-0.01, 0.04]
PANAS_NA	0.04*	0.03*	0.03*
	[0.01, 0.07]	[0.00, 0.07]	[0.00, 0.07]
Housing		0.35***	
		[0.21, 0.49]	

Age × PANAS_PA			-0.00
			[-0.00, 0.00]
Age × PANAS_NA			0.00
			[-0.00, 0.00]
N	507	507	507
AIC	644.9	622.9	645.9
BIC	661.9	644.0	671.3
Log.Lik.	-318.471	-306.429	-316.957
McFadden's Pseudo R2	0.021	0.058	0.026

Note: All independent variables are mean centered with the exception of housing. 95% confidence intervals are indicated in brackets. p < 0.05 = *, p < 0.01 = **, p < 0.001 = ***.

Medical Supplies Motivation

We next examined how age relates to participants' post-hoc motivations for either purchasing or refraining from purchasing hard to find medical supplies (Figure S2, Appendix B). For participants who indicated "Yes" (Table S7, Appendix B) to purchasing extra amounts of hard to find medical supplies, there was a significant negative effect of age in predicting the rank-order of Motivation 5 ('*I was purchasing them for a family member*'), $F(1, 137) = 5.05$, $p = .02$, $R^2 = .04$. This finding suggests that within our sample, the reported purchase of extra amounts of hard to find medical supplies for family members was more important with advancing age. Regarding those participants who indicated "No" to this question (Table S8), we found a significant positive effect of age in predicting the rank-order of Motivation 3 ('*I didn't realize that people were buying medical masks and gloves*'), $F(1, 305) = 16.84$, $p < .005$, $R^2 =$

.05. This finding suggests that within our sample, younger individuals who did not purchase extra amounts of medical supplies refrained from doing so because they were not aware that others were engaging in this behavior.

Summary

Together these findings indicate that, in general, older adults were more likely to purchase hard to find medical supplies than younger adults. Negative affect also increased the likelihood of purchasing hard to find medical supplies. Interestingly, the post-hoc motivations for these behaviors suggest that these age differences in purchasing medical supplies may reflect more utilitarian tendencies with increased age, as older individuals in our sample tended to report purchasing these supplies for family members as a higher motivation. That is, rather than hoarding these medical supplies, they were distributed to others. On the other hand, for those individuals who refrained from purchasing medical supplies, the younger the participants were, the more likely they were to indicate that they did not know people were purchasing these medical supplies. As such, their behaviors likely reflect unfamiliarity with a medical supply shortage during the early phase of the COVID-19 pandemic.

2.5 Discussion

The results from this study describe key insights into the associations between age, negative affect, and negative memory in relation to real-life moral decision-making during the COVID-19 pandemic. Increased age, negative affect, and negative memory were associated with increased purchase of extra amounts of hard to find goods, while increased age and negative affect, but *not* memory, were associated with the purchase of hard to find medical supplies.

At first glance, these findings potentially point to advancing age and increased negative affect as being associated with non-utilitarian behaviors in relation to hoarding behavior.

However, exploratory analyses examining age differences in post-hoc motivations for engaging in these behaviors paint a more nuanced picture by demonstrating significant age effects. Advancing age was associated with the purchase of hard to find goods out of a need to provide for more family members in the home throughout the day, as well as purchasing hard to find medical supplies for family members. Moreover, refraining from purchasing these goods and medical supplies in younger adults likely reflected ignorance of supply shortage, rather than intentional engagement in utilitarian behavior. These findings point to advancing age as being associated with engaging in purchasing behaviors, that at first suggest non-utilitarian behavior, but upon further examination may actually reflect utilitarian outcomes (i.e. distributing goods and medical supplies to a greater number of individuals), albeit parochial in nature. This is consistent with recent findings from this dataset, demonstrating that older adults engaged in more prosocial behaviors than younger adults, specifically toward close-others over the course of the pandemic (Cho et al., 2021).

The effects of age in our findings provide an intriguing contrast with the age-related differences revealed during hypothetical moral decision-making. That is, although purchasing extra amounts of hard to find goods and medical supplies during the COVID-19 pandemic may appear consistent with non-utilitarian behavior observed in laboratory studies examining responses to sacrificial moral dilemmas (K. Huang et al., 2021; S. Huang et al., 2021; McNair et al., 2019), the distribution of these materials to others point to utilitarian outcomes. These age-differences occur in an adult lifespan sample, suggesting that increased tendency to engage in these behaviors may not be limited to older adulthood, but extend to middle-aged as well. That said, we stress that the analyses for these post-hoc motivations were exploratory and future work should seek ways to probe motivations for age-related differences in moral decision-making behavior to further understand what individuals *believe* about their motivations for moral behaviors, regardless of the validity of these beliefs (Haidt, 2001; Pizarro & Bloom, 2003).

We expected age to interact with affect in its association with decision-making behavior, but our findings suggest additive effects of age and negative affect. As positivity biases are often discussed in the aging literature, with older adults focusing on more positive information than negative information (Mather & Carstensen, 2005) and being better able to maintain positive affect (Ford, DiBiase, et al., 2018), even during the COVID-19 pandemic (Cunningham, Fields, Garcia, et al., 2021), the findings here highlight an important perspective by suggesting that when negative affect does occur, it may be particularly influential at increasing ages with regard to purchasing behavior in moments of societal distress.

Alongside negative affect, higher report of negative memory was also associated with the increased purchase of hard to find goods, but not medical supplies. This finding extends previous literature that connects memory content to consequent behavior, but diverges from this literature with regard to valence. Ford, Gaesser, et al. (2018) highlight the role of positive memory (i.e. remembering prosocial behaviors of others) as influencing later prosocial behaviors in participants. Here we demonstrate that negative memories for the early months of the COVID-19 pandemic in particular, were associated with increased reported purchasing of extra hard to find goods. Other work demonstrates episodic simulation of imagined harms is associated with increased reporting of the likelihood to engage in future harms (Morris et al., 2022). Given the connection between memory and simulation processes, these latter findings may be consistent with the negative memory and non-utilitarian behavior associations observed in the current study.

It should be noted, however, that although previous work examined memory for others' prosocial behaviors and simulated harms as being related to the engagement of *later* prosocial behaviors engaged by participants, in the current design, the temporal order by which participants recalled negative memories and engaged in the purchasing of extra amounts of hard to find goods is unclear. In this case we cannot make claims about the role of negative memory as *influencing* purchasing behavior, but rather highlight *general* connections between memory and social behaviors as already established in the literature. Generally, this finding highlights the importance of considering not only emotional effects, but valence effects (and specifically negative valence), when examining the relation between memory and moral decision-making outcomes.

It is also important to note that these effects of age, negative affect, and negative memory remained significant even when controlling for variables associated with socioeconomic status. Although the number of persons living with the participant (housing) was used as a control variable, it also provided a significant effect in all of our models. Indeed this variable was associated with the largest odds ratios in our models. According to the theories associated with our hypotheses, however, we did not necessarily expect age, affect, or emotional memory to show the *strongest* relationships with the observed moral decision-making outcomes. Rather, the goal of this study was to determine *whether* these independent variables were associated with moral decision-making in real world settings. Together these results highlight that although socioeconomic status may play an important role in utilitarian moral decision-making with respect to purchasing behavior during a pandemic, age, affect, and memory also appear to relate to these behaviors. This finding importantly highlights the connections between these variables of interest and moral decision-making in real-world settings for examination in future research.

Limitations

There are several limitations to the present study. First, the Boston College COVID Study utilized convenience sampling, producing a homogenous sample of predominantly white female participants. Future work should examine non-hypothetical moral dilemmas in more representative samples. This will be especially important to understand how age-related changes to moral decision-making generalizes to the broader population. With that being said, in the context of an observational study, the information examined here will provide useful descriptions of factors associated with moral decision-making as it relates to purchasing behavior during potential future pandemics within the United States.

Second, our real-life moral dilemmas do not exactly line up with the hypothetical moral dilemmas examined in the literature. Previous work balances the sacrifice of one individual to save many others, allowing for explicit utilitarian calculus to be engaged if an individual can override their initial emotional response (Greene & Young, 2020). When considering whether participants purchased extra amounts of hard to find goods or medical supplies, the moral quandary is not explicitly stated. That is, refraining from purchasing extra amounts of hard to find goods, may reflect utilitarian efforts, but participants are not necessarily forced to weigh the cost of hoarding goods at the expense of others. Relatedly, this study is primarily descriptive of behaviors engaged by individuals during the pandemic. Our work presents an ecologically valid case, but future research should utilize methods to experimentally manipulate real-life, non-hypothetical moral dilemmas, so as to draw clearer conclusions about the relationships between age, affect and memory in relation to moral decision-making.

Conclusion

Finally, this study was largely descriptive of actual behaviors that have moral implications across the adult lifespan. Although causal claims cannot be made about the relationships between the independent variables and behavioral outcomes, this study is a jumping point for the examination of age-related moral decision-making in non-lethal real-world moral dilemmas moving forward. Importantly, these findings highlight the complex involvement of affective shifts that occur across the adult lifespan to potentially influence decision-making behavior.

Overall, this study demonstrates the link between age, negative affect, and negative memory in non-hypothetical moral decision-making. As in previous literature there are age-related differences in decision-making behavior that have moral outcomes. Importantly, even when adults across the lifespan engage in similar behaviors during real-life moral dilemmas, their motivations for engaging in these behaviors appear to diverge, with individuals of older ages particularly focused on family members. These findings point to a need for future research to consider the complex motivational, emotional, and cognitive changes that differentiate lifespan approaches to decision-making in the moral domain.

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3.0 MEMORY FOR MIXED-VALENCE MOTIVATIONS PREDICT MORAL JUDGMENTS ABOUT OTHERS' ACTIONS

3.1 Abstract

When learning about individuals who commit acts that have moral implications either in the news or through conversations, in some cases, these individuals may simultaneously maintain moral and immoral motivations for a given action. In many cases we might judge the actions of these individuals on the spot. As a result, much of the literature has focused on the presentation order of these motivations as they relate to third-person moral judgments. An alternative scenario can also occur whereby we need to recall the information that we learned about the individual in order to relay it to another person. It remains an open question as to how an agents' mixed-valence moral motivations are prioritized in memory. Relatedly, it is unclear whether or how explicitly retrieved memory for (im)moral motivations predict third-person moral acceptability judgments of these associated actions. The current study presented participants with vignettes containing either mixed-valence or single-valence moral motivations for an agents' actions. Participants' memory was tested, and then they made moral acceptability judgments of the action engaged by the agent in each vignette. There was a memory negativity bias such that memory was best for immoral motivational content in the single-valence condition compared to moral content, as well as immoral content in the mixed-valence conditions. Memory for motivational content predicted subsequent acceptability judgments. Specifically, memory for initial motivational content, as well as immoral motivational content, regardless of presentation order, appear to play particularly important roles in memory-judgment relationships.

3.2 Introduction

When learning about individuals who commit acts that have moral implications either in the news or through conversations, in some cases, these individuals may simultaneously maintain moral and immoral motivations for a given action. For example, a mayor needs to decide whether to cut after-school programs for at-risk youth or city-sponsored day care programs. This mayor may have the moral motivation to cut the after school programs because cutting the city-sponsored day care would put a financial burden on single parents. On the other hand, the mayor may also maintain the immoral motivation to cut the after school program because cutting the city-sponsored day care would upset parents in her city. Thich could put her re-election in jeopardy. Ultimately the mayor decides to cut after-school programs for at-risk youth. Upon learning all of the details of this scenario, it may be the case that individuals immediately make a moral judgment about the mayor. However, another commonplace occurrence related to the moral judgments made about this mayor may involve the following scenario. After learning about this situation, following a period of time (i.e. minutes, hours, or days), an individual may try to explicitly recall this situation in memory in order to convey it to another person. In doing so, it may not be until after the individual has recalled this information that they make an explicit judgment about the mayor.

This example (adapted from: Kim et al., 2022) highlights an aspect of cognition that has yet to be fully incorporated into the literature's understanding of third person moral judgments, namely explicit memory. As highlighted by Amodio (2019) much of the impression formation literature, and by extension, moral judgment literature largely focuses on associative memory models to understand how implicit learning may impact our judgments of others. But, as Amodio (2019) also appropriately suggests, advances in the cognitive neuroscience of memory point to a complex interplay between implicit and explicit memory systems that guide other cognitive processes. Prior to understanding the interplay between these different memory subsystems, however, it will be important to first establish what role, if any, the availability of explicit memory for motivations plays in third-person moral judgments. To do so, an understanding of how memory for mixed-valence moral scenarios, or scenarios that contain simultaneous moral and immoral motivations for an agent's actions, are prioritized in memory must be examined.

There are well documented emotional memory changes that occur across the adult lifespan (Carstensen et al., 2003; Carstensen & DeLiema, 2018; Carstensen & Mikels, 2005). This literature highlights that younger adults tend to demonstrate negativity biases, or better memory for negative information compared to neutral or positive information. It is possible that these negativity biases in memory may extend to the moral domain. As such, the first aim of this study was to determine how moral scenarios containing mixed-valence motivations for a given action are prioritized in memory in younger adults. Hypothesis 1a predicted that participants would demonstrate prioritized memory for immoral motivational content. This finding would be consistent with the emotional memory literature, whereby younger adults tend to demonstrate better memory for negative information compared to positive and neutral information. Unlike the literature that examines memory for purely negative stimuli, as in the case of negative images and words, immoral motivations maintain mixed-valence characteristics. For example, an immoral motivation may be negative, but the possible personal gain for the agent maintaining that immoral motivation is positive. As a result, Hypothesis 1b suggested the typical memory negativity biases demonstrated by younger adults may not extend to (im)moral motivational content. The absence of a negativity bias in this paradigm would potentially point to a boundary condition of this memory effect in the moral domain.

Although memory is often treated as a cognitive end-point, the content obtained at retrieval can also be used as a starting point for other cognitive processes (Kensinger & Ford, 2020). This idea points to the possibility that memory for the moral motivations of others may be used to predict subsequent moral judgments about their actions. The present study was particularly focused on how memory for moral motivational content predicts moral judgments of others' actions, given the literature highlighting the important role of an agent's intentions when participants judge the morality of subsequent actions (Cushman, 2008; Young et al., 2007).

Indeed, previous work has also examined the role of moral judgments on memory, highlighting that morally judging agents for harms committed can distort subsequent memory traces (Pizarro et al., 2006). This finding is important for highlighting the nature by which moral judgments can influence memory at the time of encoding. It does not, however, allow for the scenario that often occurs in real life, whereby moral judgments are not explicitly made at the time that individuals read or hear a news story about an agent. Rather, they make these judgments after retrieving motivational content for others' actions from memory.

To address this gap in the literature, the second aim of this study sought to determine whether moral judgments about others' actions can be predicted by the way that (im)moral motivations are prioritized in memory. In the moral judgment literature, it has been demonstrated that the presentation order of moral and immoral information about an agent is important for impression updating (Cone & Ferguson, 2015). For example, when participants are presented with distinct pieces of information about an individual, there tends to be a negativity bias in moral judgment. That is, the magnitude of judgment change (i.e. positive judgment to negative judgment) is larger if they are first presented with moral information and then update their judgment following the presentation of immoral information, than if that information is presented in reverse order. Recent work also highlights that when moral and immoral motivations are placed in narrative context, as typically experienced when reading a news article, the presentation of immoral and then moral information results in a larger magnitude of judgment change than if the presentation order is reversed (Kim et al., 2022). Adapting this narrative approach taken by Kim et al. (2022) and removing the initial moral judgment prior to learning about the second motivation, it was possible to test how explicit memory prioritization of moral and immoral motivations can predict subsequent moral judgments about an agent's actions.

Given these findings from the moral updating literature, the present study tests three hypotheses related to memory-judgment relationships. First, Hypothesis 2a predicted that the way (im)moral motivational content was prioritized in memory would predict moral judgments about agent's actions. For example, if as predicted in Hypothesis 1a, participants prioritized immoral motivational content in memory, this would be associated with harsher subsequent moral judgments about an agent's actions.

Alternatively, rather than the prioritization of moral motivational valence, memory recency effects may account for subsequent judgments of agent's actions. That is, the last piece of motivational information learned about an agent may be a better predictor of moral judgments about actions. Hypothesis 2b, in this case, predicted that the last piece of motivational information (i.e. moral, immoral, or control content) presented to participants would predict moral judgments about agent's actions. And finally, although previous work points to the importance of motivations when immediately judging the actions of a character (Kim et al., 2022), it may be memory for the action itself that is associated with subsequent judgments for actions rather than motivations. As a result, Hypothesis 2c predicted that memory for actions would account for acceptability judgments of agents' actions over and above memory for motivational content.

To evaluate the hypotheses in both of these aims, participants were presented a series of vignettes about an agent who had mixed-valence moral motivations for engaging in an action (adapted from Kim et al., 2022). Following a short delay, participants recalled as much as they could from these vignettes during a surprise memory test, and finally, they made judgments about the agents presented in these vignettes.

3.3 Methods

Participants

Participants for this study included 120 younger adult participants. However, 13 participants were excluded due to data quality problems. As a result, the final sample size included 107 younger adult participants (n_{Female} = 48, M_{age} = 27.86, SD_{age} = 3.23). All participants were recruited through Amazon's Mechanical Turk. Prior to participating in the study, all participants provided digital consent on a Boston College IRB approved informed consent form.

Tasks

All tasks were presented on the Qualtrics XM platform through Amazon's Mechanical Turk. Following the collection of participant demographics, and pre-task attention checks, this survey contained the following questionnaires in the order listed below.

Moral Vignettes

Participants were presented with a series of moral vignettes (*n* = 12; adapted from: Kim et al., 2022) that contained five parts (Figure 1, Panel A). The first two parts set up a moral dilemma that a particular agent faced. The third part contained either a moral or immoral motivational framing for the agent's action. Part four contained the agent's action. And finally, part five contained a motivational reframing or control condition for the agent's behavior. All vignettes and conditions used in the present study can be found in Appendix C. After participants read through the vignette, they were presented with a reading comprehension question that had to be answered in order to move onto the next screen. These were used to ensure that participants were attending to the task, as they did not know that their memory for these vignettes would be tested later in the survey.

The 12 vignettes were presented in one of four conditions based upon possible motivation combinations: 1) Moral-to-Immoral; 2) Moral-to-Control; 3) Immoral-to-Moral; 4) Immoral-to-Control (Figure 7, Panel B). Participants were presented with three vignettes of each condition. Vignette conditions were randomly presented across four counterbalance lists.

After participants read all 12 vignettes, they completed filler tasks (described below) that were designed to last for a duration of approximately 10 minutes. Following these filler tasks, participants were then presented with the following prompt:

"Earlier you read a scenario about <agent>, called <"Title">.

Please write everything that you can remember about this scenario."

Participants were presented with a text-box that allowed them to write as much as they could remember about the vignette. This process was repeated for each of the 12 vignettes. The presentation order of vignettes were randomized during this free-recall task.

After participants completed the memory task for all 12 vignettes, they were then asked to make decisions about the following three moral judgments based upon their memory for each vignette: 1) Are <agent's> actions moral? (*1- not at all; 7- completely)* ; 2) Is <agent> a moral person? (*1* - not at all; 7 - completely); 3) Based on the information provided, have you learned more about <agent>, or about the situation? (*1 – only about <agent>; 7 – only about the situation*). Moral judgment questions two (agent judgments) and three (agent vs. situation) will not be addressed here. Their description is included here to provide the experimental context in which the data was collected.

Following the presentation of the moral judgment questions, participants completed post-task attention checks and then completed the study (see Figure 1B for study timeline).

