Chapter 6: Social Function and Motivation in the Aging Brain

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Abstract

This chapter examines the influence of aging on social processes, including thinking about the self and others, mentalizing and empathizing, and responding to stigmatized others. In addition to discussing the types of processes that are age-invariant and age-dependent, we will consider ways in which the impact of aging on social processes may differ from the ways in which aging impacts cognitive processes. We will also explore the intersection between the literatures on social function and motivation, as well as the way in which these processes relate to cognition and emotion.

Introduction

In this chapter, we review some themes from the emerging literature on the social neuroscience of aging. Much of the research thus far focuses on abilities at the intersection of social function and emotion, such as empathy or thinking about the self or other people. Intriguingly, findings from social and motivational tasks largely depart from the lessons about brain aging derived from cognitive tasks. There are hints that strategy or goal shifts across the lifespan may underlie some of the age differences, which illustrate the importance of considering task context and motivation across the lifespan.

Still underappreciated are the connections between social and motivational processes. In this chapter, we will review how social abilities are affected by aging. We will then review major themes from the literature on the effects of aging on motivation, and consider how social and motivational processes can inform each other. Investigating the intersection of these domains has the potential to advance understanding of the psychology and neuroscience of aging, and such work is in its infancy.

Social Neuroscience of Aging

Older adults are motivated for social interaction. We will examine this through review of three socioemotional topics that have been the subject of several studies of aging.

Thinking about Self and Others

People-watching at a café on a street in a foreign city might invoke different ways of thinking about other people. One way people might think about others involves impression formation, which is “sizing up” others in terms of the types of traits and behaviors we might expect from them. For example, if a woman bumps another as she rushes past and fails to apologize, you might infer that she is rude. Younger and older adults tend to form converging

opinions of others (e.g., Hess & Tate, 1991; Krendl, Rule, & Ambady, 2014; Zebrowitz, Franklin, Hillman, & Boc, 2013). When receiving information that is diagnostic about one's traits, neural activation patterns also converge, with both younger (Mitchell, 2008) and older (Cassidy, Shih, & Gutchess, 2012) adults activating the mentalizing network, including dorsal and ventral medial prefrontal cortex. However, the ways in which this region is engaged across the age groups differs in line with socioemotional selective theory. Older adults exhibit more of a positivity bias, with medial prefrontal cortex (mPFC) more responsive when impressions of others are positive rather than negative, whereas young adults exhibit a negativity bias such that mPFC is more engaged for negative than positive information (Cassidy, Leshikar, Shih, Aizenman, & Gutchess, 2013). This pattern for the social process of impression formation mirrors findings from the emotion literature (Leclerc & Kensinger, 2008).

Age differences in thinking about others seems to impact how one thinks about the self. Overall, younger and older adults activate similar neural regions, particularly mPFC, when judging whether words describe oneself (e.g., am I vain?) compared to judgments about another person (e.g., is Albert Einstein cautious?) (Gutchess, Kensinger, & Schacter, 2007). This convergence with age extends to encoding self-referenced words into memory (Gutchess et al., 2015). However, making judgments about other people seems to impact the similarity of neural activity with age. When participants encoded words judged in reference to someone other than the self, this dramatically altered the patterns of neural activity for younger and older adults, such that the regions that contribute to the encoding of self-referential information into memory (i.e., more active for words judged about the self, that were successfully remembered on a later memory test) for older adults were associated with encoding words judged about *another person* for younger adults (Gutchess, Kensinger, & Schacter, 2010).

To resolve the inconsistencies across the two encoding studies, making judgments only about the self was directly compared to making judgments across different trials about the self as well as another person in a behavioral study. Whether judgments should be made relative to others (e.g., “am I smart?” versus “relative to others, am I smart?”) was also manipulated, and participants gave judgments on a scale, rather than simply endorsing “yes” or “no”. Whereas young adults’ memory was relatively unaffected across these manipulations, older adults’ memory differed depending on the presence of others, the relative nature of the judgment, and the strength of the endorsement (Gutchess et al., 2015). Younger adults’ memories seemed impervious to the context whereas older adults may be more affected by others such that they encoded information into memory in a more *relative* fashion. These results may also account for the neural differences, suggesting that younger and older adults qualitatively differ in how they think about the self, potentially influenced by the social context.

