Research

Research in our lab examines how adult age differences in motivation, affect, and cognition influence decision making across the adult life span using a combination of behavioral, computational, and neuroimaging techniques ranging from detailed measurement of functional brain activity (fMRI) and neurotransmitter receptors (PET) in the laboratory to experience-sampling in everyday life. Our research covers broad territory linking neuroreceptors at the cellular/molecular level to life outcomes such as health, wealth, and well-being through intermediate psychological and systems-level neurobiological function.

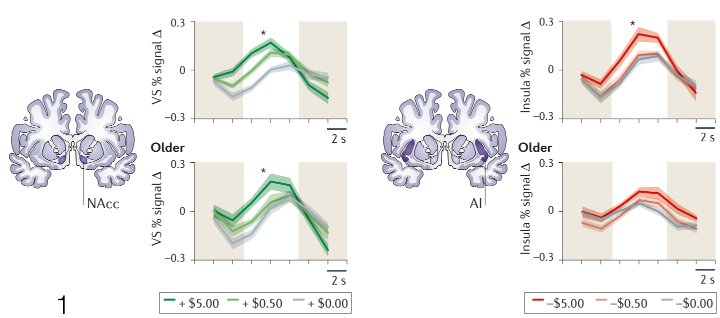
Our research examines what happens to humans, psychologically and neurobiologically, as we get older, and how these changes affect decision making and health behavior in everyday life. I became interested in the study of aging while working as a post-bacc research assistant in the early 2000s. A tidal wave of baby boomers were starting to enter retirement expecting to live longer than any previous generation at a time when many social systems were changing. This generation and future generations of aging adults would be expected to make more independent financial and health decisions. Pensions (defined-benefit plans) were being replaced by 401k's (defined contribution plans). Shared decision making was emerging in medicine. The increasing expectation of more independent choice in older age seemed like a critically important societal issue. Yet, I was surprised by the lack of research on aging and decision making in psychology, neuroscience, or economics. Not much was known. Over the past 15 years, our group and many other research groups have made rapid progress in understanding how aging affects decision making.

The initial series of studies I completed in graduate school were among the first to examine reward processing and decision making in the aging brain. These publications and those that followed during my post-doc and initial junior faculty years (collectively cited over 1000 times) have formed the foundation of a now active area of research on aging and decision making. Decision making is a fascinating topic of study because making choices depends on a complex interaction of processes: valuation, motivation, affective states, learning, experience, cognitive abilities. Many of these processes follow divergent trajectories with age (e.g., knowledge and emotional experience improve while some fluid cognitive abilities decline). Over time our research has covered several areas of focus (Reward Processing, Learning, and Risky Decision Making; Cost-Benefit Decision Making; Neuromodulation; Motivation) with a fourth area of focus on Health Behavior Change is emerging from the integration of our work to date. Despite the overlap between these areas, I summarize each separately below in mostly chronological order to illustrate where this research program started, how it has evolved, and where we are headed next.

Age Differences in Reward Processing, Learning, and Risky Decision Making

As a post-bacc research assistant I collaborated on a longitudinal study of emotion in everyday life that revealed that people experience more positive and less negative emotion in daily life as they get older (Carstensen et al 2011). Inspired by these findings, as a graduate student I was awarded an NIH Pre-Doctoral Fellowship (F31) to examine how emotional valence effects might affect reward processing and decision making. I was jointly mentored by Brian Knutson (an expert on reward processing in the brain who had never studied aging) and Laura Carstensen (an expert on emotion and aging who didn't do neuroscience). I created an area of research that benefitted from both of their expertise but allowed me to establish my own research program on decision making in the aging brain. I was awarded several internal pilot grants at Stanford to support this emerging line of work. Our first study on reward processing – and the first published study of reward processing in the aging brain – revealed a positivity effect (i.e., increased

Age Differences in Brain Function During Loss but not Gain Anticipation

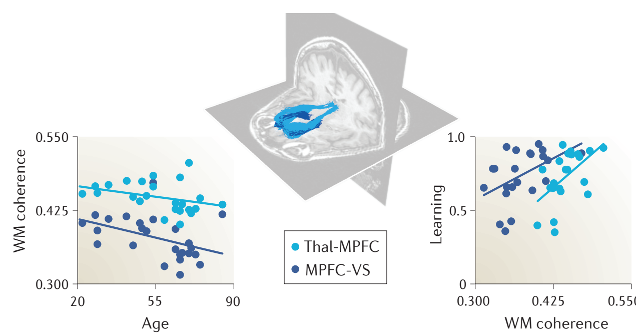


sensitivity to positive relative to negative information) in self-reported emotional experience and striatal and insular functional activation in old age (Samanez-Larkin et al 2007; replication in Wu et al 2014). Older compared to younger adults were less reactive to the prospect of financial losses although they showed similar reactivity to the prospect of financial gains. In spite of these differences in anticipatory reactivity, both age groups showed similar reactivity to actual financial gains and losses after they occurred. This study identified age differences in loss anticipation but preservation in gain anticipation and reward outcome processing. This was encouraging because it revealed areas of preservation of basic neurobiological functions that support decision making. The paper was selected by the Director of the National Institute on Aging as one of the Top 10 Scientific Advances of 2007.

In follow-up work we examined how emotional valence effects influenced other decision-making tasks in the laboratory and in everyday life. In one study we showed that individual differences in neural sensitivity to the prospect of losses were associated with persistent reward learning biases (almost one year later) across adulthood (Samanez-Larkin et al 2008). In behavioral work, my colleagues and I showed that these valence biases in reward learning are also associated with accumulation of financial assets or avoidance of debt (validated using financial credit reports) in the real world (Knutson et al 2011).

In addition to examining emotional valence effects on reward learning, we also identified more general effects of age on reward learning and risky decision making. We found that older adults learned more slowly in tasks that required rapid updating based on recent feedback. In these learning-based tasks, we provided evidence that older adults show reduced representation of reward prediction errors (the difference between the reward received and reward expected: a critical learning signal) in spite of intact reward magnitude signals (Samanez-Larkin et al 2014). Older relative to younger adults also showed reduced structural connectivity between the thalamus, medial frontal cortex, and striatum (Samanez-Larkin et al 2012) and increased neural signal variability in the striatum (Samanez-Larkin et al 2010), both of which were associated with performance on learning-based risky decision-making tasks. A subset of these age differences in neural structure and functional neural signal variability were also associated with older adults making excessively risky choices in a financial investment task in the lab and accumulating fewer financial assets over adulthood in everyday life (Samanez-Larkin et al 2010). We innovated the measurement of neural signal variability (independently but at the same time as Douglas Garrett) and published the first fMRI paper examining neural noise in this way. This was particularly innovative because the vast majority of fMRI research had ignored neural signal variability as uninformative noise. We were the first group to publish evidence that neural signal variability measured with fMRI varied across age groups and was associated with behavioral age differences. This variability measure has undergone continued development by other researchers and has been used by many research groups since then (e.g., see Garrett et al 2013).

Age Differences in Structural Connections Associated with Learning



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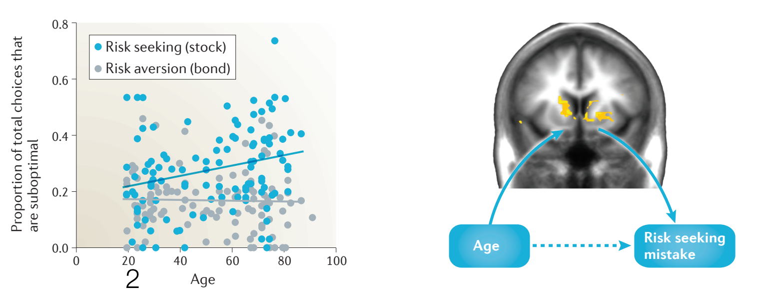
This initial series of studies provided evidence for preservation of basic reward processing in the aging brain but also revealed emotional valence effects in reward processing and that older adults learn more slowly and sometimes make excessively risky choices. Consistent with this collective evidence, we later showed that older adults are especially drawn to positively-skewed risks which promise unlikely yet large

Age Differences in Learning-based Risky Decisions Correlated with Neural Variability