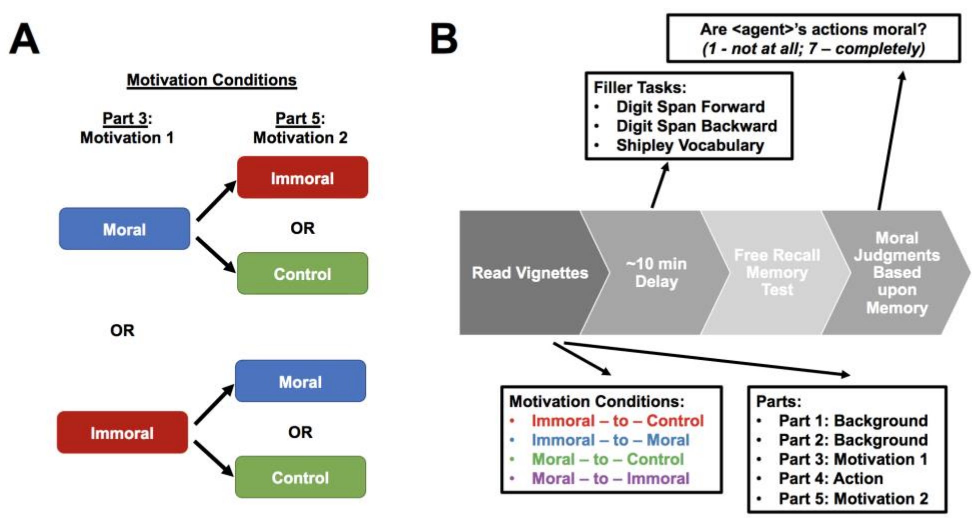

***Figure 1*. Motivation conditions and survey order.** A) Participants were presented with 12 vignettes that contained motivation conditions as indicated in Panel A. During Motivation 1 they were either presented with an initial moral motivation or immoral motivation. During Motivation 2, if they were presented with an initial moral motivation they were either presented with an immoral Motivation 2 or control content for Motivation 2. If they were presented with an initial immoral motivation they were either presented with a moral Motivation 2 or control content. Participants were randomly presented motivation conditions (n = 3 trials per condition). B) Participants first read vignettes. They then completed approximately 10 minutes of filler tasks. They then completed a free recall memory task for each vignette. Finally, they made moral judgments about the action engaged by the agent in each story based upon their memory.

Filler Tasks

Participants first completed the online version of the Digit Span Forward and Digit Span Backward task as described in Part I. They then completed the Shipley Vocabulary Test (Shipley, 1986). The collection of these tasks served two purposes: First, they were used to add a delay between participants reading the vignettes and the free-recall memory task; Second they were collected as part of a larger study to examine how age-related differences in cognitive function relate to performance on this task. Descriptions of these tasks are included here to provide the broader context by which the memory and judgment data were collected for this study. However, the analysis of these tasks are beyond the scope of this proposal and will not be discussed further.

Analyses

Memory

To address Aim 1, participant memory for each vignette was scored as the proportion of correctly recalled details from each vignette. Memory scores were converted to proportions rather than using raw scores, due to the varying number of possible details to be recalled within each vignette. Memory performance was evaluated using a 5 (Part) * 4 (Motivation Condition) repeated measures ANOVA with Part and Motivation Condition as within subject variables, and memory proportion as the dependent variable. This repeated measures ANOVA was computed using the *afex* package (v.0.27-2). Significant interactions were further interrogated using pairwise comparisons of relevant estimated marginal means using the *emmeans* package (v.1.4.8). All pairwise comparison *p*-values were Tukey adjusted.

Comparisons of correlation magnitude between memory for initial motivational framing (Part 3) and motivational reframing (Part 5) within Motivation Conditions were used to determine the extent by which (im)moral motivational content is prioritized in memory within individuals. These additional comparisons were computed because at least two possibilities could have arisen with regard to memory for initial motivational framing and motivational reframing. First, there could have been a zero-sum relationship between these two parts, leading to a negative correlation between memory for initial motivational framing and motivational reframing. Alternatively, it was possible that participants would demonstrate overall better memory for the most salient aspects of the vignettes. In this case, participants would demonstrate positive correlations between memory for initial motivational framing and motivational reframing. These comparisons of correlation magnitude were computed using Dunn & Clark (1969)'s z, and Zou (2007)'s confidence interval for comparing correlation strength in the *cocor* package (v1.1-3).

Memory-Judgment Relationships

To address Aim 2, memory-judgment relationships were modeled using a series of random intercepts models with the *lme4* package (v1.1-23) to determine whether memory for Part by Motivation Condition interactions could predict the moral acceptability judgments of agents' actions. Participant was the only random intercept included within these models. Type III analysis of variance estimates were computed using Satterthwaite's method for each model. Significant interactions were further interrogated using pairwise comparisons of estimated linear trends using the *emmeans* package. Degrees of freedom for these comparisons were computed using Satterthwaite's method, and p-values were Tukey adjusted.

To address Hypothesis 2a and Hypothesis 2b, Part 3 memory by Motivation Condition and Part 5 memory by Motivation Condition interaction terms were first examined within the same model (Table 1, Model 2). Given that Part 3 and Part 5 memory corresponded to

Motivation 1 and Motivation 2 respectively, this model simultaneously provided insight into whether the prioritization of motivational content or serial position effects are predictors of moral acceptability judgments of agent's actions. That is, if both interaction terms significantly predicted action judgments, this finding would point to the way that motivational content is prioritized in memory in both Motivation 1 and Motivation 2 would account for portions of the explained variance in action judgments. If Part 5 content alone predicted action judgments, this finding would point to support for Hypothesis 2b, such that memory for the last piece of motivational content presented to participants would explain action judgments. As explained in the results section, both Part 3 and Part 5 memory interactions with Motivation Condition were significant predictors of moral acceptability judgments (Model 2). As a result, in order to examine the contribution of Part 3 by Motivation Condition interaction independent of Part 5 memory, Model 1 only included the main effects of Part 3 memory, Motivation Condition, and their interaction, but no Part 5 memory terms were modeled. Model 1.p5 sets up a similar scenario, whereby Part 5 memory replaced all of the Part 3 memory terms in order to examine the contribution of the Part 5 by Motivation Condition interaction independent of Part 3 memory. These two models provided further clarification of Hypothesis 2a by examining how memory prioritization of Motivation Condition impacted moral acceptability judgments of agents actions.

Finally, to address Hypothesis 2c, Model 4 was created by adding the main effect of Part 4 memory and the Part 4 by Motivation Condition interaction term to Model 2. Part 4 involved the action engaged by agents in each vignette. If Model 4 provided a better overall model fit than Model 2, this would provide support for memory for an agent's actions as accounting for some variability in action judgments over and above memory for motivational content.

All analyses were conducted in R (4.0.5), in RStudio (1.3.1056).

Table 1.
Memory-Judgment Relationship Models

Model 1:	lmer(Action Judgment ~ (Part 3 Memory * Motivation Condition) + (1 | Participant))
Model 1.p5:	lmer(Action Judgment ~ (Part 5 Memory * Motivation Condition) + (1 | Participant))
Model 2:	lmer(Action Judgment ~ (Part 3 Memory * Motivation Condition) + (Part 5 Memory * Motivation Condition) + (1 | Participant))
Model 3:	lmer(Action Judgment ~ (Part 3 Memory * Part 5 *Motivation Condition) + (1 | Participant))
Model 4:	lmer(Action Judgment ~ (Part 3 Memory * Motivation Condition) + (Part 5 Memory * Motivation Condition) + (Part 4 Memory * Motivation Condition) + (1 | Participant))

3.4 Results

Memory

The 5(Part) * 4(Motivation Condition) repeated measures ANOVA on memory performance indicated that sphericity was violated for Part using Mauchly's test $X^2(3) = .48$, $p < .001$. As a result Greenhouse-Geisser corrections were applied to the degrees of freedom. There was no significant main effect of Motivation Condition, $F(2.93, 310.58) = 1.54$, $p = .21$, $\eta_p^2 = .01$. There was a significant main effect of Part, $F(2.87, 304.02) = 121.68$, $p < .001$, $\eta_p^2 = .53$, that was qualified by a significant Part * Motivation Condition interaction, $F(9.60, 1017.28) = 13.98$, $p < .001$, $\eta_p^2 = .12$ (Figure 2).

As a reminder, during Part 3, participants either saw *immoral* content that was followed by moral or control content, or *moral* content that was followed by immoral or control content. For the duration of the results section, when discussing pairwise comparisons for Motivation Conditions within Part 3, the memory content being compared will be italicized, and the follow-up content will be presented in plaintext. For example, comparing memory performance for the two Motivation Conditions in which participants were presented with immoral content in Part 3 will be presented as follows, "Participants had significantly better memory for the *Immoral*-to-Control condition compared to the *Immoral*-to-Moral condition." In this case, differences in memory performance for *Immoral* content are being evaluated, and the two conditions only differ in the context in which *Immoral* content was originally presented. In the first case *Immoral* content is followed by Control content in Part 5 (i.e. *Immoral*-to-Control) and in the latter *Immoral* content is followed by Moral content (i.e. *Immoral*-to-Moral).

Pairwise comparisons for Motivation Condition within Part 3 (Motivation 1), revealed that participants had significantly better memory for the *Immoral*-to-Control condition ($M = .20$, $SD = .14$) than the *Immoral*-to-Moral condition ($M = .14$, $SD = .12$), $t(106) = 4.61$, $p < .001$, $d = .45$. Although the memory comparison for this test involved immoral content in both conditions, it appears as though memory for immoral content in Part 3 is specifically enhanced when it is followed by control content in Part 5. Participants also had significantly better memory for the *Immoral*-to-Control condition compared to the *Moral*-to-Control ($M = .16$, $SD = .12$), $t(106) = 2.75$, $p = .03$, $d = .27$, and Moral-to-Immoral ($M = .15$, $SD = .12$) conditions, $t(106) = 4.17$, $p < .001$, $d = .40$. These comparisons suggest that immoral content was prioritized in memory for Part 3 over moral content. No other comparisons within Part 3 were statistically significant (ps > .14). In summary, these findings indicate that participants had significantly better memory for immoral content from Part 3 than moral content, as well as immoral content when it was followed by control content, rather than moral content in Part 5.

As a reminder, during Part 5, participants either saw *immoral* content preceded by control content, *moral* content preceded by immoral content, or *control* content that was preceded either by moral or immoral content. Similar to pairwise comparisons for Part 3, for the duration of the results section, when discussing pairwise comparisons for Motivation Conditions within Part 5, the memory content being compared will be italicized, and the preceding content will be presented in plaintext. For example, comparing memory performance for the two Motivation Conditions in which participants were presented with control content in Part 3 will be presented as follows, "Participants demonstrated no difference in memory for the Immoral-to-*Control* condition compared to the Moral-to-*Control* condition." In this case, differences in memory performance for *Control* content are being evaluated, and the two conditions only differ in the content that was presented prior to the *Control* content. In the first case Immoral was presented prior to *Control* content in Part 5 (i.e. Immoral-to-*Control*) and in the latter Moral content was presented prior to the control content (i.e. Immoral-to-*Control*).

Pairwise comparisons for Motivation Condition within Part 5 (Motivation 2), revealed that participants had significantly better memory for the categories that contained moral or immoral content compared control content. Specifically compared to the Immoral-to-*Control* condition (M = .04, SD = .06), participants had significantly better memory for the Immoral-to-*Moral* condition (M = .12, SD = .11), $t(106) = 8.68$, $p < .001$, $d = .84$, and the Moral-to-*Immoral* condition (M = .13, SD = .14), $t(106) = 8.07$, $p < .001$, $d = .78$. This means that moral and immoral content were remembered to a greater extent than control content in Part 5 (Motivation 2). Similarly, compared to the Moral-to-*Control* condition (M = .04, SD = .07), participants had significantly better memory for the Immoral-to-*Moral* condition, $t(106) = 8.31$, $p < .001$, $d = .8$, and the Moral-to-*Immoral* condition, $t(106) = 7.48$, $p < .001$, $d = .72$. These findings indicate that participants recalled more moral content, as in the case of the Immoral-to-*Moral* condition, and immoral content, as in the case of the Moral-to-*Immoral* condition, than control content in Part 5. There were no significant differences between the Immoral-to-*Control* and Moral-to-*Control* conditions, *t*(106) = .01, *p* = 1, *d* = .001, in Part 5. There were also no differences between the Immoral-to-*Moral* and Moral-to-*Immoral* conditions, *t*(106) = .72, *p* = .89, *d* = .07. These findings for Part 5 indicate a general (im)moral motivational memory bias, such that moral and immoral motivational content were remembered better than control content, but were not different from each other. Regarding pairwise comparisons for Motivation Condition within Parts 1, 2, and 4, no significant differences were observed (*p*s > .2).

Paired samples *t*-tests were also computed in order to examine whether memory *within* Motivation Condition differed *between* Part 3 and Part 5 for the Immoral-to-Moral and Moral-to-Immoral conditions. For the Immoral-to-Moral condition, although marginal, there was no significant difference between memory for Part 3 (Immoral) and Part 5 (Moral) content, *t*(106) = 1.76, *p* = .08, *d* = .17. Again, although marginal, there were no significant differences between Part 3 (Moral) and Part 5 (Immoral) memory for the Moral-to-Immoral condition, *t*(106) = 1.77, *p* = .07, *d* = .17. These findings paired with the comparisons between Motivation condition *within* Part 3 and Part 5 suggest that the Part * Motivation interaction was primarily driven by differences in memory performance between Motivation Conditions within Part 3 and Part 5.

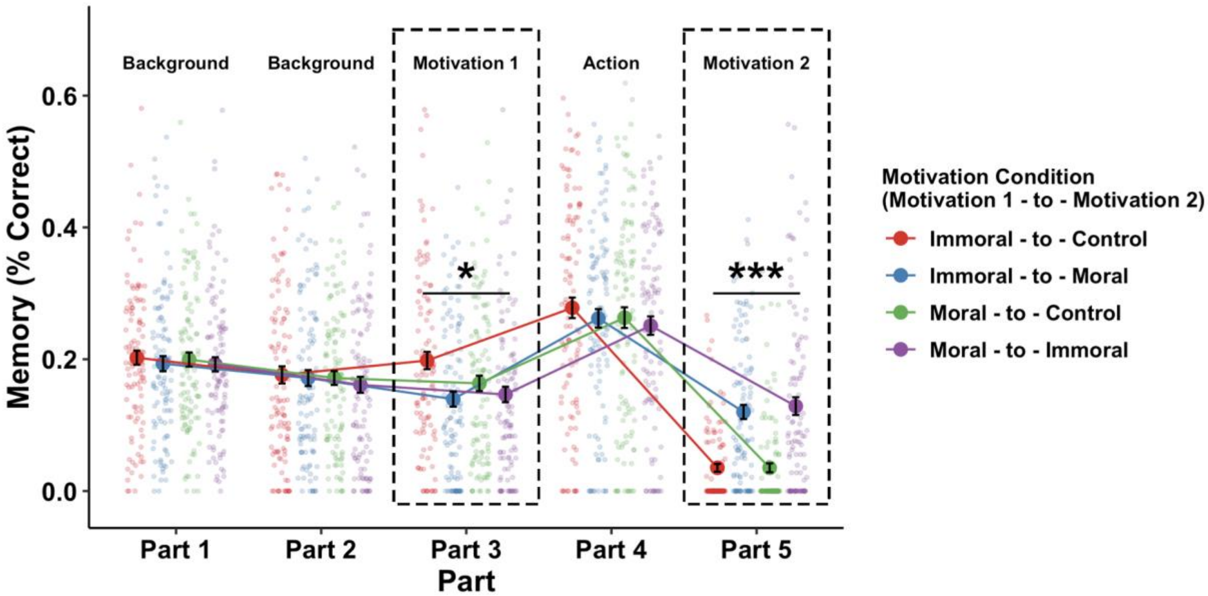

Figure 2. **Immoral motivational content is remembered best when it is followed by control content.** There was a significant Part by Motivation Condition interaction on memory performance. Pairwise comparisons of the estimated marginal means within Part 3 (Motivation 1) revealed that participants had significantly better memory for information in the Immoral-to-Control condition (red) than any other condition (all *ps* < .05). Within Part 5 participants had better memory for information in the Immoral-to-Moral condition (blue) or the Moral-to-Immoral condition than either of the other conditions (all *p*s < .001). There were no significant differences between these two conditions. All *p*-values were Tukey corrected. The large dark circles represent the condition means. The error bars are standard errors of the mean. The smaller lighter dots represent individual participant performance.

Next, to examine how individual differences in memory performance for the purely moral (Moral-to-Control) and immoral (Moral-to-Control) conditions compare to mixed-valence conditions, the correlation magnitudes of Part 3 and Part 5 within these conditions were compared to the correlation magnitudes of the Moral-to-Immoral and Immoral-to-Moral conditions respectively. As indicated in Figure 3, Part 3 and Part 5 memory showed significant positive correlations across all four motivation conditions. Comparing the correlation magnitude between Moral-to-Control and Moral-to-Immoral conditions, revealed that the correlation for the Moral-to-Immoral condition was significantly higher in magnitude than the Moral-to-Control condition, $z = 4.09$, $p < .001$, 95% *CI* [.18, .55]. Comparing the Immoral-to-Control to Immoral-to-Moral correlation magnitudes revealed no significant difference between these conditions, $z = .96$, $p = .34$, 95% *CI* [-.10, .29].

These findings indicate that when moral motivational content in Part 3 is followed by immoral motivational content, individual differences in memory performance are enhanced overall, as compared to when moral motivations are followed by control content; however, this enhancement does not occur when immoral motivational content is presented prior to moral motivational content (*Immoral*-to-Moral) or control content (*Immoral*-to-Control). Paired with the findings from the repeated measures ANOVA that participants had better memory for the Immoral-to-Control condition compared to any other condition in Part 3 on average, these findings suggest that immoral motivational content is prioritized to a greater extent than moral motivational content in memory.

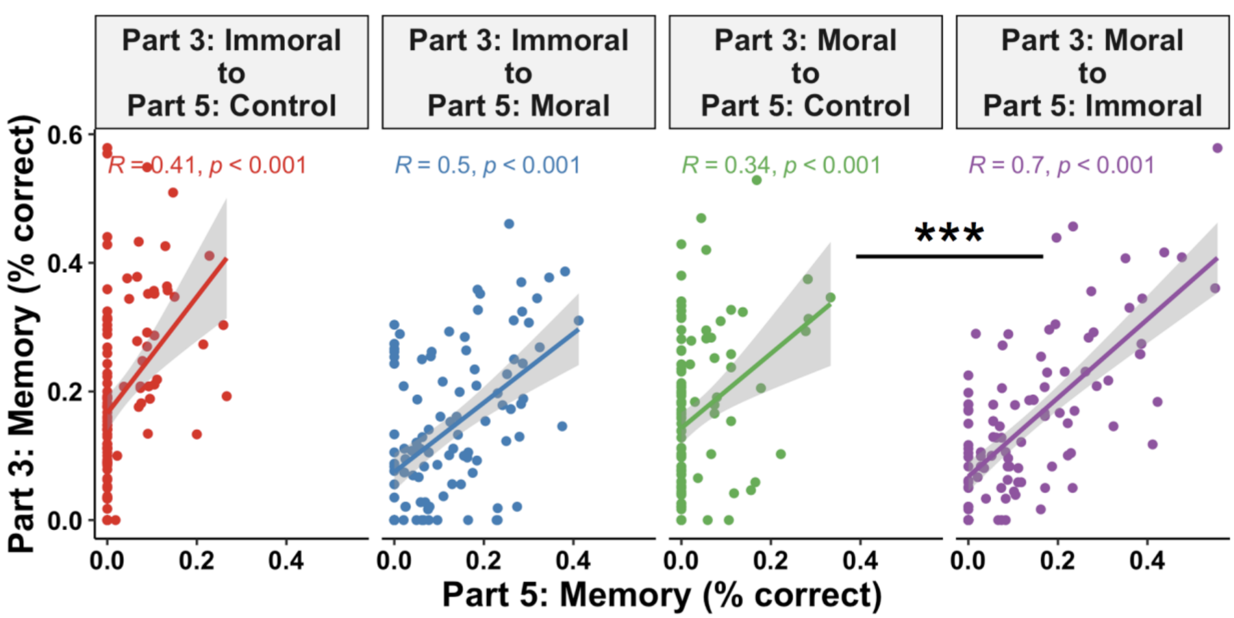

***Figure 3*. Immoral motivational content is prioritized in memory over moral motivational content.** The scatterplots reflect correlations between Part 3 (Motivation 1) and Part 5 (Motivation 2) memory broken down by Motivation Condition. Although the correlations were significant

within each condition, the magnitude of the correlation for the Moral-to-Immoral condition (purple) was significantly higher than the correlation magnitude of the Moral-to-Control condition (green), $z = 4.09$, $p < .001$, 95% CI [.18, .55].