Mentalizing and Empathizing

Another way of thinking about others while people-watching involves mentalizing, attempting to infer the mental state of another person. For example, while people-watching from the café you may spot a man looking distraught, staring at his cell phone. You might infer that he received unwelcomed news; you might even empathize, feeling some of the same emotion of disappointment or frustration that he is experiencing. Theory of mind, the ability to understand and experience events from another person’s perspective, encompasses both cognitive (mentalizing; e.g., do I understand what information the character in this story has access to, compared to others?) and affective (empathy; e.g., can I feel the emotions that this character is experiencing?) components. Research indicates that theory of mind overall is impaired with age (e.g., Henry, Phillips, Ruffman, & Bailey, 2013; Maylor, Moulson, Muncer, & Taylor, 2002;

Moran, 2013; Sullivan & Ruffman, 2004), though there is some evidence that the deficits may be larger for the cognitive than affective aspects. For example, once overall cognitive ability differences are accounted for, performance on an empathy measure is not impaired with age (Phillips, MacLean, & Allen, 2002). This indicates that cognitive demands such as integrating different cues (e.g., different facial movements, tone of voice) can impact the ability to experience another person's emotion. Performance on some economic tasks show that older adults may experience more empathy than younger adults. For example, in one study younger and older adults assigned money to an opponent in an economic game. When empathy was induced for the opponent, who revealed a recent skin cancer diagnosis, older adults assigned more money to the opponent than did younger adults (Beadle, Sheehan, Dahlben, & Gutchess, 2015). The amount of money transferred served as a measure of prosocial behavior, suggesting that older adults experienced more empathy than young in this task. Several behavioral economic studies have documented more equitable divisions of money between self and other or increased giving in older age (Bailey, Ruffman, Rendell 2013; Ebner et al, 2017; Roalf et al 2011; Lim & Yu, 2015). Preservation of empathy with age indicates that older adults are motivated to experience the mental state of another person.

There has been little investigation of the effects of aging on the neural response to affective components of empathy, but one fMRI study suggests some impairment with age. Younger, middle aged, and older adults viewed pictures of body parts in pain (e.g., a syringe stuck in a hand), intended to induce empathy compared to a "no pain" control picture (e.g., a hand holding a syringe). Younger and middle aged adults activated the anterior insula more than older adults to the painful stimuli, and middle aged adults also activated the posterior insula (Chen, Chen, Decety, & Cheng, 2014). The response of these regions was thought to reflect a

more robust empathic response in the younger and middle aged adults than older adults, though further investigation with a variety of tasks, including active ones requiring a judgment, is needed.

Age differences in the neural regions underlying mentalizing emerge across multiple tasks. One study compared younger and older adults on three different social cognitive tasks, compared to nonsocial control tasks (Moran, Jolly, & Mitchell, 2012). Across all three tasks, older adults exhibited decreased activity in dorsomedial prefrontal cortex, accompanied by increases in errors or decreases in using relevant information to inform social judgments, compared to younger adults. Whether these results generally capture effects of aging on mentalizing, or may reflect the more cognitive nature of the tasks or emphasis on negative information (as for the moral judgment task, as discussed in Cassidy et al., 2013), will require additional work in these areas. Another study employed a less cognitive task in which individuals select the word that describes another person's mental state by reading the expression displayed in the eye region (Castelli et al., 2010). Although much of the mentalizing network was activated by both younger and older adults, some differences in discrete regions emerged that were suggested to reflect strategy differences (e.g., older adults may rely more on language, based on heightened activation of regions associated with verbal processing).