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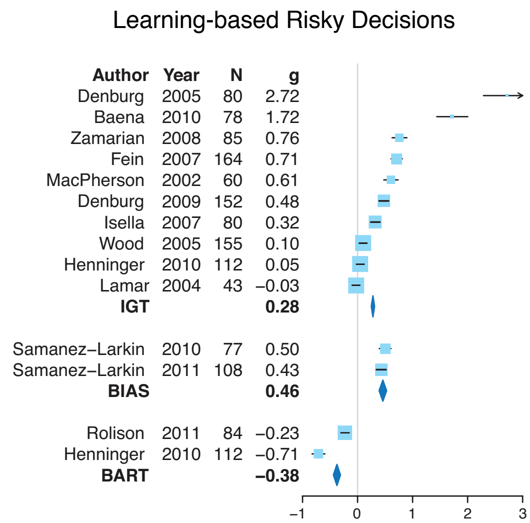
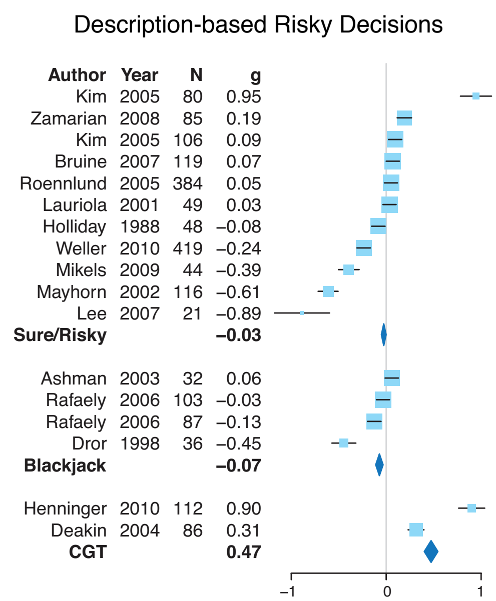
financial gains (Seaman et al 2017). Neural signal in the insula during this skewed risk-taking task was also associated with a measure of susceptibility to financial fraud. These learning deficits and risky decisions may have consequences for real-life financial risk taking and financial management. We have done some work attempting to improve financial decision making in older age. In one study we discovered that excessively risky choices could be minimized and decision making improved with the presentation of decision aids that minimized requirements for learning (Samanez-Larkin et al 2011a). Unfortunately, these decision aids did not have much translational potential for use in the real world, but the project did identify that minimizing rapid learning requirements led to more similar risky decision making across age groups.

Age Similarities in Cost-Benefit Decision Making

Near the end of this first series of studies I conducted as a graduate student, I realized that all of the tasks we were using to study risky decision making depended on learning, yet many decisions that we make in the real world are not learning-dependent. Most of the age differences we were observing in risky decision making may have been due to learning deficits but not necessarily differences in risky decision making. This became more clear after conducting a meta-analysis of behavioral studies of aging and risky decision making. In this meta-analysis my colleagues and I showed that the largest age differences in decision making emerged on tasks that depend on recent learning. Decisions that could be made from description or accumulated prior experience did not change much or at all with age (Mata et al 2011).



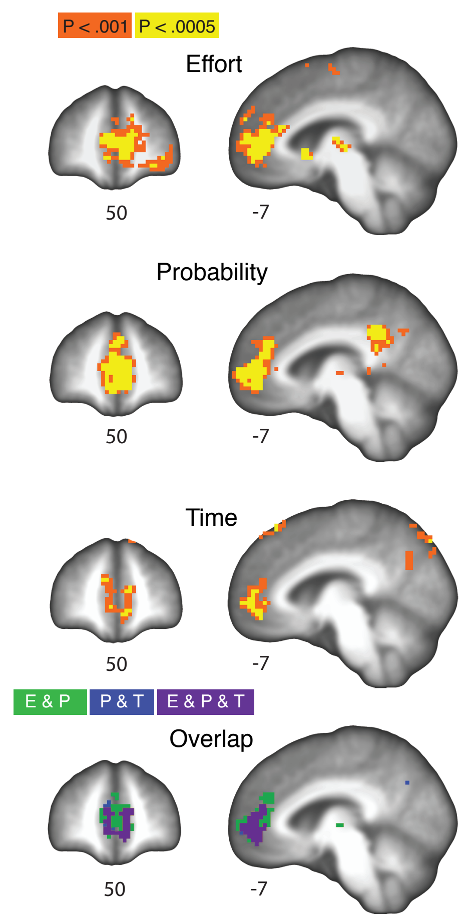


During my post-doc I started a series of studies examining adult differences in decision making tasks that did not depend on rapid learning. For this series of studies, we examined cost-benefit decision making. Most decisions made in everyday life depend on weighing costs and benefits. For example: Should I visit my children over break or take the opportunity to catch up on meetings with colleagues and visit the kids later? Should I invest my holiday bonus in the volatile stock market or leave it in my savings account? Should I walk or bike into work today or take the car? It's clear from these examples that in our attempts to maximize financial well-being, social satisfaction, and physical health, the decisions we make require the weighing of expected benefits with other associated decision features. This involves taking into costs such as varying amounts of temporal delays until outcomes are realized, uncertainty about the outcome of a choice, or the exertion of effort required to achieve various outcomes. Depending on an individual's preferences, these costs may systematically diminish – or discount – the value of decision outcomes. We sought to understand whether there were behavioral or functional neural differences between age groups in these types of decisions that may be more analogous to decision making in everyday life.

The initial challenge in starting this work was that for my post-doc I joined a lab that did not focus on decision making and had never studied aging. My post-doc advisor, David Zald, was an expert on dopaminergic neuromodulatory abnormalities related to impulsivity that contribute to addiction risk. I joined the lab and obtained funding through an NIH F32 and later a K99/R00 to learn more about dopamine function (described in detail in a later section) in healthy young adults to later apply to the study of aging and decision making. Zald had never studied aging but was open to it if I could obtain funding for it. I decided it was a good time to try writing a large grant. After writing a smaller NIH grant (R21) application that was poorly scored, I decided to propose a much larger project that would more comprehensively examine decision making across adulthood. I wrote my first NIH R01 application and it was funded on the first round. I was not PI eligible so my advisor, Zald, was PI. The project started near the end of my post-doc. I was able to hire research assistants and a post-doc to start the study while I transitioned to my first faculty position at Yale. The data collection started and remained at Vanderbilt where I was a post-doc but the data were processed and analyzed in my lab at Yale where I was a new faculty member.

As in the real-world examples above, we studied adult age differences in decisions that involved weighing financial rewards against costs related to probability (higher versus lower likelihood of obtaining the reward), time (shorter versus longer temporal delays until the reward is received), and effort (lower versus higher amounts of physical effort expenditure required to obtain the reward). In this project we found many age similarities in the choices people made and neural function during decision making.

In an earlier, initial study with a small sample (N=25) I found no differences between younger and older adults in time discounting decisions (i.e., both younger and older adults preferred more immediately available rewards even if they were smaller rewards compared to the delayed rewards) with some evidence for an enhancement of striatal function in old age (Samanez-Larkin et al 2011b). However, in this larger grant-funded study of adults of all ages (N=92) we found no age differences in time, probability, or effort-based decisions when making choices about monetary rewards (Seaman et al 2016).



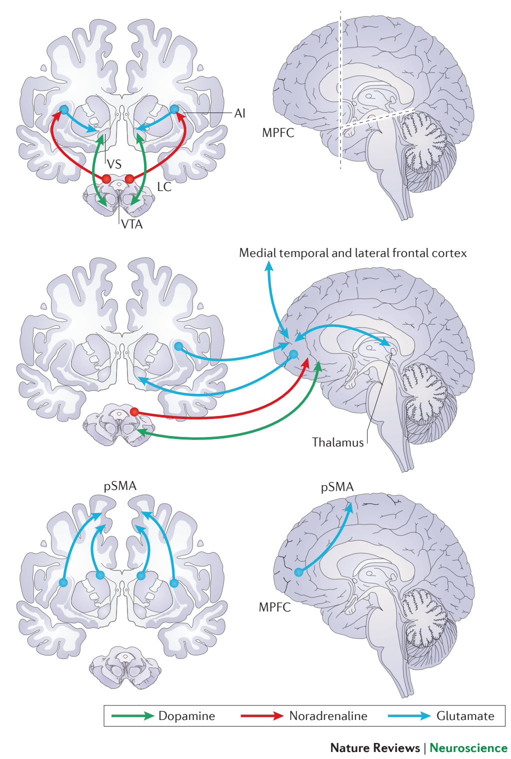
The adults in this study made decisions while undergoing fMRI (N=75), so we also examined the representation of reward value during decision making. We identified regions where functional neural signal was correlated with the discounted value – or subjective value – of reward in each task. The subjective value is the reward amount discounted by that individual's intolerance for the associated cost. For example, if someone has a strong preference for $5 today versus $10 in two weeks, that $5 today has a higher subjective value than the delayed $10 even though the $10 is objectively larger. This general approach allows us to identify the personally idiosyncratic value that an individual places on an individual choice option. Using computational models (to quantify an individual's preferences and discount rates) in combination with functional neuroimaging allows us to visualize and identify individual value signals. It reveals how much this person values, or cares, about this reward taking into account the costs and benefits at this moment. In this way to have access to a utility signal in the brain in real time. This is a powerful signal that is at the core of all value-based decisions. We found that the same brain regions, primarily in the medial prefrontal cortex, represented subjective value across the time, probability, and effort-based decision tasks across all age groups (Seaman et al 2018). Similar to the lack of behavioral age differences in decision making, we found no evidence for age differences in the representation of subjective value in the medial prefrontal cortex and minimal differences in other regions (Seaman et al 2018).

Overall in these tasks, we found evidence for similar decisions and intact function in the brain regions supporting the representation of reward value during decisions that don't depend on rapid learning. We showed that the basic processing mechanisms for computing and representing subjective value are similar across adulthood and functionally preserved. The studies documented that many decision making functions remain stable across adulthood.