Memory-Judgment Relationships

In order to determine whether memory for (im)moral motivational content can predict subsequent moral judgments about agents' actions, Part 3 and Part 5 memory and their interaction with Motivation Condition content were modeled as fixed effects with Participant as a random effect, on the moral acceptability of action judgments. To determine the model to be used for interpretation, an intercept-only model was first compared to Model 1 which contained main effects of Part 3, Motivation Condition, and their interaction terms. Model 1 provided a better overall model fit than the intercept-only model $\chi^2(7) = 170.46$, $p < .001$. Next, Model 2 updated Model 1 with the main effect of Part 5 and its interaction with Motivation Condition. Model 2 again provided a better overall model fit than Model 1, $\chi^2(4) = 11.73$, $p = .02$. And finally, Model 3 updated Model 2, by adding a three-way interaction term between Part 3, Part 5, and Motivation Condition. Model 3, did not provide a better overall model fit than Model 2, $\chi^2(4) = 1.66$, $p = .8$. As a result, Model 2 was chosen for further interpretation.

Model 2 revealed a significant main effect of Motivation Condition, $F(3, 304.71) = 58.64$, $p < .001$, $\eta_p^2 = .37$, but no main effect of Part 3 memory, $F(1, 416) = 2.5$, $p = .11$, $\eta_p^2 = .01$, or a main effect of Part 5 memory, $F(1, 413.97) = .05$, $p = .82$, $\eta_p^2 < .001$. The main effect of Motivation Condition was qualified by a Motivation Condition * Part 3 memory interaction, $F(3, 352.84) = 12.23$, $p < .001$, $\eta_p^2 = .09$, as well as a Motivation Condition * Part 5 memory interaction, $F(3, 357.01) = 3.85$, $p = .01$, $\eta_p^2 = .03$. To further interrogate these interactions, pairwise comparisons of estimated linear trends were computed for each interaction.

Prior to the examination of these pairwise comparisons, it is important to highlight that similar to the previous section on memory performance, when discussing the effect of Part 3 or Part 5 memory on subsequent judgments, the memory content being compared for each Motivation Condition will be italicized.

As depicted in Figure 4A (left plot), the comparison of linear trends for Motivation Condition within Part 3 revealed that memory for the *Moral*-to-Control condition had a significantly more positive slope than the *Immoral*-to-Control condition, $b = 5.36$, $SE = 1.05$, $t(334) = 5.09$, $p < .001$, as well as the *Immoral*-to-Moral condition, $b = 5.6$, $SE = 1.18$, $t(355) = 4.75$, $p < .001$. Similarly, the slope for the *Moral*-to-Immoral condition was significantly more positive than the *Immoral*-to-Control condition, $b = 4.15$, $SE = 1.27$, $t(357) = 3.27$, $p = .007$, and the *Immoral*-to-Moral condition, $b = 4.39$, $SE = 1.37$, $t(362) = 3.19$, $p = .008$. All other comparisons were not significant (ps > .79). These findings indicate that within Model 2, when controlling for Part 5 memory, Part 3 memory for moral motivational content is associated with higher moral acceptability ratings for action judgments than memory for immoral motivational content, regardless of the motivational reframing content it is paired with in Part 5. Put another way, when participants have better memory for moral motivational content in Part 3, they rate the actions engaged by an agent as more morally acceptable when controlling for Part 5 memory. When they have better memory for immoral motivational content in Part 3, however, they rate actions as less morally acceptable when controlling for Part 5 memory.

A relatively similar pattern emerges with the Part 5 memory by Motivation Condition interaction, when controlling for Part 3 memory (Figure 4A, right plot). Specifically, there was a significant difference in slope between the memory in the Moral-to-*Immoral* and Immoral-to-*Moral* conditions, $b = 4.43$, $SE = 1.32$, $t(359) = 3.37$, $p = .005$. No other slope comparisons were statistically significant (*p*s > .35). That is, when participants recalled more moral motivational content in Part 5 they rated the actions engaged by agents as more morally acceptable, and when they recalled more immoral motivational content they rated the actions engaged by agents as less morally acceptable, when controlling for Part 3 memory.

Despite these similar patterns of Part 3 and Part 5 memory for moral and immoral content on action judgments, relatively less memory for motivational content in Part 3 was required to influence subsequent action judgments than was required for Part 5 moral or immoral motivational content. This is depicted by the dotted lines in Figure 4A. That is, the crossover interaction occurs at lower rates of memory performance for Part 3 memory (Figure 4a, left plot) than for Part 5 memory (Figure 4a, right plot). Surprisingly, these results provide evidence contrary to Hypothesis 2b, such that although Part 3 and Part 5 memory interactions with Motivation Condition are significant predictors of action judgments, participants appear to be engaging in behavioral patterns that reflect primacy effects rather than recency effects for motivational content. Memory for the first piece of motivational content may be a better predictor of memory judgments than the last piece of motivation information presented.

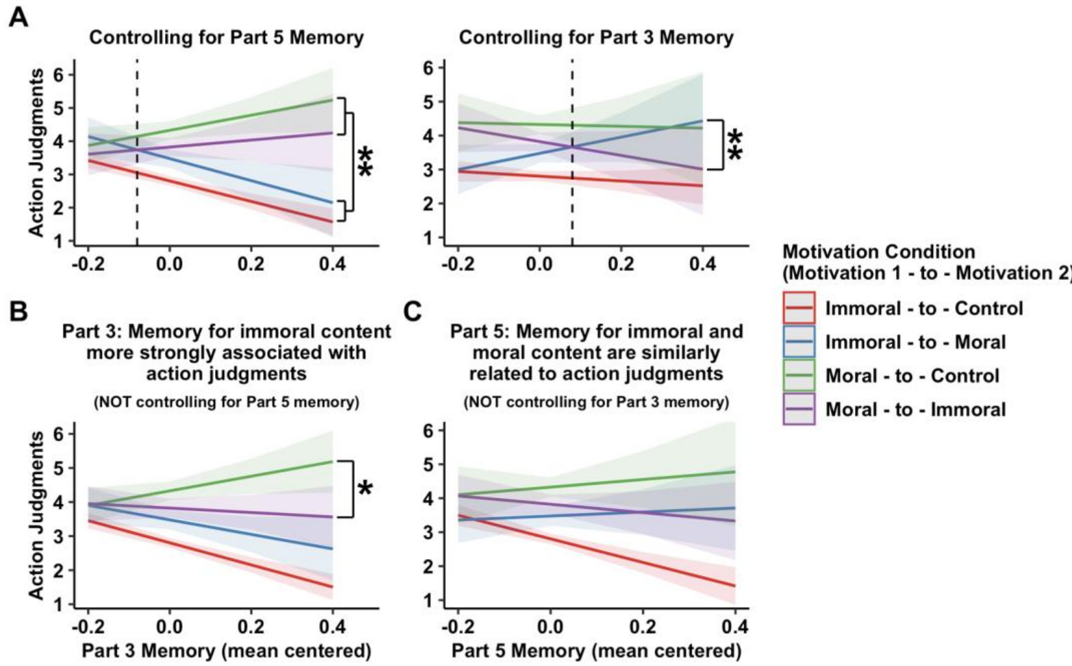

***Figure 4*. Memory for first motivation content and specifically immoral content is prioritized when predicting action judgments about others**. The y-axis in each plot reflects the predicted probabilities of action judgments. The x-axis reflects mean-centered Part 3 memory (percent correct) for the plots on the left. The x-axis reflects mean-centered Part 5 memory (percent correct) for plots on the right. A) The plots in this panel reflect the interaction terms from the following Model: Action Judgment ~ (Part 3 Memory * Motivation Condition) + (Part 5 Memory * Motivation Condition) + (1 | Participant). The plot on the left reflects the Part 3 * Motivation Condition term. The plot on the right reflects the Part 5 * Motivation Condition term. As indicated by the dotted lines, in each plot, less memory for Part 3 content than Part 5 content was required to impact Action Judgments. B) When modeling Part 3 memory alone (Model: Action Judgment ~ [Part 3 memory * Motivation Condition] + [1 | Participant]), memory for immoral motivational content appears to impact Action Judgments to a greater extent than moral content given the negative slope indicated within all of the conditions that contain immoral content; C) When modeling Part 5 memory alone (Model: Action Judgment ~ [Part 5 * Motivation Condition] + [1 | Participant]), memory for immoral and moral content appear to be similarly related to action judgments. All pairwise comparisons reflect comparisons of estimated marginal means of linear trends. All comparisons within each model reflect Tukey corrected p-values. * = $p < .05$; ** = $p < .01$; * = $p < .001$.

These memory-judgment relationships are further complicated when examining Part 3 memory, not controlling for Part 5 (Model 1, Figure 4b) memory and vice versa (Model 1.p5, Figure 4c). Model 1 demonstrated a significant main effect of Motivation Condition, $F(3, 308.2) = 57.23$, $p < .001$, $\eta_p^2 = .36$, as well as a significant main effect of Part 3 memory, $F(1, 385.7) =$

4.61, $p = .03$, $\eta_p{}^2 = .01$. Both of these effects were qualified by a significant Motivation Condition * Part 3 memory interaction $F(3, 337.06) = 10.97$, $p < .001$, $\eta_p{}^2 = .09$.

Further interrogation of this interaction by examining pairwise comparisons of estimated linear trends importantly revealed that the *Moral*-to-Control and *Moral*-to-Immoral trends were now significantly different, $b = 2.8$, $SE = 1.07$, $t(328) = 2.75$, $p = .03$, and the *Moral*-to-Immoral and *Immoral*-to-Moral conditions were no longer statistically different from each other, $b = 1.48$, $SE = 1.05$, $t(341) = 1.41$, $p = .49$. As depicted in Figure 4b, the *Moral*-to-Immoral condition has a negative slope, suggesting that although only memory for moral motivational content was explicitly modeled, immoral content may be influencing action judgments at higher levels of memory performance. All other comparisons in this model were consistent with the comparisons in Model 2 for Part 3 memory. Specifically, the *Moral*-to-Control condition was significantly more positive than the *Immoral*-to-Control condition, $b = 5.4$, $SE = 1.0$, $t(340) = 5.51$, $p < .001$, as well as the *Immoral*-to-Moral condition, $b = 4.28$, $SE = 1.04$, $t(336) = 4.11$, $p < .001$. The *Immoral*-to-Control condition was significantly different than the *Moral*-to-Immoral condition, $b = 2.6$, $SE = .98$, $t(338) = 2.66$, $p = .04$, but not significantly different than the *Immoral*-to-Moral condition, $b = 1.12$, $SE = 1$, $t(340) = 1.21$, $p = .68$.

Similar to Model 1, Model 1.p5 provided a significantly better overall model fit than the intercept-only model, $\chi^2(7) = 141.53$, $p < .001$. And yet again, Model 1.p5 revealed a significant main effect of Motivation Condition, $F(3, 313.89) = 54.63$, $p < .001$, $\eta_p{}^2 = .34$, but not Part 5 memory, $F(1, 417.36) = 1.22$, $p = .27$, $\eta_p{}^2 = .003$. This significant main effect of Motivation Condition was qualified by a significant Part 5 * Motivation Condition interaction, $F(3, 349.81) = 2.86$, $p = .04$, $\eta_p{}^2 = .02$. Further interrogation of this interaction by examining pairwise comparisons of estimated linear trends importantly revealed that none of the condition slopes were significantly different from one another (*p*s > .08).

Together the findings from Model 1 and Model 1.p5 indicate that memory for immoral motivational content may be specifically prioritized when making acceptability judgments about the actions engaged by agents. This finding provides support for Hypothesis 2a, such that the prioritization of immoral motivational content in memory appears to impact moral acceptability judgments of agents' actions to a greater extent than memory moral motivational content.

Finally, in order to determine whether memory for agents' actions can predict acceptability judgments for agents' actions over and above memory for (im)moral motivational content, Model 4 was estimated by updating Model 2 with the main effect of Part 4 memory and the Part 4 memory * Motivation Condition interaction. Model 3 did not improve overall model fit compared to Model 2, $\chi^2(4) = 4.23$, $p = .38$. This finding points to evidence against Hypothesis 2c, such that memory for actions did not explain any of the variability in acceptability judgments for agents' actions over and above (im)moral motivational content.

3.5 Discussion

The findings from the present study provide insights into how memory for mixed-valence motivations for other peoples' actions are prioritized in memory and how that memory is used to subsequently judge the moral acceptability of those actions. First, consistent with Hypothesis 1a, participants demonstrated a negativity bias in memory by prioritizing immoral motivational content compared to moral content during Part 3 (Motivation 1) memory. Relatedly, with regard to individual differences in the correlation between Part 3 (Motivation 1) and Part 5 (Motivation 2) memory, immoral motivational content appeared to also be prioritized such that the correlation magnitude for the Moral-to-Immoral condition was significantly stronger than the

Moral-to-Control condition, despite the lack of observed differences between the Immoral-to-Control condition and the Immoral-to-Moral condition. Second, content explicitly available in memory did indeed predict moral acceptability judgments for agents' actions in the vignettes presented. Although memory for both initial motivational framing (Part 3) as well as motivational reframing (Part 5) were significant predictors of acceptability judgments, the initial motivational framing appears to be prioritized when making acceptability judgments about actions in the present study. Consistent with Hypothesis 2a, the prioritization of immoral motivational content in memory appears to play a more substantial role in the moral acceptability judgments of agents' actions. Inconsistent with Hypothesis 2b, the findings from the memory-judgment relationships point to primacy effects rather than recency effects with regard to the influence (im)moral motivations on judgments. And finally, Hypothesis 2c was not supported, such that memory for actions did not predict judgments for those actions over and above memory for (im)moral motivational content. The implications for these findings in the broader context of the memory and moral judgment literatures will be discussed below.

Memory

The observed negativity bias for memory of the initial motivational framing (Part 3) is generally consistent with the negativity biases observed within the emotional memory literature. That is, younger adults, consistent with the age range of participants in our study, typically recall negative information to a greater extent than positive and neutral information (Carstensen & DeLiema, 2018). Although the conditions within the initial motivational framing in the present study did not contain neutral content, participants only had enhanced memory for immoral motivational content when it was followed by control content in the motivational reframing, compared to any other condition. Superior memory in this condition was even observed compared to the other condition that contained immoral content in the initial motivational framing, but was followed by moral content in the motivational reframing (i.e. the Immoral-to-Moral condition). As this condition was arguably the "purest" immoral motivational condition, these memory differences within the initial motivational framing suggest that negativity biases in the emotional memory literature may indeed extend to the moral domain.

Although a negativity bias within the motivational *reframing* did not occur, this is somewhat unsurprising given that memory for the Motivation Conditions in the motivational reframing corresponded to the two mixed valence conditions (i.e. Moral-to-Immoral and Immoral-to-Moral). That is, the findings from the motivational reframing were actually consistent with the findings from the initial motivational framing, in that there were no differences between these two motivation conditions in either part (i.e. Part 3 or Part 5). It is also important to highlight that despite this lack of memory difference between the mixed valence conditions for the motivational reframing (Part 5), superior memory performance for both of these Motivation Conditions compared to the conditions containing control content (i.e. Moral-to-Control and Immoral-to-Control) demonstrated a general (im)moral motivational enhancement. This finding importantly demonstrated that (im)moral motivational content is more salient than control content.

The negativity biases described above highlight the memory enhancement for immoral motivational content, but this enhancement may actually be driven by the presence of *moral* content in all the Motivation Conditions, with the exception of the Immoral-to-Control condition. One possibility is that moral motivational content is simply less memorable than the immoral motivational content. This is evident by the finding that memory for the Moral-to-Control condition was significantly worse than the Immoral-to-Control condition. Given that the mixed valence conditions were not recalled significantly better than the Moral-to-Control condition, however, it is possible that the presence of moral motivational content is somehow disrupting the memory trace within these conditions. For example, if moral motivational content was less memorable than immoral motivational content, a reasonable outcome would be enhanced memory for the initial motivational framing during the Immoral-to-Moral condition over the Moral-to-Control condition, and possibly the Moral-to-Immoral condition. Given that no differences were observed between these conditions, however, the presence of moral motivational content in the reframing of the Immoral-to-Moral condition may be disrupting memory for immoral content.

Relatedly, if the presence of moral motivational content is indeed somehow disrupting the memory trace of immoral motivational content, it is unclear at what stage this disruption occurs. For example, it is possible that the presence of moral content in mixed-valence scenarios is disrupting memory at encoding, such that it prevents portions of this motivational content from even entering the memory trace. One potential way for future work to address this possibility would involve experimental manipulation of encoding strength. Common ways to manipulate encoding strength often involve attempts to weaken encoding. For example, participants may be asked to read vignettes while completing a concurrent task (Craik et al., 1996; Naveh-Benjamin et al., 2014; Naveh-Benjamin & Brubaker, 2019). Additionally, the visual presentation of stimuli may be degraded for certain trials at encoding (Naveh-Benjamin & Kilb, 2014). Given the current speculation that that moral motivational content is already weakening the memory trace, however,a more useful approach with the present paradigm may involve experimentally *enhancing* encoding strength for certain conditions. This could be accomplished by using attention capture manipulations previously observed in the language processing literature, such as bolding or capitalizing certain Motivation Conditions at encoding (Sanford et al., 2006).

Alternatively, it is possible that the presence of moral motivational content in these vignettes weaken consolidation processes in mixed-valence conditions. Given that the present task may rely on both episodic memory and theory of mind processes to recall motivational content, the temporoparietal junction, speculatively, may serve as a brain region to examine in future work with respect to memory consolidation processes. This region is more typically associated with theory of mind (Saxe & Kanwisher, 2003; Young, Dodell-Feder, et al., 2010), however, it is also associated with episodic memory processes given its overlap with the Default Mode Network (Igelström & Graziano, 2017). Indeed other regions including the precuneus, and medial prefrontal cortex are associated with both of these cognitive processes (Abu-Akel & Shamay-Tsoory, 2011; Sestieri et al., 2011). Given the location of the temporoparietal junction, however, it serves as an optimal stimulation site to modulate cognitive processes, as made evident by previous research (Carter & Huettel, 2013; Donaldson et al., 2015; Young, Camprodon, et al., 2010). Future work examining post-encoding modulation of this region prior to retrieval, for example using transcranial magnetic stimulation, to either enhance or degrade memory may provide insight into whether the presence of moral motivational content in these mixed-valence scenarios impacts memory consolidation.

Finally, if the presence of moral motivational content is disrupting the memory trace, it is also possible that memory performance for these mixed-valence conditions are worse than the Immoral-to-Control condition due to competition between moral and immoral motivational content at the time of retrieval. That is, although successfully encoded and consolidated, memory for immoral motivational content at retrieval may be weakened due to increased competition with the presence of moral motivational content. Retrieval induced forgetting is a memory phenomenon demonstrated by the forgetting of content as a result of practiced retrievals of categorically similar content (for review see: Storm et al., 2015). Paradigms used to observe this phenomenon may provide a means by which to determine whether moral motivational content is in some way inhibiting memory for immoral motivational content via increased competition at retrieval. In light of the findings from this study, adapting the current paradigm to a retrieval induced forgetting design could also provide important insight into how rendering memory representations labile through repeated retrievals impacts the moral valence of information retrieved over time. Extrapolating such findings to conversations beyond the laboratory could have implications for how individuals share morally-valenced motivational content with several other people after hearing or reading a particular news story.

Overall the present study extends the findings of the emotional memory literature, demonstrating negative memory biases via the prioritization of immoral motivational content. Future work should seek to determine the memory mechanisms associated with the reduced negativity bias in mixed-valence motivation conditions.

Memory-Judgment Relationships

Regarding memory-judgment relationships, although memory for initial motivational framing and motivational reframing significantly predicted acceptability judgments about agents' actions, memory for the initial motivational framing may play a more important role in these judgments. This claim is due to the finding that less memory for initial motivational framing was required to influence judgments for each motivation condition. Although the present study initially predicted recency effects, such that memory for the last piece of motivational information learned about an agent would be more important for subsequent judgments, the findings suggest the opposite pattern. That is, participants' first impressions of agents based upon the initial motivational framing actually point to primacy effects with regard to the influence of memory for motivations on the moral acceptability judgments of related actions.

This finding is caveated, however, such that although memory for moral and immoral motivational content during the initial motivational framing appear to differentially impact acceptability judgments, immoral motivational content appears to play a more substantial role in these subsequent judgments. This claim is made evident by the finding from Model 1, such that the presence of immoral motivational content in a given condition was associated with lower acceptability judgments. Critically, this was even the case for the Moral-to-Immoral condition, in which immoral content was not explicitly modeled.

Although this paradigm did not use an impression updating procedure as in previous literature (Kim et al., 2022), these observed memory-judgment relationships suggest that in the absence of an initial moral judgment following the presentation of the initial motivational framing, the negative memory biases observed for motivational content appear to extend to subsequent acceptability judgments of agents' actions. These findings may be consistent with the general observation that negative information about individuals is more diagnostic than positive information (Martijn et al., 1992; Skowronski & Carlston, 1989), and this may extend to action judgments. Also, much of the work examining impression updating has been conducted in the context of implicit impression formation (for review see: Ferguson et al., 2019), however the present study appears to extend previous literature by demonstrating that immoral motivations are particularly salient for episodic memory prioritization and subsequent judgments of associated actions.