Response to Stigmatized Individuals

From your seat at the posh café, you may also see homeless people in the street, panhandling for change. Seeing stigmatized individuals, such as individuals with amputations or who are homeless, may invoke feelings of discomfort, disgust, or fear. Like younger adults, research suggests that older adults are motivated to regulate their response to seeing stigmatized individuals. Regulating this response requires cognitive control to overcome one's initial

negative reaction. Behaviorally, older adults' executive function capacity predicted their ability to regulate their response to stigmatized individuals (Krendl, 2018). A similar effect emerged for younger adults. When tested under divided attention conditions, young adults were less able to regulate their negative reactions. These results indicate the importance of executive function in regulating one's response to stigmatized individuals and the negative results when this ability is disrupted with aging, at least for older adults with limited executive function ability. The brain regions activated while undergoing fMRI were consistent with the pattern of behavioral results. Both younger and older adults activated brain regions implicated in automatic (e.g., amygdala) and controlled (e.g., inferior frontal gyrus) processes in response to viewing stigmatized individuals (Krendl, Heatherton, & Kensinger, 2009). Prefrontal regions implicated in executive function were activated the most by older adults with higher levels of executive function ability, suggesting the importance of employing regulatory processes for controlling older adults' response to stigmatized individuals. Some of the research on responses to stigmatized individuals connects to the literature on empathy. Stigmatized individuals were depicted as either responsible or not responsible for their situation, in an attempt to manipulate pity and empathy. Older adults with higher levels of global cognitive function showed greater insula activation when viewing stigmatized individuals not responsible for their status (Krendl & Kensinger, 2016). Under these conditions, older adults with lower levels of cognitive function engaged anterior cingulate cortex. Although both brain regions are associated with empathy, these results indicate individual differences in how aging affects pity responses. The authors speculated that insula activity may reflect empathy, as in seeing a situation through another person's eyes, whereas anterior cingulate activation could reflect one's own personal distress, though additional work is needed to substantiate these claims. Taken together, the literature on responses to

stigmatized individuals also serves as an indication of older adults' interest in others and attempt to preserve positive social interactions across the life span.

Emerging Themes in Social Neuroscience

Based on this brief sampling of some of the findings related to the social neuroscience of aging, we discuss observations of patterns that seem to be heightened in the social domain, compared to research on cognitive changes with age. For cognitive tasks, individuals may be constrained in the operations they apply to tasks, taxed by the cognitive load, time limits, and other task demands. It is possible that tasks can be approached more flexibly and with a variety of strategies in the social domain, potentially allowing for age differences of a different nature to materialize (see Gutchess, in press).

Many neural differences with age may reflect changes to strategy, rather than ability.

Age differences in the recruitment of neural regions that emerge for social tasks largely do not reflect the canon of literature based on more cognitive tasks (Gutchess, 2014). In many papers, there are not clear patterns of underactivation of the same networks used by younger adults or additional, perhaps compensatory, activation of prefrontal regions (for reviews of these ideas, see Buckner, 2004; Cabeza, 2002; Cabeza & Dennis, 2013). Rather, many of the age differences seem to reflect the adoption of different strategies for younger and older adults. From the literature reviewed above, the age differences in regions recruited during theory of mind (Castelli et al., 2010) or when encoding information in reference to the self or another person (Gutchess et al., 2010; Gutchess et al., 2015) may reflect the use of different strategies (e.g., verbal processing vs. mentalizing) or different ways of thinking about the targets (e.g., thinking about the self in a more relative, other-focused way).

Ultimately the recruitment of different networks and processes across age groups may reflect some role of capacity or cognitive demand. Perhaps older adults recruit different strategies than younger adults out of necessity, lacking the resources to employ successfully the strategies used during young adulthood. For example, the greater engagement of cognitive control regions in older adults with high levels of executive function in response to viewing stigmatized individuals may reflect an age-related failure (Krendl et al., 2009). Other systems may be able to regulate the negative reaction in young adults, but are not adequate to do so for older adults. Addressing the interplay of flexible social and constrained cognitive abilities will require investigation into social processes in much more depth, testing abilities under a variety of instructions and task constraints. At present, the dearth of research applying a social neuroscience approach to the study of aging makes it impossible to resolve the role of cognitive capacity.