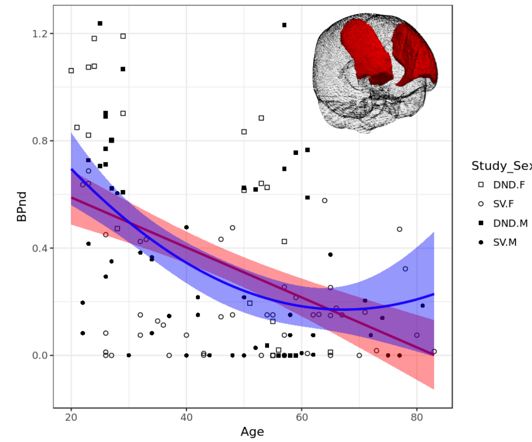
Studying Decision Making to Better Understand the Aging Brain

In the collection of studies described above, we identified both age-related declines and preservation in decision making and frontostriatal brain structure and function. In some tasks, older adults performed as well as younger adults and in others – those that had higher cognitive demands that required rapid learning – older adults performed worse. Yet, across studies we have shown these divergent effects – decline and preservation of function – in many of the same brain regions. For example, in the medial prefrontal cortex we showed reduced representation of prediction errors but intact representations of reward outcomes and subjective value signals. Naively when I started this line of work, I thought I would find out which parts of the brain relevant to decision making seemed to be working well and which were declining in old age. Not surprisingly, the data have been more complicated than that. There are at least two major explanations related to neural mechanisms for these seemingly divergent findings (and a third related possible explanation described in the next section on motivation).

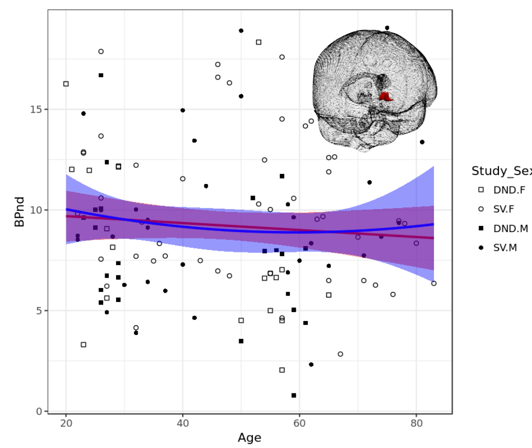
First, the brain areas that are most commonly activated by these reward-based tasks, like the striatum and medial frontal cortex, are highly interconnected with each other and many other brain regions (Samanez-Larkin & Knutson 2015). The sources of these age effects are likely to be distributed across broader networks. This is in part why we started using diffusion tensor imaging to track the structural integrity of multiple pathways that connect with the striatum and frontal cortex. These studies have revealed that age-related reductions in the structural integrity of indirect connections that pass between the thalamus, frontal cortex, and striatum are correlated with poorer performance in learning-based decision tasks (Samanez-Larkin et al 2012). In contrast, direct connections between the midbrain and striatum do not show age differences (Samanez-Larkin et al 2012; replicated in Leong et al 2016). There are also many other inputs to these regions for which we have not fully explored connectivity yet. Examination of structural and functional connectivity across these more distributed networks is an active area of research in our lab right now. Overall, variation in decision making performance may be differentially mediated across different subnetworks that we have not yet fully characterized.



Second, the MR-based imaging methods we've used do not measure specific neurotransmitter and neuromodulatory systems. For example, signaling within this network of regions is chemically modulated by glutamate, GABA, norepinephrine, and dopamine (Samanez-Larkin & Knutson 2015). The BOLD signal detected with fMRI cannot dissociate differential contributions of neurochemical systems. Further, even within neuromodulatory systems, there are multiple mechanisms which may differentially change with age. For example, dopamine has several pre- and post-synaptic receptor subtypes, synaptic mechanisms for clearance, and presynaptic mechanisms for synthesis and release. To better understand the neurochemistry related to decision making, I completed post-doctoral training at Vanderbilt to learn PET imaging and basic neuropsychopharmacology. Age-related declines in the dopamine system have been well-documented for decades. Dopamine function has also been implicated in reward learning and reward-based decision making in human and non-human animals. The first R01 grant that I received with David Zald (mentioned above) to study aging and decision making also included PET imaging of dopamine receptors. In the transition to my junior faculty position at Yale, I also wrote and received funding for a second R01 to study adult age differences in dopamine receptors, transporters, and dopamine release within striatal and frontal brain regions and across the brain. When this second grant was funded I was PI-eligible so it was multi-PI in which David Zald and I shared MPI status. We had the same arrangement as the first R01 grant-funded project where all the data would be collected at Vanderbilt and all of the data would be analyzed in my lab at Yale and now at Duke. We recently combined the receptor data from across the two studies to examine whether there is variation in the effects of age on dopamine receptors across regions and within subregions. We made the data publicly available and created an interactive web app for public online data analysis here: http://13.58.222.229:3838/agebp/. Together these studies showed that more lateral and frontal cortical regions show the steepest negative effects of age whereas some subcortical and medial brain regions show smaller or non-significant effects of age ([Seaman et al 2019]()). For example, we did not find evidence for age differences in dopamine receptors in the ventral striatum or subgenual anterior cingulate (a subcallosal medial prefrontal region that receives direct dopaminergic input from the same cells in the midbrain that project to the ventral striatum). This was consistent with the structural imaging data reported above where we showed intact structural integrity of the pathways connecting the midbrain and ventral striatum. The studies together provide evidence for variation in neurobiological age effects that may partially explain variation in age effects across decision making tasks. We are in the process of combining data and examining associations between dopamine measures and decision making tasks.

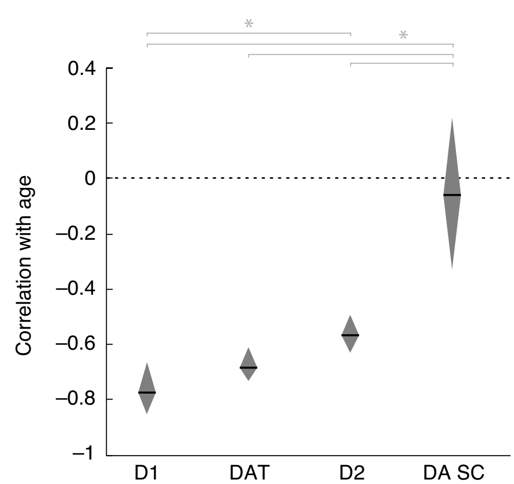


The Middle frontal gyrus shows -15.82% difference in binding potential per decade.



The Subcallosal area shows -1.78% difference in binding potential per decade.

In addition to examining variation in dopamine receptor loss across subregions of the brain, we also conducted a meta-analysis of all of the studies of aging and dopamine using PET/SPECT imaging over the past 30 years. For this meta-analytic study we examined all available measures of the dopamine system including receptors, transporters, and synthesis capacity. Overall, the meta-analysis documented significantly less age-related declines dopamine synthesis capacity relative to declines in dopamine D1-like and D2-like receptors and transporters across adulthood ([Karrer et al 2017]()). This meta-analysis of prior studies revealed a potential presynaptic mechanism, synthesis capacity, that may be preserved or even unregulated as people get older. One limitation of the study is that we were not able to examine regional variation and instead were limited to using data that combined measures across a broad range of brain areas. For example, the effect sizes for age-related declines in dopamine receptors were large although our recent studies of regional variation ([Seaman et al 2019](), just described above) revealed that some subareas are relatively preserved. Additionally, almost none of the published studies controlled for age differences in brain volume so the reported measures of dopamine receptor loss are a combination of receptor loss and general tissue loss (non-specific to dopamine). Using data from these R01-funded projects and an R00-funded project in my lab at Yale, we



documented that age-related declines in dopamine receptors are smaller when taking into account general tissue loss (Smith et al 2019). Thus, the existing literature may have overestimated dopamine receptor losses with age. It is important to note that several of the papers I have described could have been published using only the smaller sample of data collected within my own lab (and those papers would not have included my former mentor, Zald, as a co-author). However, we decided to pool all available data across sites to produce more reproducible and reliable estimates of the effects. Though it is unquestionably better for science, this may have been personally costly as it may appear as though my own research program is not independent enough from that of my former mentors. However, I hope it is clear that this program of research on decision making in the aging brain has been driven by own personal interests and evolved in collaboration with these mentors, none of whom had previous expertise in decision making in the aging brain (and have not publishing on decision making in the aging brain without me). Further, to increase the quality and reproducibility of science there has been a major transition in recent years toward multi-site, team-based neuroscience.

The combination of preservation of synthesis capacity and a network of regions for which there are relatively intact levels of available receptors suggests that there is potential for some components of the dopamine system to work well in older age. Many previously assumed that the dopamine system showed relatively global declines with age and that these declines were causally related to age-related declines in fluid cognitive abilities. There is no question that some aspects of the dopamine system do decline with age and the age-related declines in fluid cognitive abilities are also well documented. However, dopamine has been implicated in a broad range of cognitive, affective, and motivational functions. Many of these functions show divergent trajectories of functional change with age. Our research is beginning to document potential mechanisms that may account for these divergent patterns of function. In this way our research focus on decision making – which depends on interactions between affect, cognition, and motivation – may be contributing to a more comprehensive understanding of brain aging in general.