Despite the inability to provide a direct comparison with the impression updating literature, consideration of the findings from Kim et al. (2022) point to important future direction for the current work. Kim et al. (2022) found that when participants made an intervening moral judgment following the initial motivational framing, and updated these judgments immediately following the motivational reframing, there was a positivity bias in the magnitude of moral updating. This positivity bias was indicated by a larger shift in judgment during the Immoral-to-Moral condition than the Moral-to-Immoral condition. The present study tested participant memory for vignettes prior to their judgments. If the causal order of these memory judgment-relationships were reversed, however, we might expect to see more nuanced outcomes with regard to valence effects on memory. If participants make first and second-pass moral judgments following the initial motivational framing and motivational reframing respectively, these judgments may influence memory encoding prioritization in such a way that the magnitude of the judgment shift may impact the memory representation of a given vignette. This would be consistent with previous work demonstrating that negative moral judgments can lead to memory distortions for associated vignettes (Pizarro et al., 2006). Although speculative, this future work could have important implications for understanding how individuals explicitly recall information that has already been ascribed moral judgment.

Relatedly, one potential concern with the current findings is that trials containing immoral motivational content may have been more vividly remembered than moral motivations, leading to harsher judgments. Previous work demonstrated that increased vividness of the episodic simulation of imagined harms increased the reported likelihood that participants would actually engage in these simulated harms (Morris et al., 2022). Although Morris et al. (2022) examined imagined first-person harms, the increased vividness of episodic simulations being associated with subsequent moral decisions is particularly relevant in the context of the current study. According to the constructive episodic simulation hypothesis, imagining draws on aspects of episodic memories to novelly construct possible future events (Schacter & Addis, 2007, 2020; Schacter & Madore, 2016). As a result, the vividness-decision relationships observed by Morris et al. (2022) could hypothetically provide insight into the negative memory biases and subsequent judgments observed in the present study.

Despite this potential critique, memory findings of the present study seem to suggest that baseline vividness of the immoral motivational conditions did not bias episodic memory performance and by extension moral acceptability judgments of associated actions. If the immoral motivational conditions were more vivid than the moral motivational conditions, participants should have demonstrated better memory for the immoral motivations compared to the moral motivations in the mixed-valence Motivational Conditions (i.e. Moral-to-Immoral and Immoral-to-Moral). Given that memory performance was not different between these conditions within Motivation Condition (i.e. no differences between Moral or Immoral conditions within Moral-to-Immoral or Immoral-to-Moral scenarios respectively), or between mixed-valence Motivation Conditions within each Part (i.e. no difference between Moral-to-Immoral or Immoral-to-Moral within Part 3 or Part 5), these findings suggest that vividness did not differentially impact episodic memory for each Motivation Condition. Regardless, future work examining these memory-judgment relationships should also collect normative ratings of vividness for vignettes in order to address concerns about this potential confound.

Finally, one additional future direction for the present work involves the examination of age differences using this paradigm. Emotional memory biases tend to shift from negative to positive in older adulthood (Carstensen & Mikels, 2005). As such, it is possible that older adults may demonstrate positivity biases in memory in the current paradigm. These memory biases could potentially extend to subsequent judgments for agents' actions, leading to less harsh judgments. However, older adults also tend to focus to a lesser extent on the motivations of agents, and focus more on outcomes, when judging the morality of actions when harm is involved (Margoni et al., 2018). As a result, memory for motivations may not play such a significant role in older adulthood. Evaluating these potential age differences in future work will be important for understanding how people of different ages within society remember and judge actions observed by the broader community.

Limitations

Although the stimuli used provide the opportunity to observe memory differences for mixed-valence motivational content in narrative form akin to commonly viewed news articles, the present study has several limitations. Alongside vividness, the vignettes were not normed for valence, arousal, or personal relevance. As discussed to this point, younger adults tend to demonstrate negativity biases in memory with regard to emotional content. Also, the circumplex model of emotion (Russell, 1980) points to emotional arousal as playing an important role in emotional processing and memory. And finally, personal relevance may impact memory strength for each vignette, given that individuals tend to demonstrate better attention and memory for content that is highly self-relevant (Alexopoulos et al., 2012; Symons & Johnson, 1997). One way to address concerns about these potential stimuli confounds is to collect subject-level ratings for each vignette. In the present paradigm, however, these ratings were not collected during the first presentation of stimuli to avoid confounds related to the possibility of increased encoding strength associated with making these ratings. For example, it is possible that rating a vignette as more negative, highly arousing, or highly self-relevant may lead to enhanced encoding strength, subsequently confounding memory performance on the task. At the same time, collecting these ratings *after* participants completed the entire task, would likely reflect memory and judgment-induced confounds for each of these ratings. Given these concerns, future work will likely need to collect normative ratings in a separate sub-sample of participants who do not complete the memory or judgment tasks in order to address baseline stimuli characteristics.

Another potential limitation with the stimuli used in this study is that the moral and immoral motivational content may have provided a deeper level of encoding than the control content. This is because (im)moral motivational content may have required participants to engage theory of mind processes, whereas control content simply provided participants with additional contextual information for each vignette. This limitation, although speculative, also importantly highlights a gap in the memory literature. Presently it is unclear whether the presentation of agents' (im)moral motivations for engaging in behaviors is associated with deeper levels of memory encoding than other non-moral content that also engages theory of mind processes. For example, it is possible that an agents' beliefs, if morally neutral, are encoded at a shallower level than (im)moral motivational content. Future work demonstrating answers to this question may provide important insight into how agents' (im)moral motivational content is used in third-person judgments of associated actions.

The final limitation with regard to the stimuli used in the present study, involves the absence of a control condition within the initial motivational framing (i.e. Part 3). In the current design, it is possible that memory for control content was so poor, because participants deemed this content irrelevant at the time of encoding. This content was presented after the climax of each vignette (i.e. the action engaged), and given that it did not provide any motivational information, this content may not have been successfully encoded by participants. If control content is also placed during the initial motivational framing in future research (i.e. new conditions would be Control-to-Moral and Control-to-Immoral), this control content may become more salient in the context of the rest of the vignette, subsequently enhancing encoding strength. It is also possible that the (im)moral motivational content that follows will allow for encoding enhancement of this control content, given that it could potentially provide further (im)moral motivational context for control content to be incorporated into the larger memory trace.

With regard to the analysis approach, one potential critique is that the present study did not treat trial as a random effect. Indeed, a random intercept was modeled for participants when evaluating memory performance on judgments. Given that trials were not treated as a random effect, however, generalizations of the current findings to broader claims about third-person memory-judgment relationships with regard to moral motivational content should be heeded with caution. Future research should seek to determine whether vignettes should be modeled as random effects so as to broaden the generalizability claims related to memory for (im)moral motivations.

Finally, in an attempt to examine the relationships between explicitly retrieved memory content and moral acceptability judgments of others actions, the present study did not incorporate methods to determine how implicit evaluations might impact these relationships. Moral evaluations for actions and intentions can be formed implicitly (Kurdi et al., 2020). In the current design it is unclear which cognitive computations participants were engaging in when reading each vignette. It is possible that implicit moral evaluations could be formed either while reading or immediately after completing each vignette during memory encoding. As a result, although speculative, implicit moral evaluations may unintentionally impact memory encoding strength of vignettes. This would confound the observed effect of explicit memory retrieval on moral acceptability judgments, because the memories retrieved would actually reflect content that already maintains an implicit evaluation. Indeed the focus of this study was to elucidate the effect of explicitly retrieved episodic memory on associated moral judgments. In order to provide a broader account of memory-judgment relationships, future research will need to determine ways to incorporate the potentially complementary roles of implicit and explicit memory into one experimental paradigm (Amodio, 2019). This will help to better inform both the understanding of implicit-explicit memory associations in social contexts, as well as the understanding of how different memory subsystems impact the social judgment literature.

Conclusion

The present study provided the first evidence of negativity biases in explicit memory for (im)moral motivational content of agents' actions. These biases were also importantly related to subsequent moral acceptability judgments of these actions. Future work should continue to seek ways to evaluate the potential interacting roles of implicit and explicit memory systems as they relate to moral judgments. This will provide a holistic perspective on the relationships between memory and moral judgments.

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GENERAL DISCUSSION

Overview

The present research used a combination of resting-state functional connectivity and behavioral testing within and beyond the laboratory to examine how age is associated with potential cognitive and socioemotional motivational mechanisms in relation to first person moral decision-making and third person moral judgments. Generally, the findings indirectly point to the involvement of age-related motivational mechanisms in all three studies, but future work will need to experimentally manipulate motivational context in order to further provide causal evidence for these relationships.

Part I examined how resting-state functional connectivity of the Default Mode Network is related to working memory capacity and sacrificial moral decision-making in younger and older adults. Behaviorally, this work importantly extends previous literature that identifies older adults as endorsing fewer utilitarian decisions than younger adults during sacrificial moral dilemmas (K. Huang et al., 2021; McNair et al., 2019), by demonstrating that even in the absence of age-related working memory differences, older adults are less likely than younger adults to endorse the utilitarian option during sacrificial moral dilemmas that involve instrumental or direct harm to another individual. Indeed previous work has demonstrated that older adults with poorer fluid cognitive abilities also endorse fewer utilitarian decisions during dilemmas involving instrumental harm (S. Huang et al., 2021). In the absence of dilemmas involving indirect harm, however, it is unclear whether these previously observed differences in a sample demonstrating significantly different fluid cognitive abilities extend to less emotionally salient dilemmas. Although the present study did not test individual differences in working memory in relation to age-related differences in moral decision-making, these group-level outcomes point to involvement of mechanisms beyond fluid cognitive abilities as being associated with older adult reduction in the endorsement of utilitarian decisions during dilemmas involving instrumental harm.

More evidence for this claim is demonstrated by increased resting-state functional connectivity segregation of the Default Mode Network being associated with better working memory capacity in younger and older adults, but different age-related outcomes in moral decision-making. Specifically, segregation of this network was associated with similar rates of endorsing the utilitarian option across dilemmas involving instrumental and incidental harm in younger adults. In older adults, however, this behavioral performance was associated with decreased segregation of the Default Mode Network via coupling with Salience Network regions. Put another way, higher segregation of the Default Mode Network was associated with reduced endorsement of the utilitarian option during instrumental compared to incidental dilemmas in older adults, but similar endorsement of this option across dilemma types in younger adults.

If the functional integrity of this network tracked with fluid cognitive abilities and moral decision-making in similar ways, it would be expected that reduced segregation of this network would be associated with poorer working memory capacity, and similar behavioral outcomes in younger and older adults. Given that this set of relationships was not observed in the present sample, these findings further point to indirect support for mechanisms beyond age-related declines in fluid cognitive abilities as being associated with older adults' lower probability of endorsing the utilitarian option during dilemmas involving instrumental harm.

To further examine how age-related mechanisms associated with utilitarian moral decision-making extend beyond the laboratory, **Part II** asked a lifespan sample about their purchasing behaviors of extra amounts hard to find goods and medical supplies during the Spring 2020 phase of the COVID-19 pandemic in the United States. During this time period, news outlets throughout the United States highlighted shortages of goods such as toilet paper and medical supplies such as masks. As a result, panic-buying or hoarding of these materials could be thought of as non-utilitarian behaviors. Across this lifespan sample, advancing age was associated with increased purchasing of these goods and medical supplies, even when controlling for variables related to socioeconomic status. Critically, negative affective experience and negative memories related to the pandemic were also associated with these outcomes, but did not interact with age. The findings suggest that although older adults are motivated to maintain positive affective experiences and positive memory biases in particular (Carstensen & DeLiema, 2018), the presence of negative affective states, and negative memory, may be particularly consequential for the moral behaviors of adults at older ages in the midst of societal unrest.

Also, although advancing age was associated with higher reported purchasing of these supplies, of those individuals who did purchase extra amounts of these goods, advancing age was associated with an increased tendency to redistribute them to family members. Again, similar to **Part I**, the findings from **Part II**, point to support for age-related differences in motivation as supporting decreased utilitarian behaviors in older adults. This evidence is indirect given that **Part II** involved an observational study design and did not experimentally manipulate motivational context or cognitive difficulty with regard to purchasing behaviors.

Regardless of these limitations, this study also extends previous work linking negative affect in the context of moral dilemmas with reduced utilitarian decisions (McNair et al., 2019) to non-sacrificial non-hypothetical moral decision-making. It also highlights the involvement of episodic memory processes in moral decision-making in real-world settings. This extends recent work that demonstrates reduced utilitarian decision-making during sacrificial moral dilemmas in patients who have medial temporal lobe damage (McCormick et al., 2016b; Verfaellie et al., 2021). Involvement of emotional episodic memory performance did not interact with age in **Part II**, however, these findings suggest that alongside fluid cognitive abilities, future work should more extensively examine age-related changes in episodic memory and simulation abilities with regard to subsequent first-person moral decision-making.

Some work has already begun to examine the relationship between the episodic detail richness of positive memory and negative simulation in relation to subsequent moral behaviors. For example, Ford et al. (2018) demonstrated that more details of helping behaviors were associated with higher subsequent engagement of helping behaviors. In a similar vein, vivid episodic simulations of harm are positively associated with an increased likelihood to subsequently engage in harmful actions (Morris et al., 2022). Given that episodic memory and simulation rely on many similar mechanisms (Schacter & Addis, 2007), understanding age-related changes to these cognitive processes may provide yet another avenue to understand adult lifespan perspectives on first-person moral decision-making. These links between moral cognition and episodic memory processes highlight a connection between **Part II** and **Part III** of the present investigation.

Part III sought to extend previous research linking episodic memory processes with first-person moral decision-making, to third-person moral judgments in mixed-valence moral scenarios. This study specifically demonstrated that younger adults had better memory for immoral motivational content when it was followed by control content, than moral motivational content, or immoral motivational content followed by moral motivational content. Moreover, memory for an agents' motivations predict moral acceptability judgments of agents' actions, with particular emphasis on the first piece of motivational content learned about the agent, as well as recalled immoral motivational content. These findings, indeed extend previous work highlighting episodic memory processes associated with first person moral decisions to third person moral judgments. Interestingly, this pattern of result also highlights that memory for moral motivational content may reflect the negativity biases typically observed in the emotional memory literature in younger adults (Carstensen & DeLiema, 2018). These findings importantly set up future research examining whether age-related positivity biases in the emotional memory literature similarly extend to the moral domain, or whether this domain provides a contextual boundary on these age-related effects.

Cohort Effect Limitations

A limitation that was not discussed at length in **Parts I-III** is the cohort effect. The cross-sectional design employed in the current set of studies, as well as in previous research (K. Huang et al., 2021; S. Huang et al., 2021; Margoni, 2020; Margoni et al., 2018, 2019b; McNair et al., 2019) allows for the possibility that the life experiences of the older adult participants led to cohort effects that could potentially account for the observed age differences in moral decision-making (Hannikainen et al., 2018). Nonetheless, it remains important to understand differences in moral decision-making and judgments for those adults who are younger and older in this moment in history. As older adults remain active voters, are viewed as maintaining societal wisdom, and in many cases hold political office, the current explorations provide insight into the moral decision-making behavior of many who are looked to for moral insight. In this case, even if cohort effects can explain some of the variance in the age-related effects observed in the current research, it still remains important to determine other contributing mechanisms.

Relatedly, examining the mechanisms underlying these age-related effects also assists the literature, to some degree, in understanding moral cognition beyond the typical western, industrialized, educated, rich, and democratic (WEIRD; Henrich et al., 2010) research samples. "Young" is not included in the WEIRD acronym, but it is generally acknowledged that the findings from the psychological science literature are predominantly derived from undergraduate students. The advent of online data collection has helped to combat this issue of WEIRD study samples (Gosling et al., 2010), but older adults are often underrepresented in these online samples. Also, recent work questions whether data collected from online samples accurately reflects the older adult population in general (Ogletree & Katz, 2021). Although examining moral decision-making and judgments from an aging perspective can help to generalize the findings of the field, until paradigms are examined in cross-cultural contexts, it will be difficult to determine whether observed behaviors are universal or specific to western cultures. Gaining insight into how age interacts with culture to influence decision-making in moral and non-moral domains has been highlighted as an important area of future research (For review: Yates & de Oliveira, 2016). And finally, understanding the mechanisms contributing to the age-related differences in moral decision-making and judgments may not solve the issue of WEIRD participant populations, but it will at least provide the first step toward understanding the generalizability of these behaviors across the adult lifespan.

Implications

The findings of the present work highlight the complex interplay of cognitive and motivational mechanisms associated with age-related effects on first-person moral decision-making and third-person moral judgments. Indeed it is likely that cohort effects play some role in the age-related differences on these tasks. Cognitive and socioemotional motivational factors, as documented in the present work, and the broader psychology and neuroscience of aging literature, however, point to additional avenues for future research to consider. Extending the findings of the present work by further examining these mechanistic explanations will be crucial for understanding how moral decision-making and judgments are engaged by society as the aging population continues to grow.

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APPENDIX A

APPENDIX A
SECTION A.1
DESCRIPTION

There are two subsections of supplementary materials for Part I. See descriptions below for further details:

- SECTION A.2: This section contains a brief description of the Acceptability Self Bias Rating relationships with gray matter volume of the isthmus cingulate in younger and older adults.

- SECTION A.3: This section contains the supplementary Tables for Part I.

APPENDIX A
SECTION A.2
PART I: ACCEPTABILITY RATING SELF BIAS AND GRAY MATTER ANALYSES

Although gray matter volume of the posterior cingulate cortex and isthmus cingulate cortex were not associated with age-related differences in the decisions to engage or not engage in a proposed utilitarian action (i.e. Proposed Utilitarian Instrumental Bias), posterior cingulate cortex volume interacted with age to predict acceptability ratings of proposed utilitarian actions (i.e. Acceptability Rating Self Bias; Table S2 [Model 1.2.3], Figure S1). Specifically, those older adults with smaller gray matter volume in this region indicated that it was more morally acceptable to engage the utilitarian option during the Other condition compared to the Self condition, whereas younger adults demonstrated the opposite relationship at similar volumes in this region. This age group interaction with volume on Acceptability Rating Self Bias score did not replicate in the isthmus cingulate cortex (Table S3 [Model 1.2.1]).[6]

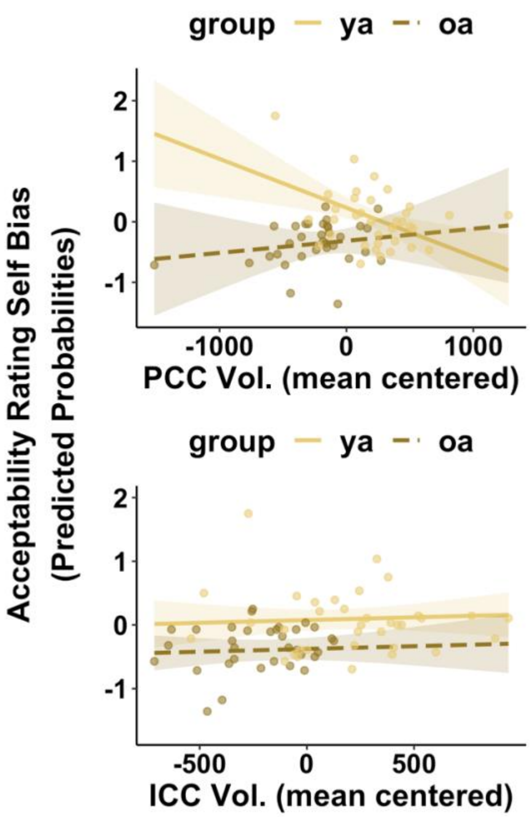


Figure S1. Age interacts with posterior cingulate cortex volume but not isthmus cingulate cortex volume to predict Acceptability Rating Self Bias scores. The plot on the top reflects the Age Group x PCC Vol. interaction term in Model 1.2.3. The plot on the left reflects the main effect of age group for Model 1.2.1 (ICC). ICC = isthmus cingulate cortex; OA = older adult; PCC = posterior cingulate cortex; YA = younger adult.

[6] Model 1.2.1 in Table S3 was chosen for plotting in the current analysis because neither Model 1.2.2, nor Model 1.2.3 with Isthmus Cingulate Cortex terms significantly improved overall model fit over Model 1.2.1.

APPENDIX A
SECTION A.3
PART I SUPPLEMENTARY TABLES

Table S1.