Context contributes to when age-related impairments emerge. The malleability of strategies and orientations that can be adopted when making social judgments may make the social domain particularly prone to context effects. According to this perspective, age differences may reflect what type of information is more motivating, or prioritized for additional processing, in one age group compared to the other. One example of this is reversals in how conditions activate a region with age, such as the engagement of mPFC for positive vs. negative information, presented earlier in the chapter. The region is more engaged by negative information for young adults but positive information for older adults, and this occurs for emotional objects (Leclerc & Kensinger, 2010) as well as impressions of other people (Cassidy et al., 2013).

Motivational factors may also affect task performance and engagement of neural networks such that age differences can be reduced when strategies or task orientations are aligned with older adults' goals. Compared to younger adults, older adults show disrupted activity in midline cortical regions, including the mPFC, when thinking about personal goals (K. J. Mitchell et al., 2009). These age differences are magnified specifically when thinking about promotion-focused goals, those related to hopes and aspirations, compared to when thinking about prevention-focused goals, related to duties and obligations. This pattern of age differences that are decreased or increased depending on the approach to thinking about goals may reflect motivational differences with age. Age differences may be reduced when task orientation is aligned with older adults' perspective.

One intriguing observation from the literature involves the effects of aging on cortical midline activation, including mPFC. As we have discussed at points throughout the chapter, the region can be robustly activated with age when thinking about the self, others, or emotionally-valenced information. Yet a large literature demonstrates impairments in engagement of this same network when individuals are at rest, or not performing a task (e.g., Grady et al., 2010; Persson, Lustig, Nelson, & Reuter-Lorenz, 2007). Under these conditions, the network is often referred to as the default mode network, indicating the heightened activity during baseline periods (between trials) compared to during cognitively demanding, externally-focused tasks. Is it possible that performing social or personally-motivating tasks mitigates these age differences? Or does the apparent preservation of these regions with aging during social and self-relevant tasks reflect methods used thus far (e.g., smaller, higher-functioning samples, or less demanding tasks)?

Connection to Cognition and Emotion

Given the long-standing focus on the study of cognitive processes with aging, it is not surprising that the intersection between socioemotional and cognitive domains has been explored to some extent. There are purported to be bidirectional connections between social and cognitive domains that reflect shared and distinct processes and neural networks. As discussed in Kensinger and Gutchess (2017), models from the cognitive domain that consider the availability of resources (e.g., level of fluid cognition predicts emotion regulation ability; Opitz, Lee, Gross, & Urry, 2014) or compensatory activation (e.g., the shift with age to engage anterior brain regions rather than posterior brain regions occurs not only for cognitive processes, but also affective ones; Ford, Morris, & Kensinger, 2014) have some utility in accounting for how aging affects socioemotional abilities with age. However, there is also a need to recognize the ways in which socioemotional domains influence cognition (e.g., orienting to the personal relevance could eliminate age differences in memory for character information; Cassidy & Gutchess, 2012), as well as the ways in which the domains are separate (e.g., environmental support, reducing cognitive demands by relying on the environment, may be more robust for socioemotional abilities).

And what about distinguishing social from emotional abilities, which were treated in tandem in the previous section under the umbrella of “socioemotional”? One theory that has shaped a substantial amount of research in this field emerged at the intersection of social and emotional processes. Socioemotional Selection Theory initially emphasized older adults’ preference to spend time with family and friends in contrast to young adults’ preference for information seeking (Carstensen, Isaacowitz, & Charles, 1999). These choices were thought to reflect older adults’ heightened awareness of the limited time available in one’s life, as preferences for emotionally meaningful social partners emerge for younger as well as older

adults as perceived endings approach (Fung, Carstensen, & Lutz, 1999). The theory was later extended to encompass age differences in attention to positive information for older adults compared to negative information for young adults, including attentional biases (Mather & Carstensen, 2003) and the valence of recalled autobiographical memories (Kennedy, Mather, & Carstensen, 2004). These differences in orientation to positive versus negative information were suggested to reflect older adults' motivation to regulate emotions and limit emotionally negative experiences (Mather & Carstensen, 2005). According to SST, social preferences can directly impact emotional processes.