For many years I have been frustrated reading papers about age effects that speculate about whether the effects are due to "biological declines" or "motivational changes". I've always found the dualism of these questions strange. It is as if the motivational change or preservation is not biological. The authors of these questions are not necessarily dualists, but rather these questions have emerged as an artifact of the tools being used to study age effects on cognition and motivation. There has been a great tension in the field between motivational theories that are largely verbal and based on behavioral evidence and cognitive theories which are often more computational and based on a combination of behavioral and neurobiological evidence. The only barrier to the neurobiological formalization of these motivational theories is a lack of data and the methods to integrate them. I'm hoping to change that. Although research has recently begun to investigate socioemotional functioning in the aging brain (Samanez-Larkin & Carstensen 2011), there is currently no established neurobiological model of how these motivational processes work in old age. Although not previously suggested by existing theories of aging, dopamine and related mesolimbic and mesocortical networks of striatal and medial frontal brain regions may play an important role in the motivational and cognitive mechanisms that support decision making.

Age Similarities and Differences in Decision Making Depend on Motivational Goals

After about a decade of progress studying monetary reward-based decision making in the aging brain, there was a reliable question that would arise after nearly every talk that I gave. Older adults have more money, so they probably don't care as much about making an extra $5 or $10 in a laboratory-based task. This might have been why older adults didn't seem to respond as strongly to the possibility of losing small amounts of money or why they made excessively risky choices in our initial learning-based risky decision tasks. I found this question somewhat frustrating for a while. I had a standard response that (1) older adults do seem to care about making the small amounts of money because we see reaction time speeding in the tasks for higher compared to lower reward amounts, (2) we see similar increases in functional neural activity as monetary reward increase from $0 to $5 to $10, and (3) we never found correlations between income and performance on the tasks or neural activity. Though all of this was true, I also spent a lot of time thinking about my experience running people through these studies. It did sometimes seem like younger and older people were there for different reasons. Many younger participants paid attention, did well in the tasks, completed everything as quickly as possible, collected their payment and went on their way. Many older participants asked more questions about our research, about my own career goals, and whether there were other studies they could do. They gave unsolicited feedback on the tasks and seemed overall much more engaged in what we were doing. As a graduate student I had several older adults make over $100 in a task and then try to give it all to me at the end since I was a "student who probably needed it more than they did." Many of them weren't there to make money; they were there to make a contribution to science and contribute to the budding career of an aspiring scientist. Most of our participants seemed to be motivated to do well in the studies, but they might have been motivated for different reasons. Instead of worrying about these different motivational goals as confounds to be controlled for or explained away, I decided to study them. Maybe there were similarities with decision making in the real world. It was possible that older adults might make one decision if focused only on the money at stake but make a different decision if considering a close social partner like a friend or if considering their own health. I wondered if some of the variation in age differences that were emerging across the literature on aging and decision making might be due to domain differences in goals and preferences.

The first study we did on the topic used the same tasks described earlier on probability, time, and effort-based choices but we examined these decisions using three different types of rewards. We had people consider different amounts of money (monetary reward), amounts of time spent with a close social partner (social reward), or the dosage of a newly developed drug that improved health and cognition (health reward). This work was inspired by earlier social psychological research showing that older relative to younger adults were more motivated to prioritize close social partners (to maximize emotional well being in the present). In the 1990's these findings formed the foundation of Socioemotional Selectivity Theory, which is arguably the dominant theory of emotional and motivational change with age. We found no age differences in monetary decision making in these tasks. However, we found that older relative to younger adults were more likely to accept smaller social and health rewards if they could have them sooner (minimizing time delays) and with greater certainty (higher probability) (Seaman et al 2016). Older people wanted social and health rewards now and with certainty. Social and health rewards seemed to be more motivating in older age.

We wondered whether using social or health rewards in some of the learning-based tasks might enhance the performance of older adults. It is possible that these rewards better engage the preserved aspects of dopamine function in older age and motivate wise decision making. We have several studies currently being designed to answer these questions. It has taken a couple of years to get started because we first developed a set of social rewards that could be manipulated easily in the lab. In a project led by one of my undergraduate students at Yale, we created over 1,000 dynamic facial emotion video stimuli that could be adapted to vary the magnitude of the emotional facial expression. This is now a public resource for the field with published normative data. In our first application of the stimuli, we showed that using these naturalistic socioemotional stimuli reduced or eliminated many of the previously observed age differences in emotion identification (Holland et al 2019). The performance of older and younger adults on an expression identification task were equated using these new stimuli. We are now using these stimuli as socioemotional rewards in learning and decision making tasks. Participants are trying to maximize positive and minimize negative socioemotional feedback in the form of a smiling or frowning expression from a social other, respectively, much like when they try to maximize positive and minimize negative monetary feedback in the form of winning or avoiding losing money.

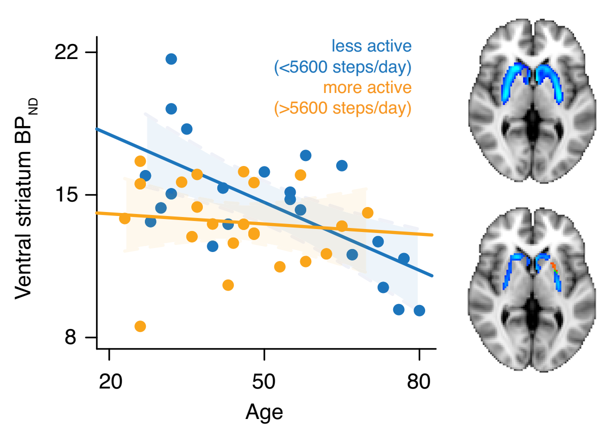
In addition to trying to use more motivationally salient stimuli to enhance performance on decision making tasks, we've also started a new line of work using social and health-related rewards to encourage health behavior change.

Maintaining Brain Health and Motivating Health Behavior in Older Age

As a new assistant professor, I was invited to a meeting jointly sponsored by the Max Planck Institute for Human Development and the Stanford Center on Longevity to collectively evaluate the evidence for the effectiveness of online brain training games. There was a rapidly emerging consumer market of online games that promised older adults cognitive benefits of playing. Scientists from all areas of aging research were invited. I had been recently approached by a startup to help develop games that would improve decision making (I declined to participate for many reasons). At the meeting we discussed the current limitations and issued a scientific consensus statement that many of the advertising claims for these products were not based on scientific evidence. This statement may have, in part, contributed to the multi-million dollar FTC fine of companies like Lumosity for deceptive advertising.

My research was not on brain training games, but this meeting did get me more interested in what, if anything, could improve or at least sustain brain health well into old age. When there was popular press coverage of our research showing declines in white matter connections with age or increases in neural signal variability, readers would comment and ask questions about how they could sustain their own brain health and maintain their decision making abilities. I was frustrated that I didn't have many answers for those readers – who also happen to be the people indirectly funding our research through federal grant dollars. I became increasingly motivated to study interventions that would enhance decision making but also brain health in general.

In that joint meeting on brain training, we talked about what did seem to reliably sustain brain health in older age: social engagement and physical activity. We had already started our line of research on social rewards but we hadn't done anything yet on physical activity. At the time, we were running several multimodal brain imaging studies that included measures of brain structure and function using MRI and measures of dopamine receptors using PET imaging. Dopamine is a neuromodulator in the brain that is implicated in supporting a broad range of cognitive functions like learning and memory but also plays a critical role in motivating behavior and controlling motor action. For all of these reasons, the dopamine system makes critical contributions to decision making. Many studies documented steep losses in the dopamine system with age and we wondered whether being physically active might be somewhat protective or minimize these losses.



As an initial study to document the potential benefits of physical activity for the health of brain systems relevant to decision making, we had all of our participants wear pedometers or activity trackers (e.g., FitBit) during the weeks in which they were involved in our studies. There was no intervention and nothing in our study was focused on physical activity. The participants were just instructed to wear them and go about their normal routines. In the first analyses of these initial data we found that even moderately physically active people (>5600 steps/day) showed less age-related decline in dopamine receptors in the striatum – a neural hub at the intersection of motivation, cognition, and action (Dang et al 2017). People with lower levels of physical activity showed the usual pattern of a strong negative correlation between age and dopamine receptor availability. Although the study was novel because of it's focus on dopamine, there have been many studies documenting the benefits of physical activity for brain health in old age. Scientists aren't the only ones who know this; most people know that being physically active is good for your brain. Yet, humans, especially Americans, are not very physically active. Instead of focusing on continuing to document the brain benefits of activity alone, we decided to start discovering ways to encourage physical activity in everyday life.

We'd spent the last 15 years studying motivational systems (i.e., thalamocorticostriatal brain networks, dopamine) in the aging brain. Could we use what we learned about what motivates adults of all ages to make wise decisions to encourage wise health decision making? Over the past few years, we've started a series of studies to find out. We conducted two studies where we showed differently framed messages about the benefits of walking or the costs of being sedentary to healthy human adults while undergoing fMRI. We monitored physical activity before and after the brain imaging session to see if we can identify which types of messages better activated motivational brain systems and led to larger increases in walking. Data analysis is in progress in my lab. We recently started a related series of studies with a similar design to evaluate whether socially-framed or positively/negatively-framed messages about physical activity would better encourage physical activity in different age groups. We have an ongoing Bass Connections project and obtained a pilot grant from the Duke Center for Population Health and Aging to begin this research. We've recently partnered with Gary Bennett and the Duke Global Digital Health Science Center to see whether we can use brain imaging to optimize the content libraries used in mobile digital health interventions designed to increase physical activity and better food choice. These studies use a neuromarketing-like design to test whether brain responses to specific content can predict effectiveness of the content when delivered through the intervention in everyday life. I'm extremely excited about this new line of work and imagine it will become an increasingly large area of focus in my lab in the coming years.