Proportion Utilitarian Instrumental Bias Model and Gray Matter Volume (Isthmus Cingulate Cortex)

	Model 1.1.1	Model 1.1.2	Model 1.1.3
(Intercept)	-0.398 ***	-0.419 ***	-0.431 ***
	[-0.452, -0.344]	[-0.493, -0.345]	[-0.511, -0.351]
Age Group	0.049	0.059	0.072 +
	[-0.021, 0.119]	[-0.016, 0.133]	[-0.008, 0.152]
mPFC Vol.	0.000	0.000	-0.000
	[-0.000, 0.000]	[-0.000, 0.000]	[-0.000, 0.000]
ICC Vol.	0.000	0.000	-0.000
	[-0.000, 0.000]	[-0.000, 0.000]	[-0.000, 0.000]
Age Group x mPFC Vol.		-0.000	0.000
		[-0.000, 0.000]	[-0.000, 0.000]
Age Group x ICC Vol.		0.000	0.000
		[-0.000, 0.000]	[-0.000, 0.001]
mPFC Vol. x ICC Vol.			-0.000
			[-0.000, 0.000]
Age Group x mPFC Vol. x PCC Vol.			0.000
			[-0.000, 0.000]
Num.Obs.	68	68	68

R2	0.190	0.203	0.215
R2 Adj.	0.152	0.139	0.124
AIC	-4.9	-2.0	0.9
BIC	6.2	13.5	20.9
Log.Lik.	7.450	7.998	8.533
F	5.004	3.157	2.353

Note: Dependent Variable = Proportion Utilitarian Instrumental Bias score. Age Group is deviation coded (YA = 1, OA = -1). All other independent variables are mean-centered. Brackets indicate 95% CI for estimate. p < 0.1 = + p < 0.05 = *, p < 0.01 = **, p < 0.001 = ***.

Table S2.

Acceptability Rating Self Bias and Gray Matter Volume

	Model 1.2.1	Model 1.2.2	Model 1.2.3
(Intercept)	-0.151 **	-0.068	-0.041
	[-0.255, -0.047]	[-0.206, 0.070]	[-0.177, 0.094]
Age Group	0.248 ***	0.237 **	0.273 ***
	[0.112, 0.384]	[0.099, 0.375]	[0.138, 0.408]
mPFC Vol.	-0.000	-0.000	-0.000 +
	[-0.000, 0.000]	[-0.000, 0.000]	[-0.001, 0.000]
PCC Vol.	-0.000	-0.000	-0.000
	[-0.000, 0.000]	[-0.000, 0.000]	[-0.001, 0.000]
Age Group x mPFC Vol.		0.000	-0.000
		[-0.000, 0.000]	[-0.000, 0.000]
Age Group x PCC Vol.		-0.000 *	-0.001 *
		[-0.001, -0.000]	[-0.001, -0.000]
mPFC Vol. x PCC Vol.			0.000
			[-0.000, 0.000]
Age Group x mPFC Vol. x PCC Vol.			0.000
			[-0.000, 0.000]
Num.Obs.	68	68	68
R2	0.200	0.266	0.352

R2 Adj.	0.163	0.206	0.277
AIC	84.0	82.3	77.7
BIC	95.1	97.8	97.7
Log.Lik.	-37.021	-34.128	-29.850
F	5.345	4.484	4.665

Note: Dependent Variable = Acceptability Rating Self Bias score. Age Group is deviation coded (YA = 1, OA = -1). Brackets indicate 95% CI for estimate. All other independent variables are mean-centered. p < 0.1 = + p < 0.05 = *, p < 0.01 = **, p < 0.001 = ***.

Table S3.

Acceptability Rating Self Bias and Gray Matter Volume (Isthmus Cingulate Cortex)

	Model 1.2.1	Model 1.2.2	Model 1.2.3
(Intercept)	-0.150 **	-0.104	-0.059
	[-0.254, -0.046]	[-0.246, 0.039]	[-0.207, 0.089]
Age Group	0.227 **	0.206 **	0.180 *
	[0.092, 0.361]	[0.064, 0.349]	[0.032, 0.328]
mPFC Vol.	-0.000	-0.000	-0.000
	[-0.000, 0.000]	[-0.000, 0.000]	[-0.001, 0.000]
PCC Vol.	0.000	0.000	0.000
	[-0.000, 0.000]	[-0.000, 0.001]	[-0.000, 0.001]
Age Group x mPFC Vol.		0.000	-0.000
		[-0.000, 0.000]	[-0.001, 0.000]
Age Group x ICC Vol.		-0.000	-0.001 *
		[-0.001, 0.000]	[-0.001, -0.000]
mPFC Vol. x ICC Vol.			0.000 +
			[-0.000, 0.000]
Age Group x mPFC Vol. x ICC Vol.			-0.000
			[-0.000, 0.000]
Num.Obs.	68	68	68
R2	0.202	0.218	0.281

R2 Adj.	0.164	0.155	0.197
AIC	83.9	86.5	84.8
BIC	95.0	102.1	104.8
Log.Lik.	-36.960	-36.260	-33.404
F	5.393	3.458	3.351

Note: Dependent variable = Acceptability Rating Self Bias score. Age Group is deviation coded (YA = 1, OA = -1). All other independent variables are mean-centered. Brackets indicate 95% CI for estimate. p < 0.1 = + p < 0.05 = *, p < 0.01 = **, p < 0.001 = ***.

Table S4.
Digit Span Backward and Gray Matter Volume

	Model 1.4.1	Model 1.4.2	Model 1.4.3
(Intercept)	9.50 ***	10.09 ***	10.08 ***
	[8.97, 10.04]	[9.32, 10.85]	[9.21, 10.95]
Age Group	0.05	0.30	0.32
	[-0.70, 0.80]	[-0.46, 1.06]	[-0.55, 1.19]
mPFC Vol.	0.00	0.00	0.00
	[-0.00, 0.00]	[-0.00, 0.00]	[-0.00, 0.00]
PCC Vol.	0.00	-0.00	-0.00
	[-0.00, 0.00]	[-0.00, 0.00]	[-0.00, 0.00]
Age Group x mPFC Vol.		-0.00	-0.00
		[-0.00, 0.00]	[-0.00, 0.00]
Age Group x PCC Vol.		-0.00 *	-0.00
		[-0.00, -0.00]	[-0.00, 0.00]
mPFC Vol. x PCC Vol.			-0.00
			[-0.00, 0.00]
Age Group x mPFC Vol. x PCC Vol.			0.00
			[-0.00, 0.00]
Num.Obs.	58	58	58
R2	0.051	0.141	0.151

R2 Adj.	-0.002	0.058	0.032
AIC	252.1	250.3	253.7
BIC	262.4	264.7	272.2
Log.Lik.	-121.052	-118.157	-117.829
F	0.963	1.707	1.267

Note: Dependent variable = Digit Span Backward Score. Age Group is deviation coded (YA = 1, OA = -1). All other independent variables are mean-centered. Brackets indicate 95% CI for estimate. $p < 0.1$ = + $p < 0.05$ = *, $p < 0.01$ = **, $p < 0.001$ = ***.

Table S5.
Digit Span Backward and Gray Matter Volume (ICC)

	Model 1.4.1	Model 1.4.2	Model 1.4.3
(Intercept)	9.51 ***	9.87 ***	9.93 ***
	[8.98, 10.05]	[9.17, 10.57]	[9.22, 10.64]
Age Group	0.14	0.10	0.23
	[-0.57, 0.85]	[-0.60, 0.80]	[-0.48, 0.94]
mPFC Vol.	0.00	0.00	-0.00
	[-0.00, 0.00]	[-0.00, 0.00]	[-0.00, 0.00]
PCC Vol.	-0.00	0.00	-0.00
	[-0.00, 0.00]	[-0.00, 0.00]	[-0.00, 0.00]
Age Group x mPFC Vol.		0.00	-0.00
		[-0.00, 0.00]	[-0.00, 0.00]
Age Group x ICC Vol.		-0.00 +	-0.00
		[-0.00, 0.00]	[-0.00, 0.00]
mPFC Vol. x ICC Vol.			0.00
			[-0.00, 0.00]
Age Group x mPFC Vol. x ICC Vol.			0.00
			[-0.00, 0.00]
Num.Obs.	58	58	58
R2	0.050	0.111	0.159

R2 Adj.	-0.003	0.026	0.041
AIC	252.2	252.3	253.1
BIC	262.5	266.7	271.6
Log.Lik.	-121.076	-119.145	-117.537
F	0.947	1.301	1.352

Note: Dependent variable = Digit Span Backward Score. Age Group is deviation coded (YA = 1, OA = -1). All other independent variables are mean-centered. Brackets indicate 95% CI for estimate. $p < 0.1$ = + $p < 0.05$ = *, $p < 0.01$ = **, $p < 0.001$ = ***.

Table S6.

Proportion Utilitarian Instrumental Bias Score, Gray Matter Volume and Resting-State Functional Connectivity (Younger Adults - ICC)

	Model 2.1.1	Model 2.1.2
(Intercept)	-1.12 *	-0.97 +
	[-1.99, -0.25]	[-1.99, 0.05]
mPFC Vol.	0.00	0.00
	[-0.00, 0.00]	[-0.00, 0.00]
ICC Vol.	0.00	0.00
	[-0.00, 0.00]	[-0.00, 0.00]
mPFC-to-PCC RSFC		-0.15
		[-0.65, 0.35]
Num.Obs.	33	33
R2	0.113	0.125
R2 Adj.	0.054	0.034
AIC	1.5	3.1
BIC	7.5	10.6
Log.Lik.	3.250	3.464
F	1.918	1.378

Note: Dependent variable = Proportion Utilitarian Instrumental Bias. All independent variables are mean-centered. Brackets indicate 95% CI for estimate. p < 0.1 = + p < 0.05 = *, p < 0.01 = **, p < 0.001 = ***.

Table S7.

Proportion Utilitarian Instrumental Bias Score, Gray Matter Volume and Resting-State Functional Connectivity (Older Adults - ICC)

	Model 2.1.1	Model 2.1.2
(Intercept)	-1.27 *	-1.26 *
	[-2.45, -0.09]	[-2.44, -0.08]
mPFC Vol.	0.00	0.00
	[-0.00, 0.00]	[-0.00, 0.00]
ICC Vol.	-0.00	-0.00
	[-0.00, 0.00]	[-0.00, 0.00]
mPFC-to-PCC RSFC		-0.25
		[-0.70, 0.20]
Num.Obs.	31	31
R2	0.087	0.128
R2 Adj.	0.021	0.031
AIC	-7.6	-7.0
BIC	-1.8	0.2
Log.Lik.	7.783	8.502
F	1.328	1.322

Note: Dependent variable = Proportion Utilitarian Instrumental Bias. All independent variables are mean-centered. Brackets indicate 95% CI for estimate. p < 0.1 = + p < 0.05 = *, p < 0.01 = **, p < 0.001 = ***.

Table S8.

Acceptability Rating Self Bias, Gray Matter Volume and Resting-State Functional Connectivity (Younger Adults)

	Model 2.2.1	Model 2.2.2
(Intercept)	1.97 +	2.02 +
	[-0.01, 3.96]	[-0.25, 4.29]
mPFC Vol.	-0.00	-0.00
	[-0.00, 0.00]	[-0.00, 0.00]
PCC Vol.	-0.00 +	-0.00 +
	[-0.00, 0.00]	[-0.00, 0.00]
mPFC-to-PCC RSFC		-0.04
		[-1.08, 1.00]
Num.Obs.	33	33
R2	0.131	0.131
R2 Adj.	0.073	0.042
AIC	49.3	51.3
BIC	55.3	58.8
Log.Lik.	-20.646	-20.642
F	2.266	1.463

Note: Dependent variable = Acceptability Rating Self Bias. All independent variables are mean-centered. Brackets indicate 95% CI for estimate. p < 0.1 = + p < 0.05 = *, p < 0.01 = **, p < 0.001 = ***.

Table S9.

Acceptability Rating Self Bias, Gray Matter Volume and Resting-State Functional Connectivity (Younger Adults - ICC)

	Model 2.1.1	Model 2.1.2
(Intercept)	-1.12 *	-0.97 +
	[-1.99, -0.25]	[-1.99, 0.05]
mPFC Vol.	0.00	0.00
	[-0.00, 0.00]	[-0.00, 0.00]
ICC Vol.	0.00	0.00
	[-0.00, 0.00]	[-0.00, 0.00]
mPFC-to-PCC RSFC		-0.15
		[-0.65, 0.35]
Num.Obs.	33	33
R2	0.113	0.125
R2 Adj.	0.054	0.034
AIC	1.5	3.1
BIC	7.5	10.6
Log.Lik.	3.250	3.464
F	1.918	1.378

Note: Dependent variable = Acceptability Rating Self Bias. All independent variables are mean-centered. Brackets indicate 95% CI for estimate. $p < 0.1$ = + $p < 0.05$ = *, $p < 0.01$ = **, $p < 0.001$ = ***.

Table S10.

Acceptability Rating Self Bias, Gray Matter Volume and Resting-State Functional Connectivity (Older Adults)

	Model 2.2.1	Model 2.2.2
(Intercept)	-0.77	-0.81
	[-2.98, 1.44]	[-3.00, 1.37]
mPFC Vol.	-0.00	-0.00
	[-0.00, 0.00]	[-0.00, 0.00]
PCC Vol.	0.00	0.00
	[-0.00, 0.00]	[-0.00, 0.00]
mpfc_to_pcc		0.52
		[-0.29, 1.32]
Num.Obs.	31	31
R2	0.090	0.144
R2 Adj.	0.025	0.049
AIC	29.2	29.3
BIC	34.9	36.4
Log.Lik.	-10.593	-9.637
F	1.382	1.517

Note: Dependent variable = Acceptability Rating Self Bias. All independent variables are mean-centered. Brackets indicate 95% CI for estimate. $p < 0.1$ = + $p < 0.05$ = *, $p < 0.01$ = **, $p < 0.001$ = ***.

Table S11.

Acceptability Rating Self Bias, Gray Matter Volume and Resting-State Functional Connectivity (Older Adults - ICC)

	Model 2.1.1	Model 2.1.2
(Intercept)	-1.27 *	-1.26 *
	[-2.45, -0.09]	[-2.44, -0.08]
mPFC Vol.	0.00	0.00
	[-0.00, 0.00]	[-0.00, 0.00]
ICC Vol.	-0.00	-0.00
	[-0.00, 0.00]	[-0.00, 0.00]
mPFC-to-PCC RSFC		-0.25
		[-0.70, 0.20]
Num.Obs.	31	31
R2	0.087	0.128
R2 Adj.	0.021	0.031
AIC	-7.6	-7.0
BIC	-1.8	0.2
Log.Lik.	7.783	8.502
F	1.328	1.322

Note: Dependent variable = Acceptability Rating Self Bias. All independent variables are mean-centered. Brackets indicate 95% CI for estimate. $p < 0.1$ = + $p < 0.05$ = *, $p < 0.01$ = **, $p < 0.001$ = ***.

Table S12.

Digit Span Forward, Gray Matter Volume and Resting-State Functional Connectivity (Younger Adults - ICC)

	Model 2.3.1	Model 2.3.2
(Intercept)	16.46 **	15.09 *
	[5.29, 27.64]	[3.43, 26.74]
mPFC Vol.	-0.00	-0.00
	[-0.00, 0.00]	[-0.00, 0.00]
ICC Vol.	-0.00	-0.00
	[-0.00, 0.00]	[-0.00, 0.00]
mPFC-to-PCC Vol.		2.40
		[-2.95, 7.74]
Num.Obs.	24	24
R2	0.056	0.095
R2 Adj.	-0.034	-0.040
AIC	105.9	106.8
BIC	110.6	112.7
Log.Lik.	-48.936	-48.422
F	0.619	0.702

Note: Dependent variable = Digit Span Forward. All independent variables are mean-centered. Brackets indicate 95% CI for estimate. p < 0.1 = + p < 0.05 = *, p < 0.01 = **, p < 0.001 = ***.

Table S13.

Digit Span Forward, Gray Matter Volume and Resting-State Functional Connectivity (Older Adults - ICC)

	Model 2.3.1	Model 2.3.2
(Intercept)	3.18	2.97
	[-11.16, 17.52]	[-11.57, 17.50]
mPFC Vol.	0.00	0.00
	[-0.00, 0.00]	[-0.00, 0.00]
ICC Vol.	0.00	0.00
	[-0.00, 0.01]	[-0.00, 0.01]
mPFC-to-PCC RSFC		1.68
		[-3.56, 6.91]
Num.Obs.	30	30
R2	0.065	0.080
R2 Adj.	-0.004	-0.026
AIC	138.9	140.4
BIC	144.5	147.4
Log.Lik.	-65.447	-65.198
F	0.938	0.757

Note: Dependent variable = Digit Span Forward. All independent variables are mean-centered. Brackets indicate 95% CI for estimate. p < 0.1 = + p < 0.05 = *, p < 0.01 = **, p < 0.001 = ***.

Table S14.

Digit Span Backward, Gray Matter Volume and Resting-State Functional Connectivity (Younger Adults)

	Model 2.4.1	Model 2.4.2
(Intercept)	11.33	11.44
	[-3.79, 26.45]	[-4.15, 27.03]
mPFC Vol.	0.00	0.00
	[-0.00, 0.00]	[-0.00, 0.00]
PCC Vol.	-0.00	-0.00
	[-0.00, 0.00]	[-0.01, 0.00]
mPFC-to-PCC RSFC		0.51
		[-5.65, 6.66]
Num.Obs.	24	24
R2	0.027	0.028
R2 Adj.	-0.066	-0.117
AIC	107.2	109.1
BIC	111.9	115.0
Log.Lik.	-49.589	-49.571
F	0.290	0.194

Note: Dependent variable = Digit Span Backward. All independent variables are mean-centered. Brackets indicate 95% CI for estimate. p < 0.1 = + p < 0.05 = *, p < 0.01 = **, p < 0.001 = ***.

Table S15.

Digit Span Backward, Gray Matter Volume and Resting-State Functional Connectivity (Younger Adults - ICC)

	Model 2.4.1	Model 2.4.2
(Intercept)	9.40	9.51
	[-2.09, 20.90]	[-2.74, 21.76]
mPFC Vol.	0.00	0.00
	[-0.00, 0.00]	[-0.00, 0.00]
ICC VOl.	-0.00	-0.00
	[-0.00, 0.00]	[-0.00, 0.00]
mPFC-to-PCC RSFC		-0.19
		[-5.81, 5.43]
Num.Obs.	24	24
R2	0.024	0.024
R2 Adj.	-0.069	-0.122
AIC	107.2	109.2
BIC	112.0	115.1
Log.Lik.	-49.623	-49.620
F	0.259	0.166

Note: Dependent variable = Digit Span Backward. All independent variables are mean-centered. Brackets indicate 95% CI for estimate. p < 0.1 = + p < 0.05 = *, p < 0.01 = **, p < 0.001 = ***.

Table S16.

Digit Span Backward, Gray Matter Volume and Resting-State Functional Connectivity (Older Adults)

	Model 2.4.1	Model 2.4.2
(Intercept)	-2.53	-2.68
	[-14.06, 9.01]	[-14.39, 9.03]
mPFC Vol.	0.00	0.00
	[-0.00, 0.00]	[-0.00, 0.00]
PCC Vol.	0.00	0.00
	[-0.00, 0.00]	[-0.00, 0.00]
mPFC-to-PCC Vol.		1.18
		[-3.07, 5.44]
Num.Obs.	30	30
R2	0.171	0.181
R2 Adj.	0.110	0.087
AIC	126.3	127.9
BIC	131.9	134.9
Log.Lik.	-59.157	-58.970
F	2.786	1.919

Note: Dependent variable = Digit Span Backward. All independent variables are mean-centered. Brackets indicate 95% CI for estimate. p < 0.1 = + p < 0.05 = *, p < 0.01 = **, p < 0.001 = ***.

Table S17.

Digit Span Backward, Gray Matter Volume and Resting-State Functional Connectivity (Older Adults - ICC)

	Model 2.4.1	Model 2.4.2
(Intercept)	-2.51	-2.66
	[-14.25, 9.23]	[-14.59, 9.26]
mPFC Vol.	0.00	0.00
	[-0.00, 0.00]	[-0.00, 0.00]
ICC Vol.	0.00	0.00
	[-0.00, 0.01]	[-0.00, 0.01]
mPFC-to-PCC RSFC		1.18
		[-3.11, 5.48]
Num.Obs.	30	30
R2	0.155	0.166
R2 Adj.	0.093	0.069
AIC	126.9	128.5
BIC	132.5	135.5
Log.Lik.	-59.438	-59.254
F	2.484	1.721

Note: Dependent variable = Digit Span Backward. All independent variables are mean-centered. Brackets indicate 95% CI for estimate. $p < 0.1$ = + $p < 0.05$ = *, $p < 0.01$ = **, $p < 0.001$ = ***.