A neural approach reveals largely distinct networks supporting memory for social and emotionally valenced information (Macrae, Moran, Heatherton, Banfield, & Kelley, 2004). However, the same regions, such as the amygdala, can emerge in both domains (as discussed in Kensinger & Gutchess, 2015). It seems important to consider its role in tasks and its connectivity with other regions in distinguishing the domains, as the amygdala may operate more automatically and in conjunction with lower-level regions (e.g., visual cortex) for emotional processes but in a more resource-intensive manner, and with higher-level regions (e.g., prefrontal cortex) for social processes (Sakaki, Niki, & Mather, 2012).

Kensinger and Gutchess (2017) propose some future directions for examining how social and affective processes influence each other, as well as intersect with cognition. But importantly, they more broadly raise questions as to how these domains intersect with motivation. In the next section, we discuss the effects of aging on motivation and related neural systems. Then we will consider why the combined study of social and motivational processes is an important future direction.

Connection to Motivation and Reward

The neuroscience of aging literature has only somewhat recently begun to focus on adult age differences in motivational brain systems. The vast majority of studies on motivation and aging use monetary incentives or points-based performance feedback in cognitive tasks (Samanez-Larkin & Knutson 2015). For example, a number of studies have examined how the structure and function of frontostriatal circuits are differentially involved in reward processing, reinforcement learning, and decision making in older age (Samanez-Larkin & Knutson, 2015). Some of these studies document age-related impairments whereby older adults have more difficulty learning from reward feedback and show less activation in frontostriatal circuits (Eppinger, Hämmerer, Li, 2011). Others demonstrate that basic reward signals are intact well into old age especially in reward-based tasks where older adults perform better or no differently than younger adults (Samanez-Larkin & Knutson, 2015). Importantly, although most of these studies use monetary incentives to motivate performance, studies (Seaman et al., 2016; Jimura, Myerson, Hilgard, Keighley, Braver, Green, 2011) have identified domain effects such that adult age differences in decision making, for example, differ depending on the reward domain (e.g., food, money, social reward, health). Thus, it appears that motivational systems may be differentially engaged across adulthood depending on the type of task or reward being offered. The strong focus on monetary reward in the current neuroimaging literature is a limitation for our understanding of broader motivational function in the aging brain.

Although most existing studies use fMRI and thus cannot directly measure specific neurotransmitters, often age differences in these circuits are assumed to be related to age differences in the dopamine system. The dopamine system is composed of an interconnected network of structures in the midbrain, striatum, and cortex (Haber & Knutson, 2009). In the midbrain, the substantia nigra and ventral tegmental area serve as the core source of dopamine

for the striatum and other cortical and subcortical regions. Beyond these initial projections, these regions are organized into ascending anatomical loops through glutamatergic and GABAergic direct connections and relays through the globus pallidus and thalamus (Alexander, DeLong, Strick, 1986). The connectivity of these circuits, drawn from early studies in non-human primates (Haber 2003) recently replicated in humans using diffusion tensor imaging (Cohen et al 2009; Draganski et al 2008), verifies the strong connectivity between the striatum and cortex. The lateral cortical circuit has been referred to as a cognitive/executive loop whereas the ventral striatal, medial temporal, and ventromedial cortical circuit has been referred to as a motivational loop (Lawrence, Sahakian, Robbins 1998; Seger et al 2010).