Summary and Broader Long-Term Goals

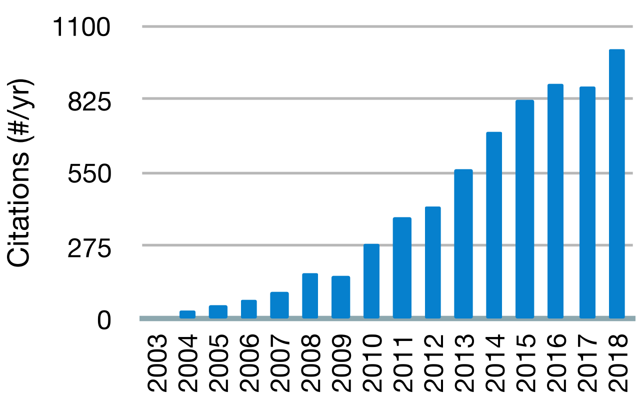
All of the research described above is consistent with our goal of better understanding the neurobiological systems supporting motivation, cognition, and decision making across adulthood. Historically, the scientific study of aging was focused primarily on deterioration and decline. Over the past twenty-five years, the view of brain aging as a decades-long period of deterioration and decline has been slowly replaced with a more complex characterization of changes - growth, decline, adaptation, and reorganization - in brain structure and function across adulthood. We believe that our work has made critical contributions to this evolving understanding of the adaptive aging brain (Samanez-Larkin, 2019).

Beyond filling in additional gaps in current knowledge, our future work will help refine models of the aging brain, enhance understanding of individual differences in decision making at all ages through a life-span approach, and facilitate translation to the real world. We believe that a better understanding of the brain will facilitate more refined interventions which will lead in turn to an increase in public health and well being. By integrating knowledge of which specific networks are most vulnerable to age-related decline and which are preserved we can target specific brain circuits when developing interventions (Samanez-Larkin & Knutson 2015).

A Life-span Approach. With the exception of two studies (on age-related improvements in emotional experience, Carstensen et al 2011, and on stability of risk preferences across adulthood, Josef et al 2016), all of the research I have conducted to date has been cross-sectional. A major future priority for my laboratory will be to conduct longitudinal studies of motivation, cognition, and aging that integrate measures of behavior, brain structure, and brain function. I recently received another R01 grant, MPI with Roberto Cabeza, to run a large cross-sectional study of aging and decision making that we can later extend into a longitudinal design. More generally, I strongly believe that a life-span perspective will contribute to a better understanding of these processes across adulthood. Finding out what is stable or changes across age groups is essential for determining the generalizability of research findings to the broader adult population of human decision makers. Interventions designed based on knowledge of the function of adults of all ages will be more successfully translated to adults of all ages (compared to only studying healthy, young college students). Even for those not especially interested in aging, a more complete characterization of individual differences across adulthood will likely contribute to a better understanding of differences between people at any age (Samanez-Larkin 2015).

Translation from the Laboratory to Everyday Life. Translation is vital for social impact. In the lab we study behaviors that we believe are directly related to real-world behavior. My previous work has documented that performance on many laboratory tasks is related to real-world financial behavior (Ersner-Hershfield et al 2009, Samanez-Larkin et al 2010, Knutson et al 2011). This translational research and much of our basic research has been covered in the popular press (e.g., The New York Times, Boston Globe, USA Today, Forbes, Scientific American). Beyond the walls of the academy, there is a surge of interest in aging and decision making in response to the current tidal wave of baby boomers aging into retirement every day. As described below in the Service section, I recently received a grant (NIA R25) in collaboration with the Stanford Center on Longevity to establish research partnerships between academics and the financial services and healthcare industries. In several current and future projects in my lab, we are collecting measures of real-world decisions and experience-sampling of behaviors outside of the lab in everyday life in younger, middle-aged, and older adults. In addition to facilitating dissemination of knowledge, I am working to directly apply research findings to interventions aimed at improving financial and health-related choices with the goal of maximizing well being in old age. Over the past several years I've worked with the Financial Industry Regulatory Authority (FINRA) Investor Education Foundation on studies of financial fraud aimed at improving their fraud prevention education programs (along with AARP Foundation). I've also worked with the Securities Industry and Financial Markets Association (SIFMA) to attempt to create a collaborative network of scientists and private sector partners to develop new products making financial management easier and increasing income security in retirement. I plan on maintaining these relationships and identifying new opportunities as my career progresses.

Overall, the long-term goal of my research program is to improve health and well-being in daily life. We are currently at a unique moment in human history where demographic changes are and will continue to drastically alter the profile of decision makers in the global population. To the extent that we can respond to the immediate demand for integrative and translational research, we as scientists have the potential to make major contributions to improving the health and well being of humans of all ages.

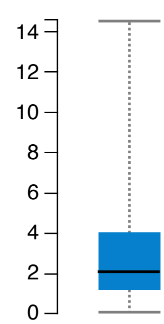


Google Scholar Citation Data

Total Citations: 7205 (last 5 years: 4836)

h-index: 30

i10 index: 38



iCite Citation Data

Relative Citation Ratio mean: 3.12 (cites/yr relative to other NIH-funded papers same year: icite.od.nih.gov)

Teaching

I grew up in Flint, Michigan in a community that was not academically oriented, to say the least. None of my male cousins finished high school. But I had the great fortune and privilege of being raised by a middle-school teacher – one of the only members of my extended family on either side with a college degree. I made it into a good college, but before starting I wasn't really sure what I wanted to do with my life. As an undergraduate at Michigan I changed my major several times in the first two years. I was interested in too many things – economics, business, psychology, neuroscience, philosophy – and it wasn't clear to me which path to follow. I had a hard time connecting all of my interests and couldn't find a class that combined them. Over the years I've been able to merge most of these interests through research. Through my teaching, I bring that multidisciplinary approach to the classroom.

I started gaining teaching experience as an undergraduate. At Michigan I served as a teaching assistant for a community outreach course in psychology. The purpose of the course was to provide an opportunity for undergraduates to participate in increasing public knowledge and applying research findings to enhance well being in everyday life in the local community. This focus on translation is also a major theme of my ongoing research program. I continued teaching in graduate school at Stanford where I spent six quarters as a teaching assistant or head teaching assistant for three different courses (Introductory Statistics, Brain and Cognition, Longevity). Through leading sections I learned that creating an open atmosphere and providing clear applications of the course content encouraged creative and critical thinking and motivated learning. I was honored to receive a departmental teaching award in 2008 and was pleasantly surprised at graduation in 2010 to receive Stanford's Hastorf Prize for Teaching for my overall record of teaching as a graduate student.

As an Assistant Professor at Yale and Duke I have continued to focus on teaching undergraduate courses. I alternate between teaching an upper-level undergraduate neuroscience seminar and introductory statistics primarily for psychology majors.

As an Assistant Professor at Yale I designed an undergraduate senior seminar on decision neuroscience (PSYC 458 / ECON 263), a small, interdisciplinary, discussion-based class. The course required at least some foundation in economics, psychology, neuroscience, and statistics. The material of the course was composed completely of research papers in decision neuroscience (nearly all computational neuroscience papers). I primarily led and steered the discussion each week but I got students involved through what I called "jumpstarts" which are brief demonstrations (e.g., games, contests, interactive activities) that provide the introduction to a set of papers led by the students. It gets the students to jump right into the topic and get engaged as soon as class begins. I model several different ways to do this during the first few weeks of class and over the years I've been blown away by the creativity of what the students come up with. I continue to use these in my current seminar at Duke. One of the things that surprised me was that students found the class extremely hard but also seemed to enjoy the challenge. In 2013 it was the most highly rated undergraduate course in the Psychology Department at Yale and in 2014 it was the second highest rated course in the department (behind Paul Bloom's senior seminar on Good and Evil). In 2013 the course was also rated as the most difficult course in the department and was rated the second most difficult in 2014. The course was cross-listed in Economics and was the highest rated course in the Economics Department during the two years it was offered. The course rating was at the 94th percentile of all courses at Yale with rating data provided by at least one student (rank 113 out of 1930) and was at the 97th percentile of all courses at Yale with rating data provided by at least 15 students (rank 14 out of 489) (rank data extracted from coursetable.com). Student course evaluation ratings and sample comments appear at the end of this document.

After the second time teaching the course, I realized that the most fun class discussions were when we talked about applications to the real world. Students were often impressed with the methods and results but wondered if any of this actually mattered in the real world. For example, did 25 random psychology undergrads' brain responses to investing money in a small-stakes financial market in a brain scanner actually reveal any useful insights about how to help real people make financial decisions in the world? I decided to re-create the whole course based on this question.