APPENDIX B

APPENDIX B
SECTION B.1
DESCRIPTION

There are three subsections of supplementary materials for Part II. See descriptions below for further details.

- SECTION B.2: This section contains all of the supplementary tables and figures referenced in the body of the manuscript in Part II. Supplementary Tables and Figures are denoted by the prefix “S” (e.g., Table S1, Figure S1, etc.).

- SECTION B.3: This section contains the additional control analyses and tables for the models examined in the body of the manuscript. Control tables are denoted by the prefix “C” (e.g., Table C1).

- SECTION B.4: This section contains additional analyses that were originally included in the preregistration for this study, but do not appear in the body of the manuscript. See this section for rationale behind this decision. Additional analysis tables are denoted by the prefix “A” (e.g. Table A1).

APPENDIX B
SECTION B.2
PART II: SUPPLEMENTARY TABLES AND FIGURES

Table S1.
Demographics (Goods and Medical Memory Sample)

Variable	Category	n (total = 441)	%
Race	African American	9	2.0
	American Indian / Alaska Native	1	0.2
	Asian	43	9.8
	Latinx	6	1.4
	More than one race	3	0.7
	Prefer Not to Say	1	0.2
	Unknown	1	0.2
	White	377	85.5
Ethnicity	Ethnicity Unreported	4	0.9
	Hispanic	20	4.5
	Not Hispanic	417	94.6
Biological Sex	Female	362	82.1
	Male	79	17.9
Income	$0 - $25,000	23	5.2
	$25,001 - $50,000	70	15.9
	$50,001 - $75,000	71	16.1
	$75,001 - $100,000	81	18.4
	$100,001 - $150,000	94	21.3
	$150,001 - $250,000	54	12.2
	$250,000+	48	10.9

Table S2.

Memory Sample Behavioral Outcomes (1 = Engaged in Behavior; 0 = Did Not Engage in Behavior)

Question	Value	n
goods_scarcity	0	313
goods_scarcity	1	128
med_scarcity	0	287
med_scarcity	1	154

Table S3.
Independent Variable Summary Statistics (Goods and Medical Memory Sample)

	Mean	SD	Min	Max	1	2	3	4	5
1. Age	40.19	17.87	18.00	90.00	1	.	.	.	.
2. PANAS_PA	23.31	9.28	10.00	50.00	.36	1	.	.	.
3. PANAS_NA	15.67	6.08	10.00	43.00	-.08	-.14	1	.	.
4. Housing	1.70	1.44	0.00	8.00	-.30	-.03	.06	1	.
5. Dependents	0.34	0.79	0.00	6.00	.11	.01	.07	.40	1

Note: The last five columns indicate Pearson r correlation coefficients. N = 441.

Table S4.

Goods Scarcity Post-Hoc Motivations: Yes Responses

	1	2	3	4	5	6	7	8
(Intercept)	5.43***	5.43***	4.85***	6.77***	5.79***	3.86***	2.70***	1.40***
	[4.55, 6.31]	[4.71, 6.15]	[4.09, 5.61]	[6.14, 7.40]	[4.87, 6.71]	[2.93, 4.79]	[1.89, 3.51]	[0.76, 2.05]
Age	-0.00	0.01	0.01	-0.00	-0.03**	-0.00	0.00	0.01+
	[-0.02, 0.02]	[-0.00, 0.03]	[-0.01, 0.03]	[-0.02, 0.01]	[-0.05, -0.01]	[-0.03, 0.02]	[-0.01, 0.02]	[-0.00, 0.03]
N	128	135	127	139	131	118	121	130
R2	0.001	0.015	0.010	0.001	0.064	0.002	0.002	0.026
F	0.143	2.066	1.270	0.184	8.847	0.206	0.283	3.402

Note: Column numbers correspond to motivations listed in Figure S1. 95% confidence intervals are indicated in brackets. + < 0.1, * < 0.05, ** < 0.01, *** < 0.001.

Table S5.

Goods Scarcity Post-Hoc Motivations: No Responses

	1	2	3
(Intercept)	2.34***	2.59***	1.03***
	[2.18, 2.49]	[2.45, 2.73]	[0.93, 1.12]
Age	-0.00	0.00	0.00*
	[-0.00, 0.00]	[-0.00, 0.00]	[0.00, 0.00]
N	345	351	347
R2	0.000	0.000	0.011
F	0.082	0.012	3.923

Note: Column numbers correspond to motivations listed in Figure S1. 95% confidence intervals are indicated in brackets. + < 0.1, * < 0.05, ** < 0.01, *** < 0.001.

Table S6.
Medical Supply Scarcity Model (Memory Sample)

	Medical Model 2.1	Medical Model 2.2	Medical Model 2.2 (Control: Housing)	Medical Model 2.3	Medical Model 2.4
(Intercept)	-0.64***	-0.61***	-1.19***	-0.62***	-0.59***
	[-0.84, -0.44]	[-0.82, -0.41]	[-1.54, -0.85]	[-0.82, -0.42]	[-0.80, -0.38]
Age	0.01*	0.02**	0.02***	0.01*	0.02**
	[0.00, 0.03]	[0.00, 0.03]	[0.01, 0.04]	[0.00, 0.03]	[0.00, 0.03]
PANAS_NA	0.04**	0.04*	0.04*	0.04*	0.04*
	[0.01, 0.08]	[0.01, 0.08]	[0.01, 0.08]	[0.00, 0.08]	[0.00, 0.08]
Age × PANAS_NA		0.00*	0.00*	0.00+	0.00+
		[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[-0.00, 0.00]
Housing			0.33***		
			[0.18, 0.48]		
Negative Memory				0.17	0.17
				[-0.06, 0.41]	[-0.06, 0.42]
Positive Memory				0.04	0.03
				[-0.18, 0.27]	[-0.20, 0.27]
Age x Negative Memory					0.00
					[-0.01, 0.01]
Age x Positive Memory					-0.01

					[-0.02, 0.00]
N	441	441	441	441	441
AIC	564.3	561.7	544.5	563.3	565.4
BIC	576.6	578.0	564.9	587.8	598.1
Log.Lik.	-279.165	-276.845	-267.244	-275.632	-274.683
McFadden's Pseudo R2	0.022	0.03	0.063	0.034	0.037

Note: Age, PANAS_PA, and PANAS_NA are mean centered. 95% confidence intervals are indicated in brackets. p < 0.05 = *, p < 0.01 = **, p < 0.001 = ***.

Table S7.

Medical Supply Scarcity Post-Hoc Motivations: Yes Responses

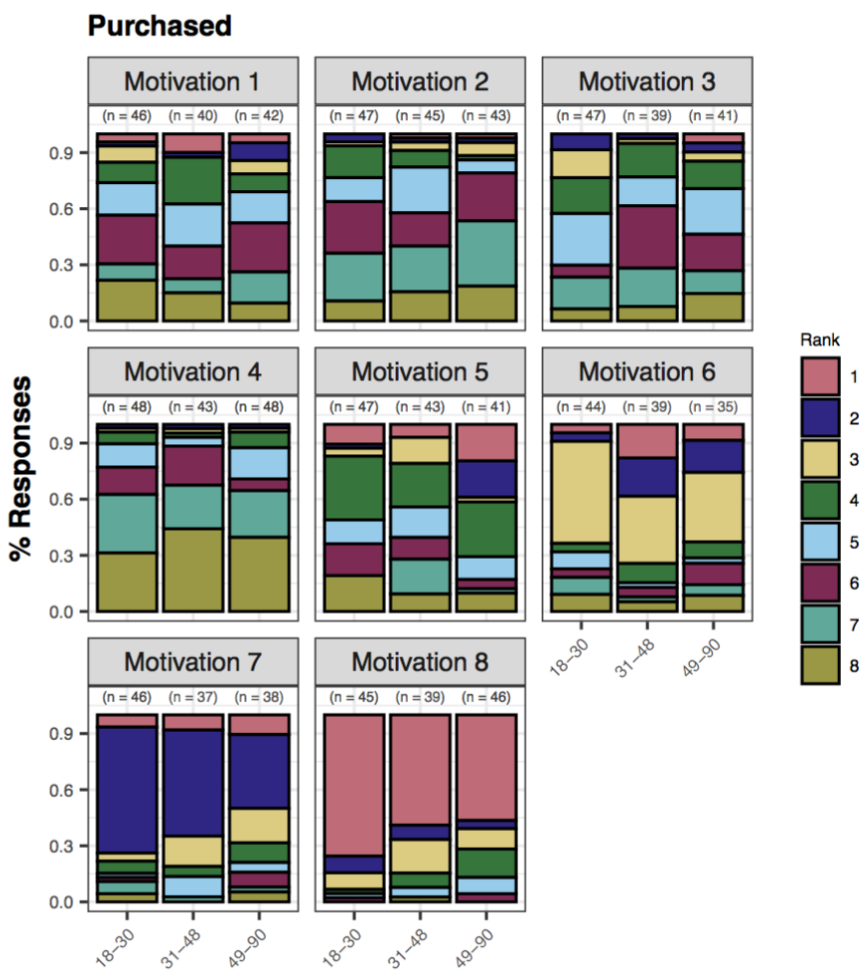
	1	2	3	4	5	6	7
(Intercept)	5.30***	4.93***	2.46***	3.32***	3.72***	2.50***	1.82***
	[4.90, 5.70]	[4.53, 5.33]	[1.89, 3.02]	[2.82, 3.81]	[3.17, 4.27]	[2.01, 3.00]	[1.13, 2.52]
Age	0.00	0.00	0.00	0.01	-0.01*	-0.01	-0.00
	[-0.01, 0.01]	[-0.01, 0.01]	[-0.01, 0.02]	[-0.00, 0.02]	[-0.02, -0.00]	[-0.02, 0.00]	[-0.01, 0.01]
N	149	151	124	140	139	119	86
R2	0.003	0.002	0.004	0.018	0.036	0.018	0.000
F	0.376	0.246	0.479	2.478	5.048	2.163	0.012

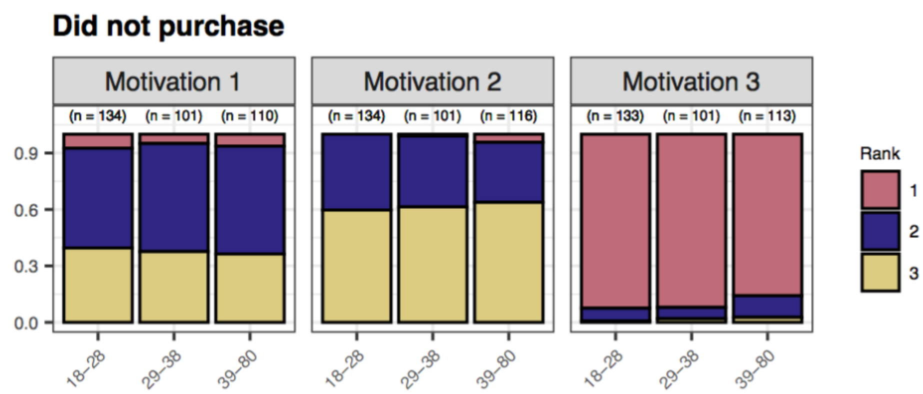
Note: Column numbers correspond to motivations listed in Figure S2. 95% confidence intervals are indicated in brackets. + < 0.1, * < 0.05, ** < 0.01, *** < 0.001.

Table S8.
Medical Supply Scarcity Post-Hoc Motivations: No Responses

	1	2	3	4
(Intercept)	3.37***	3.01***	1.11***	2.42***
	[3.14, 3.60]	[2.77, 3.25]	[0.93, 1.28]	[2.10, 2.75]
Age	-0.00	-0.00	0.01***	0.00
	[-0.01, 0.00]	[-0.01, 0.00]	[0.00, 0.01]	[-0.01, 0.01]
N	311	320	307	318
R2	0.003	0.004	0.052	0.000
F	0.907	1.183	16.839	0.074

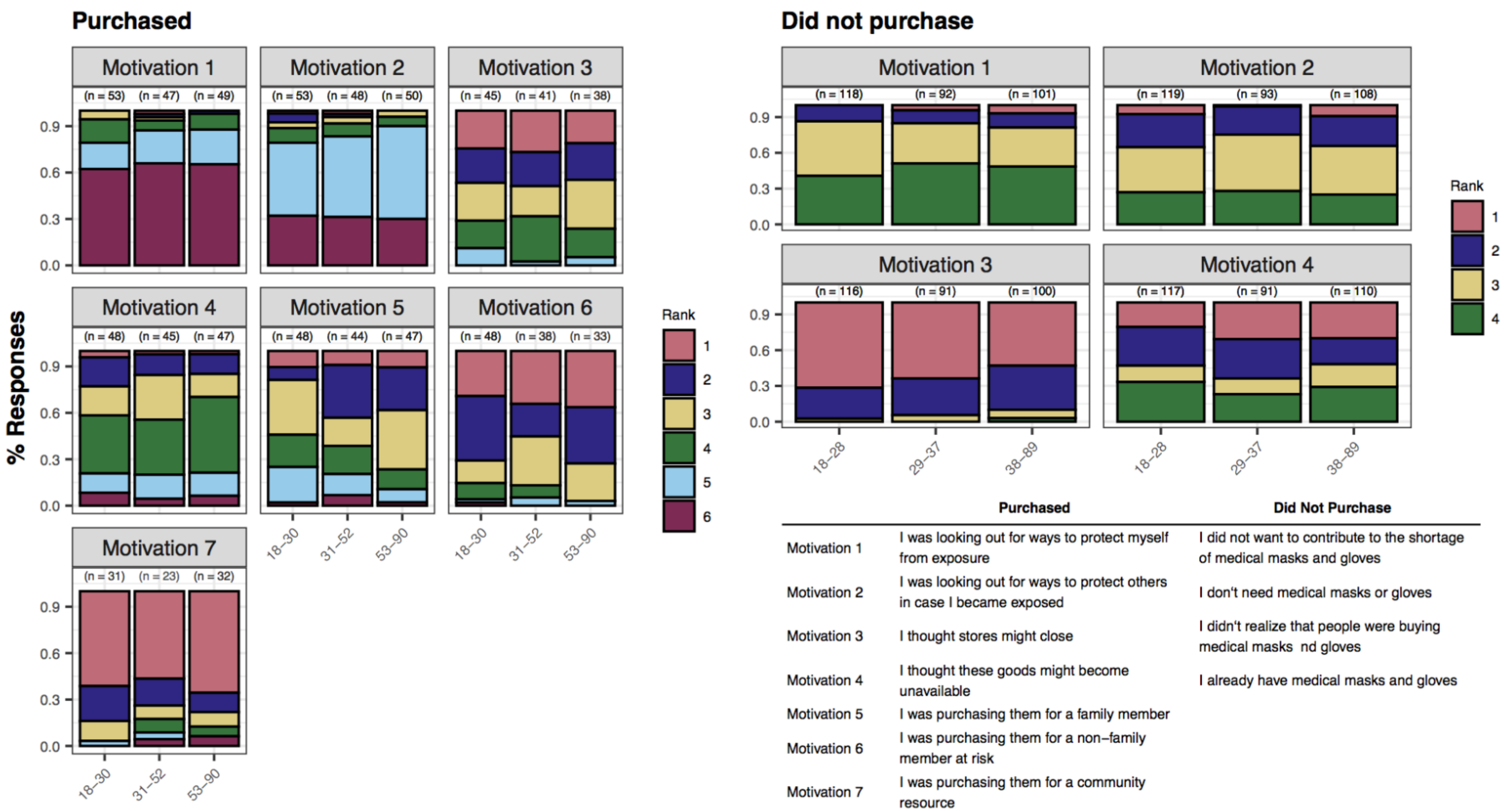
Note: Column numbers correspond to motivations listed in Figure S2. 95% confidence intervals are indicated in brackets. + < 0.1, * < 0.05, ** < 0.01, *** < 0.001.





	Purchased	Did Not Purchase
Motivation 1	I was looking out for myself	I did not want to contribute to the shortage of toilet paper and hand sanitizer
Motivation 2	It seemed like the smart thing to do	I didn't need extra toilet paper or hand sanitizer
Motivation 3	I thought stores might close	I didn't realize that people were buying extra toilet paper and hand sanitizer
Motivation 4	I thought these goods might become unavailable	
Motivation 5	I had an increased need due to more people at home throughout the day	
Motivation 6	I was shopping for a family member who could not get to the store	
Motivation 7	I was shopping for a non–family member at risk	
Motivation 8	I was shopping for a community resource (i.e. Food Pantry)	

Figure S1. Distributions of post-hoc motivations for goods purchasing behavior. The stacked bar plots to the left indicate the rank order of motivations for purchasing extra amounts of hard to find goods during the pandemic. The bar plots to the right indicate rank order of motivations for not purchasing extra amounts of hard to find goods during the pandemic. Each sub-plot is binned by age with roughly the same number of participants in each bin. These bins are not exactly equal across sub-plots because participants were not required to rank every option. The motivation numbers for each sub-plot correspond to those laid out in the table in the bottom right-hand corner.



	Purchased	Did Not Purchase
Motivation 1	I was looking out for ways to protect myself from exposure	I did not want to contribute to the shortage of medical masks and gloves
Motivation 2	I was looking out for ways to protect others in case I became exposed	I don't need medical masks or gloves
Motivation 3	I thought stores might close	I didn't realize that people were buying medical masks nd gloves
Motivation 4	I thought these goods might become unavailable	I already have medical masks and gloves
Motivation 5	I was purchasing them for a family member	
Motivation 6	I was purchasing them for a non–family member at risk	
Motivation 7	I was purchasing them for a community resource	

Figure S2. Distributions of post-hoc motivations for medical supply purchasing behavior. The stacked bar plots to the left indicate the rank order of motivations for purchasing extra amounts of hard to find medical supplies during the pandemic. The bar plots to the right indicate rank order of motivations for not purchasing extra amounts of hard to find medical supplies during the pandemic. Each sub-plot is binned by age with roughly the same number of participants in each bin. These bins are not exactly equal across sub-plots because participants were not required to rank every option. The motivation numbers for each sub-plot correspond to those laid out in the table in the bottom right-hand corner.

APPENDIX B
SECTION B.3
PART II: CONTROL ANALYSES

Goods Model 1.1 Control Analyses

Table C1 contains the control analyses for Goods Model 1.1. In the model comparison tables (Tables C2-C6) below, controlling for income (Table C2) or education (Table C3) do not improve the overall model fit for Goods Model 1.1. Controlling for housing (Table C4) provides a better overall model fit for Goods Model 1.1, as does controlling for dependents (Table C5). When controlling for dependents in addition to housing (Table C6), however, this does not provide a better overall model fit than the model that controls for housing (Table C4). Given the outcomes of these control analyses, the model controlling for housing was included in the manuscript.

Goods Model 2.3 Control Analyses

Table C7 contains the control analyses for Goods Model 2.3. Controlling for income (Table C8), education (Table C9), or dependents (Table C11) did not improve overall model fit for Goods Model 2.3. Controlling for housing (Table C10) improved overall model fit for Goods Model 2.3. Given the outcomes of these control analyses, the model controlling for housing was included in the manuscript.

Medical Model 1.1 Control Analyses

Table C12 contains the control analyses for Medical Model 1.1. Controlling for income (Table C13) or education (Table C14) do not improve the overall model fit for Medical Model 1.1. Controlling for housing (Table C15) provides a better overall model fit for Medical Model 1.1, as does controlling for dependents (Table C16). When controlling for dependents in addition to housing (Table C17), however, this does not provide a better overall model fit than the model that controls for housing (Table C15). Given the outcomes of these control analyses, the model controlling for housing was included in the manuscript.

Table C1.