Many theories of cognitive aging are centered on age-related change in neuromodulation, focusing specifically on dopamine. Although a number of theoretical accounts link dopamine function with age-related cognitive decline (Li, Lindenberger, Sikström, 2001; Braver & Barch, 2002), there has been little attempt to explore the potential role of the dopamine system and these ventromedial corticostriatal circuits for supporting motivation across adulthood. Dopamine clearly also plays an important role in motivation. Midbrain and striatal dopamine function is associated with several motivational individual difference characteristics such as reward sensitivity, novelty seeking, and impulsivity (Buckholz et al 2010a, 2010b; Zald et al 2008). Theories suggesting a link between mesolimbic dopamine and positive emotional experience and improvements in cognitive control (Ashby, Isen, Turken, 1999) have not been thoroughly tested or applied to understanding age differences in motivation.

Although theories of cognitive aging are not only *supported by* but also *based on* neurobiological evidence for age-related change (e.g., Braver & Barch 2002; Li, Lindenberger, Sikström, 2001), the same is currently not the case for motivational theories of aging (e.g.,

Carstensen, Isaacowitz, Charles, 1999; Freund, 2006). In addition to the work cited above on reward processing, other related neuroscientific research has begun to investigate affective and emotional functioning in the aging brain (Samanez-Larkin & Carstensen, 2011), but there has been little to no neurobiological theory development around motivation. There is currently no established neuropsychological model of the adult development and aging of motivational function. Although not previously articulated by existing theories of aging, dopamine might also play an important role in these motivational age effects. Overall, the relation between age-related declines in dopamine functioning and motivational factors have received little study, and no studies have explored the potential overlap of, or dissociations in, dopamine's influence on neurobiological systems that are associated with motivation across adulthood.

A potential neurobiological theory of motivation and aging is complicated by the strong neural evidence for declines in the dopamine system (Bäckman, Nyberg, Lindenberger, Li, Farde, 2006; Karrer et al 2017) and behavioral evidence for mostly preservation in many forms of motivational function (Mather & Carstensen 2005). However, recent research has identified preservation in some aspects of dopamine function and the ventromedial corticostriatal-midbrain circuit in old age. A meta-analytic study revealed that synthesis capacity (the potential to produce dopamine in presynaptic neurons) does not appear to decline with age (Karrer et al 2017). Additionally, both structural and functional neuroimaging studies have documented preservation or even enhancement with age within the midbrain and striatum (Samanez-Larkin & Knutson, 2015) and preserved or enhanced connectivity between these regions and medial prefrontal regions like the anterior cingulate cortex (ACC) (Schott et al., 2007). Thus, it is possible that relative preservation within aspects in these systems supports both social and motivational function in older age, although this has not yet been directly assessed.

Interplay between social context and motivation

As medial prefrontal cortex (mPFC) is a region that features prominently in our review of findings from the social literature, contributing to mentalizing, forming impressions of others, and making judgments about the self, we will focus on this region in considering connections between social and motivational processes. Thus far we have largely considered the effects of aging on this region in terms of its role in social cognition. However, the region has multiple functions, including regulation of emotion and computation of value (Delgado et al., 2016). There are several subdivisions of mPFC; the most general subdivision into three segments identifies the posterior region as reflecting motor function, the middle region as reflecting affective and cognitive control functions, and the anterior region reflecting social cognition, as well as reward and memory processes, though each of these segments can be partitioned more finely into further subdivisions (de la Vega, Chang, Banich, Wager, & Yarkoni, 2016; see also Dixon, Thiruchselvam, Todd, & Christoff, 2017). The dorsomedial prefrontal region identified in some studies likely maps on to the middle region, while the ventromedial prefrontal region strongly implicated in studies of self and other falls into the anterior region.

The ventromedial prefrontal cortex region that in humans is implicated in thinking about self and others is most strongly implicated in rodents in reward, such as cocaine seeking (e.g., Moorman, James, McGlinchey, & Aston-Jones, 2015). Lesions of mPFC lead to deficits in making choices, particularly in terms of recognizing the consequences of choices (Kennerley & Walton, 2011). These findings converge with those from the fMRI literature (see review by Rushworth, Noonan, Boorman, Walton, & Behrens, 2011), including multivoxel pattern analysis (MVPA) methods (as reviewed by Kahnt, 2017), which show that patterns of activity in the region reflect information about value, including predictive information about gains and losses.