At Duke I designed a new upper-level seminar cross-listed in Neuroscience and Psychology called Neuroscience Applications for Everyday Decision Making (NSCI/PSY 462S). The students and I call the course Neuroeverything, because it covers a broad range of topics in which human neuroscience research has been applied over the past two decades. For each topic we read a set of papers and then during class we discuss what the researchers found, what it means, and whether we think it matters. Each week we ask, "Does doing the neuroscience actually make a difference?" Has is revealed any unique insights that will, for example, help people better manage their emotions, judges and juries make fairer decisions, treat neurological and psychological disorders, help people make better lifestyle choices that maximize long-term health, or make the world a more fair and equitable place? Sometimes the answer is no, at least not yet, but the most fun discussions are when there is a mixed opinion in the room. Students have different perspectives and respectfully disagree with each other. I encourage this every week. In my classroom, it's not only okay to disagree with each other, it's also okay to disagree with me. I have my own biases and limited world view. I honestly believe that I learn as much from them as they do from the course. The first time I taught the course at Duke I received my highest teaching evaluations yet, and the evaluations put the course in the Top 5% of undergraduate instructors teaching in the Natural Sciences. It was in the top 5% again in fall 2018.

When I'm not teaching the seminar, I teach introductory statistics primarily for psychology majors. I taught the course at Yale (PSYC 200) and have taught it for the past two years at Duke (PSY 201L). Statistics was my least favorite course as an undergraduate and it wasn't until graduate school that I realized how important and fun it could be (thanks in large part to an excellent instructor and teaching role model, Ewart Thomas). To counter the lack of clear applications in the version of the course I took as an undergraduate, in my own course I introduce all statistical tests using real-world examples that apply to many fields. Over the years, I also have collected examples of applications of statistics by former students in the class. For nearly every topic I have examples of how the stats were useful in research labs, summer internships, or eventual jobs. Some examples include former students who went on to work for the Houston Astros, Spotify, Disney, a major law firm, and McKinsey. The course is completely hands-on and nearly all of the data students analyze for homework assignments and exams are created by the students or drawn from partners in the local university community. For example, my final exams have been based on previously unanalyzed marketing and sales data that I acquired from the Yale Farm, data on a school intervention for healthy eating by a former student working in New York public schools, and the effects of a resume masking experiment run by a former student during an internship at Spotify (that increased the hiring of women on the tech side). My goal for the course is to foster the development of practical statistical thinking and communication skills. I have succeeded if a student can walk into a research assistantship in one of our department's lab and be able to run some basic stats and also tell you what they mean. The exams are practical and applied; students get some data, make decisions about how to analyze it, and write a few paragraphs of results and discussion in an actual manuscript.

> "…what we learned was interesting and so useful to not only my psych research and pre-med aspirations, but also just to everyday life."
>
> -Statistics student evaluation comment

My first time teaching the course at Duke (PSY 201L), I decided to test whether we could generate data that were publishable as a class. Students wore FitBits all semester and for the final exam they analyzed the data to find out whether activity or sleep were related to academic performance during the semester. We found an association between sleep variability and homework grades and now have a manuscript that we plan to submit to an academic journal with every student as a co-author. I plan to do something similar (i.e., a data collection and analysis project with publication potential) every time I teach the course. This activity and exam were featured here at Duke in The Chronicle but also by the Association for Psychological Science in the society Observer magazine as part of a series on Innovations in Teaching. The evaluations for this course also led to recognition in the Top 5% of undergraduate instructors teaching in the Natural Sciences.

Our department is currently in the process of redeveloping two of our core courses for Psychology majors: Statistics (PSY201) and Research Methods (PSY202). Through a seminar in teaching (PSY601S) open to undergraduate and graduate students, in the Fall of 2019 I will begin leading the creation of a two course series on Quantitative Methods that combines methods and statistics. I look forward to working with former students and graduate teaching assistants to design a new course series that will be foundational for all psychology majors at Duke for many years to come. The plan is to create a forward-looking modern course that provides foundational knowledge and practical skills to conduct psychological research in our traditional research labs but also in other non-academic settings. I'm looking forward to co-developing a two-course series that includes some of the innovations I've developed in my own teaching of statistics. The course has the potential to be one of a kind and a model for other institutions.

Before becoming a faculty member, I knew I loved research but I discovered that I also love teaching. My record of teaching at Yale was honored with a university-level teaching award, the Poorvu Family Award for Interdisciplinary Teaching. The Poorvu Award was established to "recognize and enhance Yale's strength in interdisciplinary teaching. [The] award is to be made to outstanding members of the junior faculty who have demonstrated excellence in teaching in interdisciplinary undergraduate programs." In communicating the news of the award, the Dean of Yale College, Jonathan Holloway, said, "This honor reflects your countless contributions, in a still-short space of time on our campus, to innovative teaching at Yale."

At Yale I was on the campus-wide teaching and learning committee. Our primary charge during those two years was to overhaul the course evaluation system to keep response rates high (they were and still are over 80%) while also providing more useful and unbiased ratings of courses and instructors. I would be more than happy to contribute to any related efforts at Duke if asked.

I have the great privilege of spending my days as a scientist and university professor teaching and learning from young, brilliant minds. There are two foundational beliefs at the core of my approach to college teaching. First, doing well in school gives you choices; education is the path to freedom. This has certainly been true for me. The second belief is that the best way to teach anyone is by never losing sight of what really matters in the real world outside of the classroom. My primary goal in teaching college students is to share knowledge and develop critical thinking skills that inspire a new way of thinking about and seeing the world that can be applied to becoming a scientist or any profession where understanding how humans think and behave is critical – so, pretty much every job.

As a kid in Flint, I never imagined that I would get free and become a professor at Duke University. I am doing this job thanks to the inspiration and mentorship of former professors. There is a Toni Morrison quote (right) I strongly identify with that captures my perceived obligations as a university professor, especially at an elite institution. Through my teaching in the classroom and mentorship in my laboratory, I hope to continue to inspire the next generation and equip them with critical thinking and research skills that can be used to make scientific discoveries in the lab or anywhere else in the world. I feel obligated through teaching and mentorship to raise students up and set them on the path to success – all students and especially students from communities like mine.

> "I tell my students, 'When you get these jobs that you have been so brilliantly trained for, just remember that your real job is that if you are free, you need to free somebody else. If you have some power, then your job is to empower somebody else. This is not just a grab-bag candy game.'
>
> -Toni Morrison

Service

Service to the Department

At Duke I serve as an academic advisor to about a dozen undergraduate psychology and neuroscience majors each year. For the 2018/2019 academic year, I was the Arts & Sciences Council alternate representative from the Department of Psychology & Neuroscience. In 2018 I served on an anonymous review committee to discuss applications for departmental research awards supported by a financial gift to our department from the Lafitte Foundation.

At Yale I served as the Undergraduate Neuroscience Track Advisor in the Department of Psychology for 3 years (2013–2016). It was an informal associate DUS position where I was responsible for all of the Neuroscience track students within our major (about 40 students per year). After I left Yale they started a Neuroscience major and converted the track advisor position into a full DUS. I served on a Cognitive Area Faculty Search Committee in 2015 that identified and successfully recruited Nick Turk-Browne to Yale. I served on a Targets of Opportunity Faculty Search Committee in 2014 that identified and eventually successfully recruited Jen Richeson.

Service to the University

At Duke, I ran the Colloquium series for the Center for Cognitive Neuroscience for 2018/2019 (68% of the speakers were women, 47% were under-represented racial/ethnic minorities in science). I was the Faculty organizer for the Center for Cognitive Neuroscience spring retreat in 2018. I have been on the Steering Committee for Cognitive Neuroscience Admitting Program for the past two years and hope to continue serving on that committee. I was an anonymous grant reviewer for the Duke Institute for Brain Sciences Incubator Awards in 2017. I am Program Faculty for the Postdoctoral Training Program in the Center for Aging & Human Development. I am a Faculty Affiliate of the Duke-UNC Brain Imaging and Analysis Center (BIAC), Duke Center for Interdisciplinary Decision Science (D-CIDES), Duke University Population Research Institute (DUPRI), and Duke Center for Population Health and Aging.

At Yale, I was a member of the Yale College Committee on Teaching and Learning (2014–2015), a regular faculty lecturer for Cultural Connections, a panelist for a workshop on Valuing Diversity in Teaching and Learning at the Center for Teaching and Learning Spring Teaching Forum in 2016, and a Social Science Faculty Panelist for Bulldog Days in 2014.

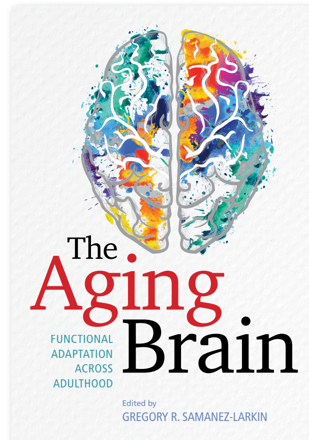
Service to the Profession

In 2010, as a post-doc I obtained funding for (R24) and founded the Scientific Research Network on Decision Neuroscience and Aging (SRNDNA). On the initial 5-year grant I was MPI with Laura Carstensen after becoming PI-eligible as a faculty member but I am the solo PI on the latest 5-year award. The grant and network provide training, funding, and collaborative support for researchers studying decision making whose work has implications for health and well being in older age. We provide training and collaboration workshops, pilot grants, mentorship awards (to support graduate students connecting with an outside senior researcher in the field), summer research awards for under-represented minority undergraduates, and run conferences on decision making and aging. All of our events are free and nearly all of our workshop materials are made freely available on our website after the events. The goal of the network is to support and increase research on decision making in the aging brain.