Goods Scarcity Model (Full Sample and Control Variables)

	Goods Model 1.1	Goods Model 1.1 (Control: Income)	Goods Model 1.1 (Control: Education)	Goods Model 1.1 (Control: Housing)	Goods Model 1.1 (Control: Dependents)	Goods Model 1.1 (Control: Housing & Dependents)
(Intercept)	-0.91 ***	-0.85 *	-0.28	-1.28 ***	-1.00 ***	-1.26 ***
	[-1.11, -0.71]	[-1.73, -0.06]	[-1.68, 1.02]	[-1.62, -0.95]	[-1.23, -0.79]	[-1.60, -0.94]
Age	0.02 ***	0.02 ***	0.02 ***	0.03 ***	0.02 ***	0.03 ***
	[0.01, 0.03]	[0.01, 0.04]	[0.01, 0.03]	[0.02, 0.04]	[0.01, 0.03]	[0.01, 0.04]
PANAS_PA	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
	[-0.03, 0.01]	[-0.04, 0.01]	[-0.03, 0.01]	[-0.04, 0.01]	[-0.03, 0.01]	[-0.04, 0.01]
PANAS_NA	0.05 ***	0.05 **	0.06 ***	0.05 **	0.05 **	0.05 **
	[0.02, 0.09]	[0.02, 0.08]	[0.02, 0.09]	[0.02, 0.08]	[0.02, 0.09]	[0.02, 0.08]
Income$25,001 - $50,000		-0.32				
		[-1.28, 0.68]				
Income$50,001 - $75,000		0.15				
		[-0.78, 1.13]				
Income$75,001 - $100,000		-0.01				

	[-0.94, 0.96]				
Income$100,001 - $150,000	-0.24				
	[-1.16, 0.73]				
Income$150,001 - $250,000	-0.33				
	[-1.34, 0.71]				
Income$250,000+	0.49				
	[-0.48, 1.51]				
EducationSome College		-0.41			
		[-1.84, 1.10]			
EducationCollege Degree		-0.76			
		[-2.11, 0.70]			
EducationSome post-baac education		-0.87			
		[-2.32, 0.66]			
EducationGrad, Med, or Prof. Degree		-0.60			
		[-1.93, 0.83]			
Housing			0.21 **		0.17 *
			[0.06, 0.35]		[0.01, 0.33]

Dependents					0.26 *	0.13
					[0.02, 0.50]	[-0.14, 0.40]
N	507	507	507	507	507	507
AIC	597.5	602.6	603.1	591.4	594.9	592.5
BIC	614.4	644.9	636.9	612.6	616.1	617.9
Log.Lik.	-294.746	-291.306	-293.527	-290.710	-292.461	-290.255
McFadden's Pseudo R2	0.043	0.054	0.047	0.056	0.05	0.057

Note: Age, PANAS_PA, and PANAS_NA are mean centered. 95% confidence intervals are indicated in brackets. p < 0.05 = *, p < 0.01 = **, p < 0.001 = ***.

Table C2.
Model Comparison (Chi Square Test)

	Resid. Df	Resid. Dev	Df	Deviance	Pr(>Chi)
Goods Model 1.1	503	589			
Goods Model 1.1 (Control: Income)	497	583	6	6.88	0.332

Table C3.
Model Comparison (Chi Square Test)

	Resid. Df	Resid. Dev	Df	Deviance	Pr(>Chi)

Goods Model 1.1	503	589			
Goods Model 1.1 (Control: Education)	499	587	4	2.44	0.656

Table C4.
Model Comparison (Chi Square Test)

	Resid. Df	Resid. Dev	Df	Deviance	Pr(>Chi)
Goods Model 1.1	503	589			
Goods Model 1.1 (Control: Housing)	502	581	1	8.07	0.00449

Table C5.
Model Comparison (Chi Square Test)

	Resid. Df	Resid. Dev	Df	Deviance	Pr(>Chi)
Goods Model 1.1	503	589			
Goods Model 1.1 (Control: Dependents)	502	585	1	4.57	0.0325

Table C6.
Model Comparison (Chi Square Test)

	Resid. Df	Resid. Dev	Df	Deviance	Pr(>Chi)
Goods Model 1.1	503	589			
Goods Model 1.1 (Control: Housing)	502	581	1	8.07	0.00449
Goods Model 1.1 (Control: Housing & Dependents)	501	581	1	0.911	0.34

Table C7.
Goods Scarcity Model (Memory Sample and Control Variables)

	Goods Model 2.3	Goods Model 2.3 (Control: Income)	Goods Model 2.3 (Control: Education)	Goods Model 2.3 (Control: Housing)	Goods Model 2.3 (Control: Dependents)
(Intercept)	-0.95***	-0.97*	-0.75	-1.28***	-1.01***
	[-1.17, -0.74]	[-1.97, -0.08]	[-2.36, 0.65]	[-1.64, -0.93]	[-1.25, -0.78]

Age	0.02***	0.02**	0.02**	0.03***	0.02**
	[0.01, 0.03]	[0.01, 0.03]	[0.01, 0.03]	[0.01, 0.04]	[0.01, 0.03]
PANAS_NA	0.04*	0.03+	0.04*	0.04*	0.04*
	[0.00, 0.07]	[-0.00, 0.07]	[0.00, 0.07]	[0.00, 0.07]	[0.00, 0.07]
Negative Memory	0.39**	0.38**	0.40**	0.39**	0.37**
	[0.13, 0.67]	[0.11, 0.66]	[0.14, 0.68]	[0.13, 0.66]	[0.11, 0.65]
Positive Memory	-0.04	-0.02	-0.03	-0.05	-0.03
	[-0.27, 0.21]	[-0.26, 0.23]	[-0.26, 0.22]	[-0.29, 0.19]	[-0.27, 0.21]
Income$25,001 - $50,000		-0.01			
		[-1.06, 1.10]			
Income$50,001 - $75,000		0.11			
		[-0.92, 1.22]			
Income$75,001 - $100,000		0.18			
		[-0.84, 1.27]			

Income$100,001 - $150,000	-0.29	
	[-1.31, 0.81]	
Income$150,001 - $250,000	-0.31	
	[-1.44, 0.87]	
Income$250,000+	0.55	
	[-0.53, 1.69]	
EducationSome College		0.09
		[-1.46, 1.81]
EducationCollege Degree		-0.34
		[-1.80, 1.31]
EducationSome post-baac education		-0.29
		[-1.84, 1.42]
EducationGrad, Med, or Prof. Degree		-0.18
		[-1.61, 1.45]

Housing				0.19*	
				[0.03, 0.34]	
Dependents					0.17
					[-0.09, 0.43]
N	441	441	441	441	441
AIC	515.8	521.8	522.5	512.0	516.2
BIC	536.3	566.8	559.3	536.6	540.8
Log.Lik.	-252.923	-249.904	-252.239	-250.025	-252.119
McFadden's Pseudo R2	0.048	0.059	0.05	0.059	0.051

Note: Age, PANAS_PA, and PANAS_NA are mean centered. 95% confidence intervals are indicated in brackets. p < 0.05 = *, p < 0.01 = **, p < 0.001 = ***.

Table C8.
Model Comparison (Chi Square Test)

	Resid. Df	Resid. Dev	Df	Deviance	Pr(>Chi)
Goods Model 2.3	436	506			
Goods Model 2.3 (Control: Income)	430	500	6	6.04	0.419

Table C9.
Model Comparison (Chi Square Test)

	Resid. Df	Resid. Dev	Df	Deviance	Pr(>Chi)

Goods Model 2.3	436	506			
Goods Model 2.3 (Control: Education)	432	504	4	1.37	0.85

Table C10.
Model Comparison (Chi Square Test)

	Resid. Df	Resid. Dev	Df	Deviance	Pr(>Chi)
Goods Model 2.3	436	506			
Goods Model 2.3 (Control: Housing)	435	500	1	5.8	0.0161

Table C11.
Model Comparison (Chi Square Test)

	Resid. Df	Resid. Dev	Df	Deviance	Pr(>Chi)
Goods Model 2.3	436	506			
Goods Model 2.3 (Control: Dependents)	435	504	1	1.61	0.205

Table C12.
Medical Supply Scarcity Model (Full Sample and Control Variables)

	Medical Model 1.1	Medical Model 1.1 (Control: Income)	Medical Model 1.1 (Control: Education)	Medical Model 1.1 (Control: Housing)	Medical Model 1.1 (Control: Dependents)	Medical Model 1.1 (Control: Housing & Dependents)
(Intercept)	-0.67***	-0.36	-0.44	-1.29***	-0.76***	-1.30***
	[-0.86, -0.49]	[-1.14, 0.40]	[-1.83, 0.85]	[-1.63, -0.97]	[-0.97, -0.56]	[-1.63, -0.98]
Age	0.01*	0.01*	0.02**	0.02***	0.01*	0.02***

	[0.00, 0.02]	[0.00, 0.02]	[0.00, 0.03]	[0.01, 0.03]	[0.00, 0.02]	[0.01, 0.04]
PANAS_PA	0.01	0.01	0.01	0.01	0.01	0.01
	[-0.01, 0.03]	[-0.01, 0.03]	[-0.01, 0.03]	[-0.02, 0.03]	[-0.01, 0.03]	[-0.02, 0.03]
PANAS_NA	0.04*	0.03*	0.04*	0.03*	0.04*	0.03*
	[0.01, 0.07]	[0.00, 0.07]	[0.01, 0.07]	[0.00, 0.07]	[0.00, 0.07]	[0.00, 0.07]
Income$25,001 - $50,000		-0.66				
		[-1.57, 0.26]				
Income$50,001 - $75,000		-0.65				
		[-1.55, 0.27]				
Income$75,001 - $100,000		-0.39				
		[-1.27, 0.51]				
Income$100,001 - $150,000		-0.07				
		[-0.92, 0.81]				
Income$150,001 - $250,000		-0.25				

	[-1.18, 0.69]				
Income$250,000+	-0.00				
	[-0.93, 0.95]				
EducationSome College		0.49			
		[-0.90, 1.97]			
EducationCollege Degree		-0.29			
		[-1.62, 1.14]			
EducationSome post-bacc education		-0.47			
		[-1.88, 1.03]			
EducationGrad, Med, or Prof. Degree		-0.36			
		[-1.68, 1.05]			
Housing			0.35***		0.35***
			[0.21, 0.49]		[0.20, 0.52]
Dependents				0.24*	-0.03
				[0.01, 0.48]	[-0.30, 0.24]

N	507	507	507	507	507	507
AIC	644.9	649.6	644.5	622.9	642.8	624.8
BIC	661.9	691.9	678.3	644.0	664.0	650.2
Log.Lik.	-318.471	-314.810	-314.226	-306.429	-316.417	-306.405
McFadden's Pseudo R2	0.021	0.033	0.034	0.058	0.028	0.058

Note: Age, PANAS_PA, and PANAS_NA are mean centered. 95% confidence intervals are indicated in brackets. p < 0.05 = *, p < 0.01 = **, p < 0.001 = ***.

Table C13.
Model Comparison (Chi Square Test)

	Resid. Df	Resid. Dev	Df	Deviance	Pr(>Chi)
Medical Model 1.1	503	637			
Medical Model 1.1 (Income)	497	630	6	7.32	0.292

Table C14.
Model Comparison (Chi Square Test)

	Resid. Df	Resid. Dev	Df	Deviance	Pr(>Chi)

Medical Model 1.1	503	637			
Medical Model 1.1 (Education)	499	628	4	8.49	0.0752

Table C15.
Model Comparison (Chi Square Test)

	Resid. Df	Resid. Dev	Df	Deviance	Pr(>Chi)
Medical Model 1.1	503	637			
Medical Model 1.1 (Housing)	502	613	1	24.1	9.22e-07

Table C16.
Model Comparison (Chi Square Test)

	Resid. Df	Resid. Dev	Df	Deviance	Pr(>Chi)
Medical Model 1.1	503	637			
Medical Model 1.1 (Dependents)	502	633	1	4.11	0.0427

Table C17.
Model Comparison (Chi Square Test)

	Resid. Df	Resid. Dev	Df	Deviance	Pr(>Chi)
Medical Model 1.1	503	637			
Medical Model 1.1 (Housing)	502	613	1	24.1	9.22e-07
Medical Model 1.1 (Housing & Dependents)	501	613	1	0.047	0.828

APPENDIX B
SECTION B.4
PART II: ADDITIONAL ANALYSES

Description

In the original pre-registration for this study, we planned on examining participant responses to the following question: "*Since the start of the pandemic have you voluntarily self-isolated without showing COVID19 symptoms?*". For the reasons outlined below, we refrained from including this question in the main body of the manuscript.

Behavior

Although indicated in the pre-registration that we planned to examine the relationship between age, affect, and voluntary self-isolation, nearly all of participants in our sample indicated that they engaged in voluntary self-isolation (Table A1). With such a small sample of participants who did not voluntarily self-isolate, we do not have the variability to detect which variables would be associated with self-isolation (Table A2). As such, the subsequent analyses were not included in the main body of the manuscript.

Self-Isolation Motivation

Although we did not examine the relationship between age and voluntary self-isolation in our sample, it is possible that age may be associated with the motivations for voluntary self-isolation or the lack thereof. For those individuals who indicated "Yes" to the voluntary self-isolation question (Table A3, Figure A1), there was a significant positive effect of age in predicting the rank ordering of Motivation 1 (*'To avoid contracting the coronavirus (COVID-19)'*), suggesting that voluntarily self-isolating due to concerns about contracting the virus were more important at younger ages. There was also a significant negative effect of age for Motivation 3 ('*I don't want to contribute to community spread of the disease'*), suggesting that older age was associated with more motivation to avoid contributing to the community spread of COVID-19.

With regard to those individuals who did not voluntarily self-isolate (Table A4), Motivation 4 ('*I don't think the virus is a threat*') showed a significant positive effect of age. This finding demonstrates that this was a more important motivation for the younger adults who did not self-isolate in our sample.

Self-Isolation Memory Sample Behavior

We also preregistered analyses related to emotional memory and self-isolation. The descriptive statistics and regression models are reported in Tables A5-A7. Given the null results of these findings, they will not be discussed further.

Summary

These findings suggest that, within our sample, there were age differences in the motivation to voluntarily self-isolate. Ultimately, it appears that older participants were motivated by more utilitarian intentions as in the case of attempts to prevent community spread, whereas younger participants were more concerned with more self-preserving motivations such as avoiding contracting the virus. For the subset of participants who refrained from voluntarily self-isolating, younger age appeared to be associated with less concern about the seriousness of the virus.

Discussion

Although we did not examine age or emotion effects in relation to self-isolation behavior, age differences in post-hoc motivations for these behaviors suggest that older adults in our sample may have engaged in voluntary self-isolation for reasons that could arguably be labeled as more prosocial than the motivations espoused by younger adults. That is, with advancing age, individuals were more concerned with preventing community spread, whereas younger individuals were more motivated to avoid contracting the virus. This, tendency toward a more prosocial motivational perspective with advancing age is not only consistent with work suggesting that generativity becomes the focus of middle age and older adulthood (Lodi-Smith et al., 2021; Schoklitsch & Baumann, 2012), but is consistent with recent findings from this dataset demonstrating increased prosocial tendencies with advancing age (Cho et al., 2021).

Table A1.
Behavioral Outcomes (Full Sample)

	Value	N
Did not Voluntary Self-Isolate	0	64
Voluntary Self-Isolated	1	443

Table A2. *Voluntary Isolation Model (Full Sample)*

	Voluntary Isolation Model 1.1	Voluntary Isolation Model 1.2
(Intercept)	1.95***	1.90***
	[1.69, 2.22]	[1.64, 2.18]
Age	0.00	0.00
	[-0.01, 0.02]	[-0.01, 0.02]
PANAS_PA	-0.02	-0.02
	[-0.05, 0.01]	[-0.05, 0.01]
PANAS_NA	0.01	0.02
	[-0.03, 0.06]	[-0.03, 0.07]
Age × PANAS_PA		0.00
		[-0.00, 0.00]
Age × PANAS_NA		-0.00
		[-0.00, 0.00]
N	507	507
AIC	390.7	393.4
BIC	407.6	418.8
Log.Lik.	-191.344	-190.692

McFadden's Pseudo R2	0.005	0.008

Note: All independent variables are mean centered. 95% confidence intervals are indicated in brackets. p < 0.05 = *, p < 0.01 = **, p < 0.001 = ***.

Table A3.

Voluntary Isolation Post-Hoc Motivations: Yes Responses

	1	2	3	4	5
(Intercept)	2.24***	3.83***	4.32***	2.09***	2.02***
	[1.89, 2.58]	[3.52, 4.14]	[4.06, 4.57]	[1.79, 2.39]	[1.74, 2.30]
Age	0.03***	-0.00	-0.02***	0.01+	0.01+
	[0.02, 0.04]	[-0.01, 0.00]	[-0.02, -0.01]	[-0.00, 0.01]	[-0.00, 0.01]
N	400	398	396	407	437
R2	0.111	0.002	0.066	0.008	0.009
F	49.593	0.826	27.841	3.288	3.835

Note: Column numbers correspond to motivations listed in Figure A1. 95% confidence intervals are indicated in brackets. + < 0.1, * < 0.05, ** < 0.01, *** < 0.001.

Table A4.
Voluntary Isolation Post-Hoc Motivations: No Responses

	1	2	3	4	5	6	7	8
(Intercept)	7.05***	3.32***	3.56***	1.47*	5.00***	3.35***	5.78***	6.87***
	[5.54, 8.57]	[1.70, 4.95]	[2.15, 4.96]	[0.06, 2.88]	[3.60, 6.40]	[1.98, 4.72]	[4.55, 7.01]	[5.05, 8.68]
Age	-0.03	-0.00	0.01	0.04*	-0.01	0.01	-0.02+	-0.03
	[-0.06, 0.01]	[-0.04, 0.04]	[-0.02, 0.05]	[0.00, 0.07]	[-0.05, 0.02]	[-0.02, 0.05]	[-0.05, 0.00]	[-0.07, 0.01]
N	52	49	47	51	51	50	56	61
R2	0.034	0.001	0.009	0.082	0.007	0.008	0.051	0.035
F	1.786	0.026	0.388	4.393	0.369	0.382	2.878	2.156

Note: Column numbers correspond to motivations listed in Figure A1. 95% confidence intervals are indicated in brackets. + < 0.1, * < 0.05, ** < 0.01, *** < 0.001.

Table A5.
Demographics (Voluntary Isolation Memory Sample)

Variable	Category	n (total = 437)	%
Race	African American	9	2.1
	American Indian / Alaska Native	1	0.2
	Asian	43	9.8
	Latinx	6	1.4
	More than one race	3	0.7
	Prefer Not to Say	1	0.2
	Unknown	1	0.2
	White	373	85.4
Ethnicity	Ethnicity Unreported	4	0.9
	Hispanic	20	4.6
	Not Hispanic	413	94.5
Biological Sex	Female	359	82.2
	Male	78	17.8
Income	$0 - $25,000	22	5.0
	$25,001 - $50,000	69	15.8
	$50,001 - $75,000	71	16.2
	$75,001 - $100,000	81	18.5
	$100,001 - $150,000	93	21.3
	$150,001 - $250,000	53	12.1
	$250,000+	48	11.0

Table A6.
Independent Variable Summary Statistics (Full Sample)

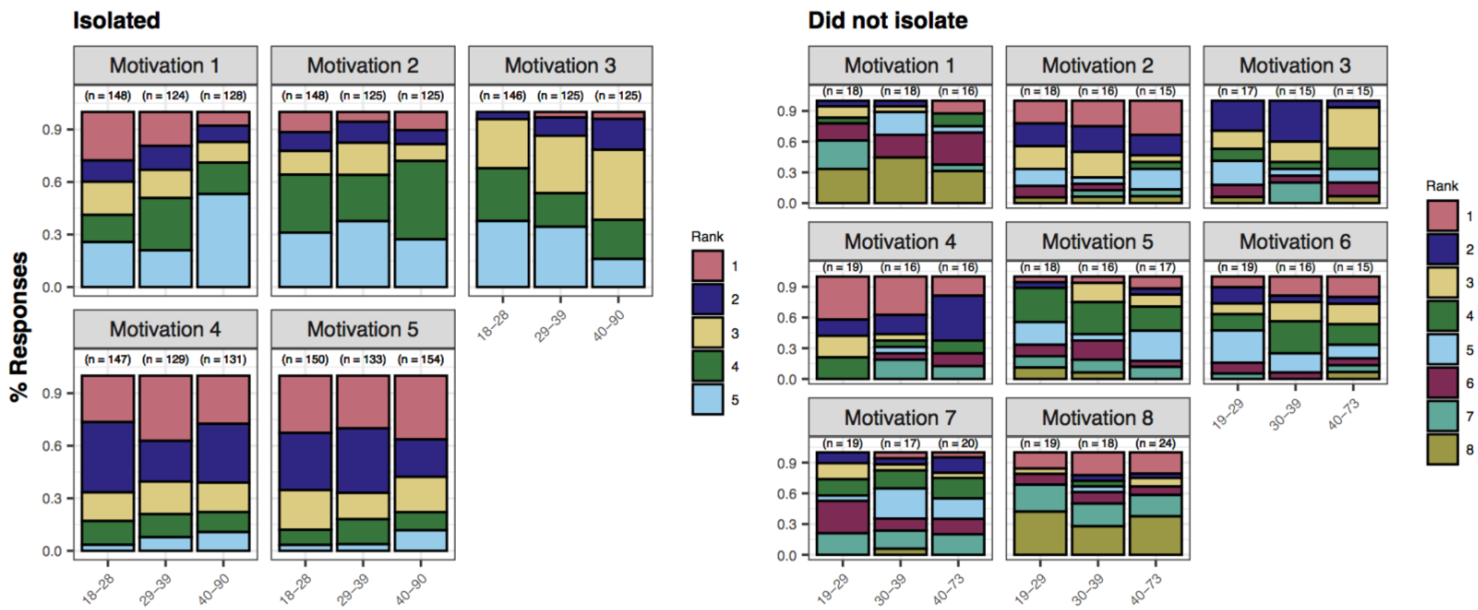
	Mean	SD	Min	Max	1	2	3	4
1. Age	40.35	17.81	18.00	90.00	1	.	.	.
2. PANAS_PA	23.17	9.23	10.00	50.00	.35	1	.	.
3. PANAS_NA	15.35	5.88	10.00	43.00	-.08	-.14	1	.
4. Emotional Memory Composite	0.34	0.07	0.09	0.67	.01	-.01	-.12	1

Note: The last five columns indicate Pearson r correlation coefficients. N = 437.