It may be that different subcircuits (Moorman et al., 2015), cortical subdivisions (de la Vega et al., 2016), or white matter pathways connecting regions (Rushworth et al., 2011) are implicated in different processes. More research has broached the idea of differing functional connectivity, demonstrating that a region can operate as part of multiple networks, working in conjunction with different regions for different processes (Delgado et al., 2016). But it is also possible that age differences in ventromedial prefrontal cortical activity reflect differences in what social information motivates younger and older adults. The potential intersection of social and reward domains has been investigated little with age. In the remainder of this section, we review literature bridging social and reward in younger adults that holds promise for the study of aging.

A role for mPFC has been recognized across typical decision making tasks (e.g., economic decisions involving money or other consumables, like food) as well as social ones, perhaps distinguishing better and worse outcomes of choices (Lee & Harris, 2013). Some research, however, suggests that different regions of mPFC are sensitive to social and nonsocial evaluation. For example, posterior anterior cingulate cortex responds to stimulus valence, regardless of whether tasks are social or nonsocial (Harris, McClure, van den Bos, Cohen, & Fiske, 2007; van den Bos, McClure, Harris, Fiske, & Cohen, 2007). In contrast, anterior regions of mPFC are selective for people, responding to positive over negative information regardless of whether the judgment is evaluative or not (Harris et al., 2007) or to social contexts (e.g., whether feedback is from a computer or another person) (van den Bos et al., 2007). The mPFC response is consistent with findings that viewing negative outgroup members (e.g., those that elicit disgust) decreases the response of the region (Harris & Fiske, 2006, 2007).

Although this section focuses narrowly on mPFC and adjacent regions, an important direction for future work is to probe the interactions of explicit learning (e.g., hippocampal), implicit learning (e.g., striatal), and social valuation (e.g., mPFC) systems in order to understand how one makes decisions and learns socially-relevant information. Interestingly, there is substantial spatial overlap in the subcortical and medial frontal neural systems proposed to underlie social behavior and reward motivation. For example, the striatum, strongly implicated in reward learning, also responds to expectancy violations for social information, suggesting that social and reward systems overlap in some situations (Harris & Fiske, 2010). Delineating under what circumstances the systems work together, and how these systems, or their interactions, are impacted by aging is an important direction for future work. Indeed, Lee and Harris (2013) note the lack of consideration of social contexts in the neuroeconomic literature and the lack of consideration of economic contexts in the social neuroscience literature. This is particularly true for the study of older adults.

One interesting direction for future work concerns the effects of aging on the interaction of reward systems with self and other. The ventral mPFC region implicated in reward is also the region that responds to thinking about oneself. Some work has suggested that thinking about oneself is highly rewarding. When young adults self-disclosed their own opinions or thoughts about their own personality traits, regions associated with reward and the striatal system, including the nucleus accumbens and the ventral tegmental area, as well as mPFC, were engaged more than when they judged the disclosures of another person (Tamir & Mitchell, 2012). It is possible that older adults are less motivated by self-relevant information than young adults. Earlier we discussed evidence that older adults may be more sensitive than younger adults to the social context when making judgments about oneself and others (Gutchess et al., 2015).

Combined with evidence that older adults may play economic games with more of a prosocial orientation than younger adults (Bailey, Ruffman, & Rendell, 2013; Beadle et al., 2015) a promising hypothesis may be that the discrepancy in valuing self above other in youth may be reduced with age. This suggests the possibility of differences across the lifespan in the motivational value of self and other, which could be in line with socioemotional selectivity theory's recognition of the heightened value placed on meaningful interactions with social partners with age (Carstensen et al., 1999).

Better understanding the neurobiology of social function and motivation across adulthood has great potential not only for more comprehensive understanding of brain aging in general but also for bringing together cognitive, social, and motivational theories of the psychology and neuroscience of aging.

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