In 2016, as a junior faculty member at Yale I obtained funding for (R25) and co-founded the Summer in Social Neuroscience and Neuroeconomics. I am the PI on the grant, now at Duke, and I run the summer school with Jamil Zaki (Stanford) and Molly Crockett (Yale). The grant provided support for an initial training workshop on replicability and reproducibility in neuroscience (all talks and materials available free online) and has supported annual summer schools with about a dozen faculty and about 40 trainees from around the world each year. The goal of the school is to bring together research at the intersection of social neuroscience and neuroeconomics. The school has been and will continue to be hosted at the Duke Institute for Brain Sciences. Every year we have at least gender parity in the faculty (BiasWatchNeuro: 2017, 2018, 2019) and broad diversity among attendees. To maximize inclusivity, we provide childcare and nursing support for breastfeeding mothers (providing space for feeding or to ship milk home to babies using MilkStork). Young parents are often excluded from these training and social activities during the summer because of family responsibilities. We are doing everything we can to eliminate those barriers.

In 2016, I obtained funding for (R25) a new initiative to connect academic scientists with private sector partners for research collaborations that target increasing health and well being in older age. I am MPI with Laura Carstensen on the grant and the activities are primarily hosted at the Stanford Center on Longevity.

I have edited 3 volumes that include a collection of reviews related to decision making and aging in the Annals of the New York Academy of Sciences in 2011, a series of empirical papers for a Frontiers Research Topic on Decision Making and Aging in 2012/2013, and a book for APA Books in 2019 titled The Aging Brain: Functional Adaptation Across Adulthood. I regularly serve as an ad-hoc reviewer and occasional guest editor for a range of journals across fields relevant to my expertise (Publons profile) and am a Consulting Editor for the journal *Psychology and Aging*. I have been on the program committees for conferences in my field (Society for Neuroeconomics, International Symposium on Decision Neuroscience, Social and Affective Neuroscience Society) and have served as an invited symposium chair at several conferences. Full details of these and other related activities are listed on my CV.



Future Plans for Service to the Scientific and Local Duke-Durham Community

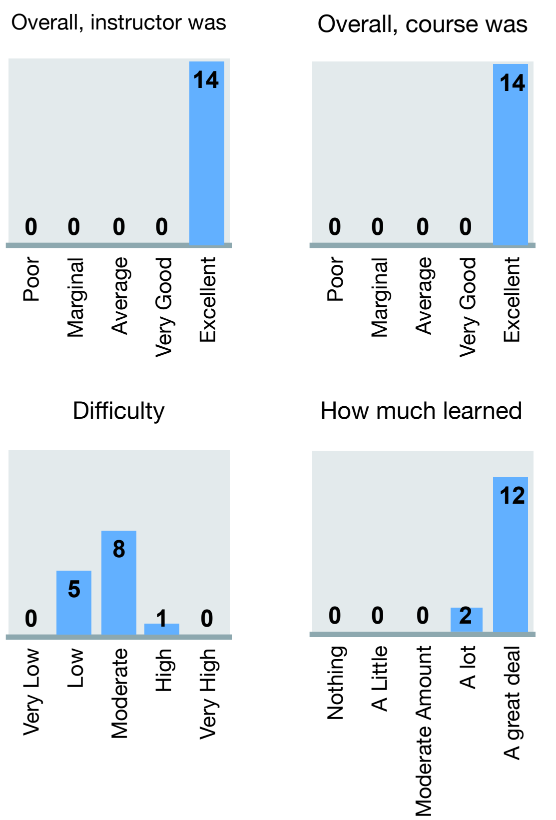
One of my goals in the next two years is to apply for a grant to create a Resource Center for Minority Aging Research (RCMAR) at Duke. A RCMAR is a multi-core P-level grant that primarily supports research and training. Cores vary across sites but the most common ones include funding for graduate and postdoctoral trainees, community subject recruitment, and a community advisory board. The overall goal of these centers is to both increase the number of URMs doing aging research but also to increase the number of people of color and from understudied communities (e.g., low income and/or rural) who are included in studies of aging (which, like most areas of research, have focused heavily on mostly white convenience samples of participants). The training component provides funding to support graduate students and postdoctoral fellows who are URMs in aging research. The subject recruitment core creates and maintains a database of local volunteers interested in participating in research. The goal of this core is to make it easier for other faculty doing aging or life-span research at the local institution to include people of color and from lower-income backgrounds in research studies. A focus of these Centers is on community engagement. The community advisory board is composed of non-expert, non-scientists who are living in the local communities from which researchers would like to recruit participants. These individuals come to campus to hear about plans for future studies, provide feedback, and make suggestions. Given the number of individuals doing aging research across campus (e.g., Psychology and Neuroscience, Sociology, Cultural Anthropology, Neurology, Psychiatry, Geriatrics), I am confident that the resources created by a Center would have broad benefits across campus and also that we would have a strong application to create such a Center at Duke. I considered applying for one on my way to Duke but decided that I was probably too junior to run it. Over the past year, I have connected with other faculty on campus that are interested in leading the grant and eventual center with me. Tyson Brown (Sociology) and I have plans to write the grant together and Linda Burton (Sociology) has enthusiastically agreed to be a senior advisor. Many others including Angela O'Rand (Sociology), Debbie Gold (Psychiatry), Jenny Tung (Cultural Anthropology), Roberto Cabeza (Psychology and Neuroscience), and Terrie Moffit (Psychology and Neuroscience) have agreed that this would be very useful local resource and have agreed to support such as application and participate in an eventual center if we can obtain funding.

In the meantime, my own lab has started a number of local community engagement activities. Post-docs and advanced graduate students are volunteering to give accessible science talks on brain aging to local community centers. We plan to continue doing a few of these each semester. The lab has also been developing a "Neuroscientist for a Day" program for local community members to come to campus and see what it is that we do in the lab. The program primarily targets local youth (especially Black/Latinx students from low-income areas). We have developed separate programs for elementary, middle, and high school students but also have an adult version for people of any age who want to get a behind the scenes look at what we do in the lab. Most of the undergraduates in our lab are co-designing and running these activities.

In addition to the long-term goals of helping humans live longer, healthier lives by making discoveries about brain aging, we've been asking what we can do right now and in the near future for the local Durham community as neuroscientists and psychologists at an elite institution. We look forward to continuing to build local partnerships and engage with the broader, local Duke and Durham community.

Neuroscience Applications for Everyday Decision Making (NSCI/PSY 462S) Duke

Fall 2017

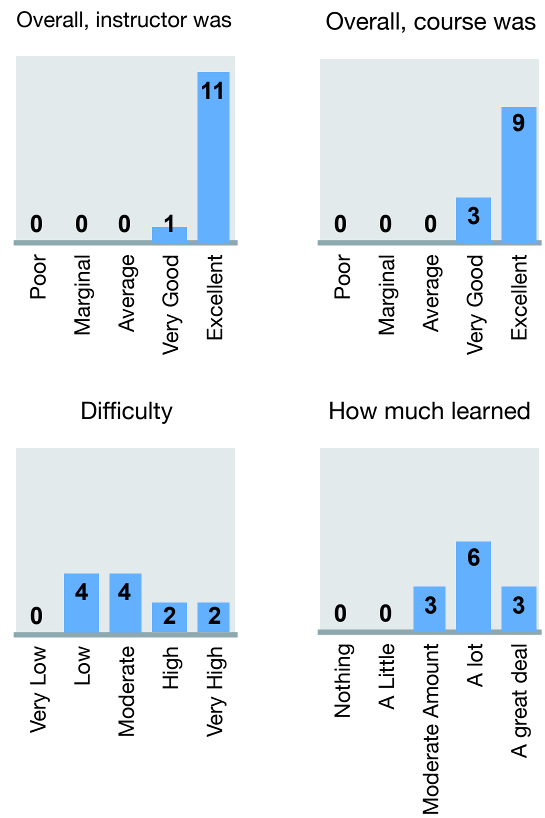


Enrollment: 14

Comments

- “Every class was a good discussion, and the professor created a really fun class environment. This has been one of the most engaging neuro classes I've taken at Duke.”
- “I felt that I could share opinions and they did not have to match the professor's in order to do well in the class. It was exciting to be challenged each class on topics that I have never previously been asked to consider … we learned how to relate our knowledge and ideas to the larger world”
- “perfect balance of conversation [and] engagement with papers”
- “Dr SL is so much fun, brilliant, and provides insight into the field of neuroscience that I have not experienced in any other course.”
- “my favorite class I've ever taken in my life, and I wish I could take it again and just keep exploring more topics”
- “Best class I've taken at Duke”
- Full evaluation comments