Table A7.
Voluntary Isolation Model (Memory Sample)

	Voluntary Isolation Model 2.1
(Intercept)	1.20+
	[-0.20, 2.65]
Emotional Memory Composite	2.11
	[-2.01, 6.26]
N	437
AIC	337.6
BIC	345.8
Log.Lik.	-166.804
McFadden's Pseudo R2	0.005

Note: 95% confidence intervals are indicated in brackets. $p < 0.1$ = +



	Isolated	Did not isolate
Motivation 1	To avoid contracting the coronavirus (COVID19)	I am healthy and not at risk even if I get sick
Motivation 2	I don't want to endanger my loved ones	It is not my responsibility to prevent the spread of the disease
Motivation 3	I don't want to contribute to community spread of the disease	I don't think isolation is the solution
Motivation 4	I am trying to follow what public health officials recommend	I don't think the virus is a threat
Motivation 5	I am concerned about the number of hospital resources available	There is conflicting information coming from places of authority regarding the benefits of self–isolating
Motivation 6		The cost to my freedom outweigh the public health risks
Motivation 7		The financial costs of self–isolating outweigh the public health risks
Motivation 8		I don't have the option to stay home

Figure A1. Distributions of post-hoc motivations for voluntary self-isolation behavior. The stacked bar plots to the left indicate the rank order of motivations for voluntarily self-isolating during the pandemic. The bar plots to the right indicate rank order of motivations for not voluntarily self-isolating during the pandemic during the pandemic. Each sub-plot is binned by age with roughly the same number of participants in each bin. These bins are not exactly equal across sub-plots because participants were not required to rank every option. The motivation numbers for each sub-plot correspond to those laid out in the table at the bottom of the figure.

APPENDIX C

APPENDIX C
SECTION C.1
DESCRIPTION

There is one subsection of supplementary materials for Part III. See the description below for further details.

- SECTION C.2: This section contains all of the vignettes and possible motivation conditions presented to participants. These vignettes were adapted from Kim et al., (2022), however, several of these vignettes were also previously adapted from other sources. These other sources are indicated where necessary. Each one of the vignettes listed include the following parts:
    - Background: Part 1 and Part 2
    - Motivation (Initial): 3a or 3b
    - Action: 4
    - Motivation (Reframing): 5a, 5b, or 5c

APPENDIX C
SECTION C.2
PART III: STIMULI

Experimental Instructions

"This study consists of a series of brief scenarios. You will read each story as it unfolds, and you will answer a question about each story.

There are 12 scenarios in total. Unfortunately we are unable to display a progress bar with this survey. We apologize for the inconvenience."

Scenario Text

Scenario 1 - Adapted from Lichtenstein et al., 2007

1. Rebecca is in charge of running a yearlong drug trial at McAdam Hospital. The drug was given to the experimental group of patients, and a placebo was given to the control group. At two months, early results suggest that the drug is effective.

2. Rebecca has the option to give the control group the medicine early. This could potentially save the lives of patients who would die without immediate access to the treatment.

3a. **[Moral Initial]**: Holding the trial at the original length would produce more conclusive data. This would help develop better treatments in the long run, and save the lives of patients in the future.

3b. **[Immoral Initial]**: Giving treatment to the control group before a study is complete is frowned on in the medical community. If Rebecca ends the study early, she will have trouble progressing her career.

4. Rebecca thinks very carefully and ultimately decides to continue the study at its original length. The drug trial continues for the remainder of the year, but some patients in the control group die during this time.

5a. **[Immoral Reframing]**: Giving treatment to the control group before a study is complete is frowned on in the medical community. If Rebecca ends the study early, she will have trouble progressing her career.

5b. **[Moral Reframing]:** Holding the trial at the original length would produce more conclusive data. This would help develop better treatments in the long run, and save the lives of patients in the future.

5c. **[Control]:** After Rebecca arrives home from work, she makes herself spaghetti for dinner and watches television. After dinner she washes the dishes and takes a shower before going to bed.

Scenario 2

1. Emil owns a small farm in Argentina. Emil is considering expanding his farm, which would allow him to grow more varieties of fruits and vegetables.

2. Emil sells his crops to a nearby village. He knows that what he grows does not contain enough nutrients for a healthy diet. By expanding his farm he could save the villagers from malnourishment.

3a. **[Moral Initial]**: Emil knows that the area of the rainforest that borders on his farm contains an exceptional number of endangered species, and that expanding into it will cause many of them to die out.

3a. **[Immoral Initial]**: Emil regularly brings in tourists who pay for tours of the rainforest near his house, and continuing to give these tours will be more profitable then planting more crops and feeding the village.

4. Emil thinks very carefully and ultimately decides not to expand his farm into the rainforest. His farm is not developed any further, and the villagers continue to suffer from malnourishment.

5a. **[Immoral Reframing]**: Emil regularly brings in tourists who pay for tours of the rainforest near his house, and continuing to give these tours will be more profitable then planting more crops and feeding the village.

5b. **[Moral Reframing]**: Emil knows that the area of the rainforest that borders on his farm contains an exceptional number of endangered species, and that expanding into it will cause many of them to die out.

5c. **[Control]**: Emil received a call the next day from an acquaintance he had lost contact with. They agreed to meet the next week at a café in the city in order to catch up on their lives since high school.

Scenario 3

1. Sarah and her five year old son Jeffery were recently evicted from their house and are living in a homeless shelter. A very rich couple has approached Sarah explaining that they are unable to conceive and that they would be willing to adopt Jeffery.

2. The couple has told Sarah that they will be moving to California. They do not plan to return and it is unlikely that Sarah will ever see her son again if they adopt him.

3a. **[Moral Initial]**: Sarah can barely feed Jeffery, let alone provide a comfortable life for him. She is absolutely certain that Jeffery would be very well off with his new family.

3b. **[Immoral Initial]**: Sarah has been told by the couple that they will buy her an expensive new car to replace her old one. They will purchase the car when she signs over custody of Jeffery.

4. Sarah thinks very carefully and ultimately decides to allow the family to adopt Jeffery. Jeffery moves to California with the family, and Sarah never sees him again.

5a. **[Immoral Reframing]**: Sarah has been told by the couple that they will buy her an expensive new car to replace her old one. They will purchase the car when she signs over custody of Jeffery.

5b. **[Moral Reframing]**: Sarah can barely feed Jeffery, let alone provide a comfortable life for him. She is absolutely certain that Jeffery would be very well off with his new family.

5c. **[Control]**: Sarah goes to her former high school's basketball game that weekend. Her high school used to rank poorly, but recently has improved its standing in the league.

Scenario 4

1. Candace is the Mayor of a small mid-western American city. The city needs to make cuts to the education budget. The council has brought two proposals to her about programs that could potentially be cut.

2. Candace could cut after school programs for at-risk youth. This would leave many adolescents without alternatives to getting involved with drugs and crime. It would almost certainly negatively affect their future prospects.

3a. **[Moral Initial]**: Cutting day-care programs would put a financial strain on single parents. Parents with jobs would need to work more hours and see their children less. Parents without jobs would have to balance childcare and their time to job hunt.

3b. **[Immoral Initial]**: Cutting day-care programs would make parents unhappy, and Candace is up for reelection next year. The votes of these parents were essential to her victory in the last election. Losing the support of parents could lose her the next election.

4. Candace thinks carefully and ultimately decides to cut the after school programs for at-risk youth. As a result, many of these children get involved with drugs and crime.

5a. **[Immoral Reframing]**: Cutting day-care programs would make parents unhappy, and Candace is up for reelection next year. The votes of these parents were essential to her victory in the last election. Losing the support of parents could lose her the next election.

5b. **[Moral Reframing]**: Cutting day-care programs would put a financial strain on single parents. Parents with jobs would need to work more hours and see their children less. Parents without jobs would have to balance childcare and their time to job hunt.

5c. **[Control]**: Candace takes her dog, Spot, on a walk through the downtown city park. The park allows dogs to go off of their leashes, but only in certain areas. When Candace reaches the area, she lets Spot off of his leash and throws the ball with him.

Scenario 5 - Adapted from Lichtenstein et al., 2007

1. Abby is the CEO of Morrison Motors, a large car manufacturing company. Abby must make a decision about whether to issue a recall due to a defect in the Ellipsis line of cars.

2. Abby could issue a recall to fix this defect, which would return the thousands of Ellipsis cars to the factory. This would protect customers from the fatal accidents that can occur when the brakes fail.

3a. **[Moral Initial]**: Abby knows that the finances of the company are poor, and the negative press and expense of a recall would bankrupt them. Thousands of long-time employees would lose their jobs and pensions.

3b. **[Immoral Initial]**: The cost of settlements with the families of the victims would be much cheaper than the cost of a recall. Not issuing a recall could save the company money and even set Abby up for a promotion.

4. Abby thinks carefully, and ultimately decides not to issue the recall. The company saves a great deal of money, but fatal accidents occur as a result.

5a. **[Immoral Reframing]**: The cost of settlements with the families of the victims would be much cheaper than the cost of a recall. Not issuing a recall could save the company money and even set Abby up for a promotion.

5b. **[Moral Reframing]**: Abby knows that the finances of the company are poor, and the negative press and expense of a recall would bankrupt them. Thousands of long-time employees would lose their jobs and pensions.

5c. **[Control]**: Abby went to the gym next to the office to exercise after work. She had originally planned to run on the treadmill, but they were all occupied so she used the bicycle machine instead.

Scenario 6 - Adapted from Lichtenstein et al., 2007

1. Brock is a clerk working for the Canadian military and can decide to approve or reject draftees that have been referred to him. He is currently considering the case of Aaron, a young man who is eligible to be drafted.

2. Brock knows that Aaron has experience with engineering and could be put on a bomb defusal squad. This expertise could potentially save the lives of civilians and fellow soldiers.

3a. **[Moral Initial]**: Brock read that Aaron works with Engineers without Borders. If rejected from the draft, Aaron would continue to build wells in South Africa, giving the poor access to fresh water.

3b. **[Immoral Initial]**: Brock was contacted by Aaron's family, who are very influential. They will contact Brock's superiors and get him promoted if he rejects Aaron's file and spares him the draft.

4. Brock thinks very carefully and ultimately decides to reject Aaron's file. Aaron is not drafted into the army.

5a. **[Immoral Reframing]**: Brock was contacted by Aaron's family, who are very influential. They will contact Brock's superiors and get him promoted if he rejects Aaron's file and spares him the draft.

5b. **[Moral Reframing]**: Brock read that Aaron works with Engineers without Borders. If rejected from the draft, Aaron would continue to build wells in South Africa, giving the poor access to fresh water.

5c. **[Control]**: The following afternoon, Brock attends a meeting along with the other clerks. They discuss a new database program that will help to reduce the amount of paper used in their jobs.

Scenario 7 - Adapted from Lichtenstein et al., 2007

1. Gregory is the captain of a fishing vessel that operates off the coast of Cape Cod. He is considering implementing a new fishing method for himself and his crew.

2. The new method involves specialized nets that release larger creatures caught in them. If used, it would decrease the number of dolphins that are accidentally caught and strangled in the netting.

3a. **[Moral Initial]**: Gregory knows that by implementing the new method he would be forced to lay off a third of his crew due to the related expenses. These people would have a very difficult time finding other jobs.

3b. **[Immoral Initial]**: Gregory has run a profitable business on the side where he sells dolphin fins to natural medicine distributors. If he implemented the new fishing method, he would need to shut down this business.

4. Gregory thinks carefully and ultimately decides not to implement the new fishing method. The vessel continues to kill several dolphins per month.

5a. **[Immoral Initial]**: Gregory has run a profitable business on the side where he sells dolphin fins to natural medicine distributors. If he implemented the new fishing method, he would need to shut down this business.

5b. **[Moral Initial]**: Gregory knows that by implementing the new method he would be forced to lay off a third of his crew due to the related expenses. These people would have a very difficult time finding other jobs.

5c. **[Control]**: On Saturday, Gregory drives to Connecticut to spend the weekend with his parents. The traffic is very light and Gregory arrives at his parent's house two hours earlier than he had expected to.

Scenario 8 - Adapted from Lichtenstein et al., 2007

1. Cassandra is a member of the transportation board in a large American city. The board is considering the addition of a lane to a dangerous section of the freeway at the edge of the city.

2. Cassandra knows that this stretch of highway is notorious for causing vehicles to lose control, and that there have been fatal accidents year round on it. Adding an additional lane would prevent approximately 50 deaths due to accidents per year.

3a. **[Moral Initial]**: Cassandra recently spoke to the mayor, who told her that the money for the lane would need to come from the education budget. By rejecting the repairs to the highway, Cassandra could prevent the city from having to lay off 100 teachers.

3b. **[Immoral Initial]**: Cassandra's husband is a personal injury lawyer who makes most of his income from settling accidents. Approving the additional lane would create less business for Cassandra's husband, decreasing their combined income by a great deal.

4. Cassandra thinks carefully and ultimately decides not to approve the construction of the new highway lane.

5a. **[Immoral Reframing]**: Cassandra's husband is a personal injury lawyer who makes most of his income from settling accidents. Approving the additional lane would create less business for Cassandra's husband, decreasing their combined income by a great deal.

5b. **[Moral Reframing]**: Cassandra recently spoke to the mayor, who told her that the money for the lane would need to come from the education budget. By rejecting the repairs to the highway, Cassandra could prevent the city from having to lay off 100 teachers.

5b. **[Control]**: When Cassandra arrives home she notices that the sports magazine "NFL Monthly" is in her mailbox. She does not subscribe to this magazine, and has received magazines that were intended for a former tenant of her apartment since she moved in.

Scenario 9

1. Dr. Robertson is the medical administrator at St. Luke's hospital. The hospital has received a $10,000 donation and she must decide how it will be spent.

2. Dr. Robertson could use the $10,000 to save the life of Caleb, an 8 year-old boy who has a rare, but curable, degenerative disease. Caleb's family cannot afford the treatment on their own, and if it were given then Caleb would be cured immediately.

3a. **[Moral Initial]**: Dr. Robertson knows that many patients who come to St. Luke's hospital cannot afford basic immunizations. Setting up a free immunization clinic with the $10,000 could provide an essential service and save hundreds of lives in the long term.

3b. **[Immoral Initial]**: Dr. Robertson knows that the hospital board has promoted past administrators who implemented new programs. Creating a free immunization clinic with the money would set Dr. Robertson up for promotion.

4. Dr. Robertson thinks very carefully and ultimately uses the $10,000 to set up the free immunization clinic.

5a. **[Immoral Reframing]**: Dr. Robertson knows that the hospital board has promoted past administrators who implemented new programs. Creating a free immunization clinic with the money would set Dr. Robertson up for promotion.

5b. **[Moral Reframing]**: Dr. Robertson knows that many patients who come to St. Luke's hospital cannot afford basic immunizations. Setting up a free immunization clinic with the $10,000 could provide an essential service and save hundreds of lives in the long term.

5c. **[Control]**: Dr. Robertson later attends a seminar on a database the hospital is implementing. The database will help to coordinate organ transplants with other area hospitals. The meeting runs late and Dr. Robertson arrives home after dark.

Scenario 10

1. Dr. Ingris is a professor at McAdams University. Dr. Ingris employs Eric, a graduate student, and is part of an international project investigating the causes of cancer. A fire has broken out in her lab and when she arrived the lab was filled with smoke.

2. Eric is lying unconscious on the floor. Dr. Ingris could drag her graduate student to safety, saving his life. This would leave the lab server, which stores all of the lab's data, to be destroyed in the fire.

3a. **[Moral Initial]**: The lab server contains five years of research into the causes of cancer. Losing this data would set back progress in treatment by several years and lead to hundreds of patients' needless deaths.

3b. **[Immoral Initial]**: Dr. Ingris has stored her own research on the server, which is unrelated to the cancer work. If she left the lab server behind then it could take several more years for her to obtain tenure.

4. Dr. Ingris thinks very carefully and ultimately decides to save the lab server.

5a. **[Immoral Reframing]**: Dr. Ingris has stored her own research on the server, which is unrelated to the cancer work. If she left the lab server behind then it could take several more years for her to obtain tenure.

5b. **[Moral Reframing]**: The lab server contains five years of research into the causes of cancer. Losing this data would set back progress in treatment by several years and lead to hundreds of patients' needless deaths.

5c. **[Control]**: Outside the building, Dr. Ingris learns that the fire began in the lab beside hers after unstable chemicals were left too close to a hotplate. The fire had then spread through the walls into Dr. Ingris' lab.

Scenario 11

1. Matthew is 32 years old and lives in Argentina, next door to his brother. He is woken in the night by a tornado warning. There is a storm shelter in the basement of Matthew's apartment building.

2. Matthew's brother is disabled and cannot move without help. Unless Matthew helps him, he will be killed when the tornados hit.

3a. **[Moral Initial]**: Matthew's neighbors left their two children home alone for the night. If Matthew saves his brother he will not have time to get them to shelter.

3b. **[Immoral Initial]**: Matthew is listed as the beneficiary in his brother's life insurance. If his brother dies then Matthew will receive a large compensation package.

4. Matthew thinks very carefully and ultimately decides not to save his brother.

5a. **[Immoral Reframing]**: Matthew is listed as the beneficiary in his brother's life insurance. If his brother dies then Matthew will receive a large compensation package.

5b. **[Moral Reframing]**: Matthew's neighbors left their two children home alone for the night. If Matthew saves his brother he will not have time to get them to shelter.

5c. **[Control]**: Days later, Matthew learns that there were five other tornados that night. He hears that international aid might help with the rebuilding effort.

Scenario 12

1. Carver is a contractor for a private company hired by the Federal Emergency Management Agency (FEMA). Carver is in charge of containing a nuclear meltdown in a major American city.

2. Fixing the nuclear reactor will expose Carver's crew to dangerous radiation. By waiting on special equipment for defusal, Carver could guarantee the safety of his crew when they are sent inside to contain the reaction.

3a. **[Moral Initial]**: By sending in his crew immediately, Carver could be sure that the radiation is stopped before it could contaminate the city's water supply. If the water supply is contaminated the city will be uninhabitable for years.

3b. **[Immoral Initial]**: Carver's contract makes it clear that future work is only guaranteed if the situation can be resolved quickly. By sending his crew in immediately Carver would bring more business to the company and possibly be promoted.

4. Carver thinks very carefully and ultimately decides not to wait for special equipment, sending his crew in immediately.

5a. **[Immoral Reframing]**: Carver's contract makes it clear that future work is only guaranteed if the situation can be resolved quickly. By sending his crew in immediately Carver would bring more business to the company and possibly be promoted.

5b. **[Moral Reframing]**: By sending in his crew immediately, Carver could be sure that the radiation is stopped before it could contaminate the city's water supply. If the water supply is contaminated the city will be uninhabitable for years.

5c. **[Control]**: Carver sends a team to collect radiation readings throughout the city. Hundreds of samples must be collected and sent back to the laboratory. This information will determine how the clean-up proceeds next.