Fall 2018



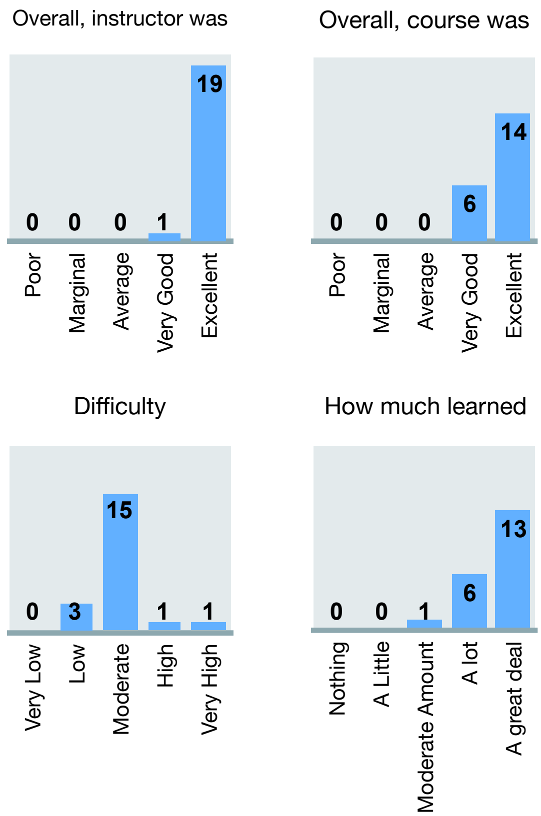
Enrollment: 15

Comments

- “enjoyed discussions and even reading and writing reactions. They made me really think critically and evaluate things in other classes from a similar lens”
- “It helps take all of the things you have learned about and put them into practical application. It really makes you think about neuroscience applications and validity and makes you think critically … in a larger context rather than just within neuroscience.”
- “Dr. SL is a brilliant, funny and caring professor who challenges you in class and really encourages you to think more critically about the implications, validities and limitations of neuroscience”
- “Professor SL is one of the most encouraging and engaging teachers I've had at Duke”
- Full evaluation comments

Introduction to Statistical Methods in Psychology (PSY 201L) Duke

Spring 2018

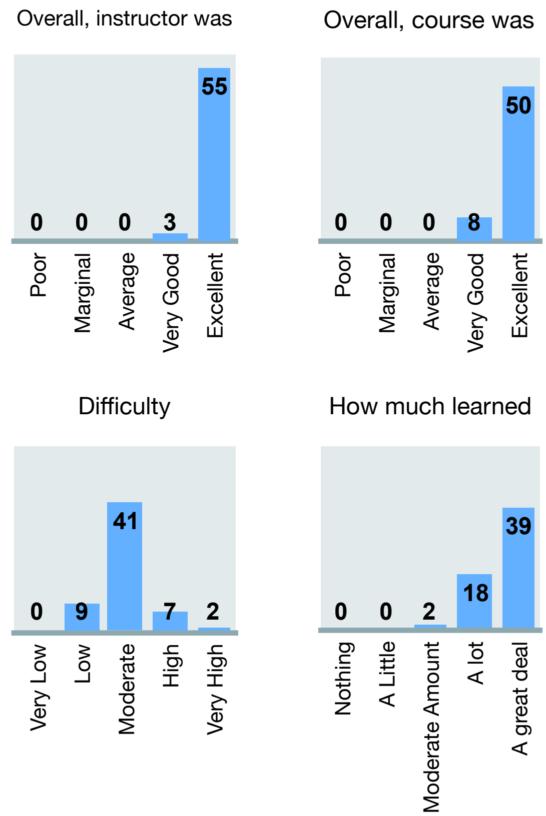


Enrollment: 56

Comments

- “The professor and TAs do a great job of making stats applicable and understandable.”
- "One of the classes that I've learned the most from at Duke"
- “a class I wish I had taken earlier in my Duke career. It's not often, at least in my major, that an instructor takes the time to learn 50 names … was a warm environment, the TAs were great, the skills were highly transferable”
- “Professor Samanez-Larkin created a class environment where it made learning statistics fun and also took away the stigma of effortless perfection.”
- “Absolutely take this course. Regardless of what major you are, there is so much in this course that can be used in the future.”
- “extremely grateful that Duke offers a course like this and wish they had other classes tailored for different major clusters”
- Full evaluation comments

Spring 2019



Enrollment: 78

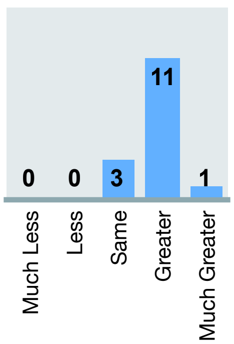
Comments

- “This is such an amazing course. The ‘big picture’ is painted every lecture, and there is a good balance between bringing in new information, and rehashing and reconsolidating old information. Every-day/relatable examples also make the information stick well.”
- “This class will supply you with the necessary tools to understand the "results" in a scientific paper and will teach you how to analyze and interpret data using many different types of statistical tests.”
- “This class made me really enjoy statistics, and I have already applied the concepts to other classes I am taking a Duke.”
- “Professor SL is truly phenomenal. It is obvious that he cares a lot about not only how the students in the class learn the material, but also their wellbeing.”
- “It is not just a "statistics" class. It is a real life skills class.”
- Full evaluation comments

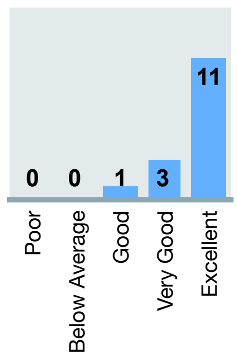
Decision Neuroscience (PSYC 458 / ECON 263) Yale

Fall 2013

Workload compared to other Yale courses



Overall Assessment

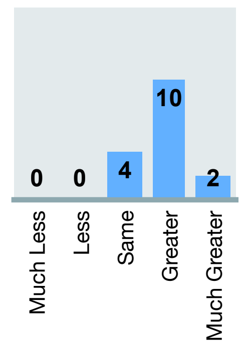


Enrollment: 18
Comments

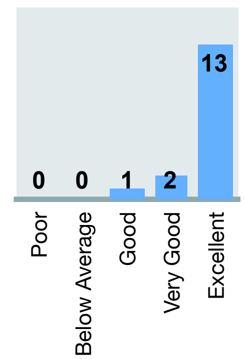
- …one of my favorite classes at Yale. While challenging and informative, Professor Samanez-Larkin creates a laid-back but focused atmosphere for optimal learning."
- "Absolutely amazing course. The subject matter is (obviously) applicable to everyday life. Professor SL is nothing short of a gem."
- "Great course! Perfect balance between being pushed to learn and not being overwhelmed by too much or too complex content."
- "…one of the best professors I had during my Yale career. He is not only extremely knowledgeable, but also extremely nice, funny, and helpful. He will help you understand the most difficult concepts with ease."
- "Best professor I have had in my four years at Yale. Bar none."
- "Professor Samanez-Larkin was amazing (and not just for a first-time professor, but in comparison to others I've had who've been here for decades). He structured the course very well, really encouraged class discussion from the beginning, and was very clear in his explanation of some of the more challenging papers and concepts. The class was tons of fun, but I also genuinely learned A LOT - that's a difficult balance to strike"
- Full evaluation comments

Fall 2014

Workload compared to other Yale courses



Overall Assessment

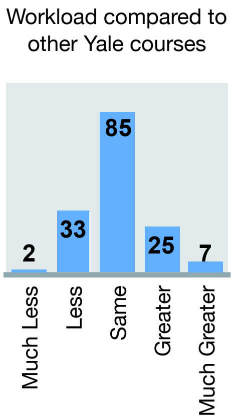


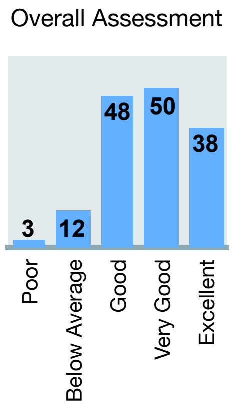
Enrollment: 19
Comments

- "This course was an absolute pleasure … I gained a really solid understanding of a lot of neuroanatomy and learned so much about decision neuroscience … Greg was phenomenal and made every class a blast wish we met more than once a week (I can't believe I'm asking for more class...)!"
- "Prof SL was caring, invested, brilliant, quick to give feedback, and highly organized. I learned a ton … truly feel like I now know this demanding material a mile deep. More than that, I got tremendously better at reading and writing about scientific articles."
- "The best professor I've had. I was not always interested in the readings or topics but looked forward to discussions because I knew he would change my mind. Thinks a lot about students and cares about the whole experience. Really really great."
- "Greg is without a doubt the best professor I've ever had, for his overall brilliance, his thoughtful pedagogy, and most of all for his genuine care for each student. I know it's not very productive to say, but I honestly wouldn't change a thing."
- "This course is fantastic, I would even say the best course I've had at Yale."
- "Class discussions are AWESOME and Professor SL? He's probably the B-E-S-T professor at Yale University."
- Full evaluation comments

Statistics (PSYC 200) Yale

Spring 2014

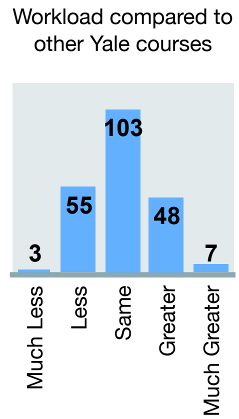


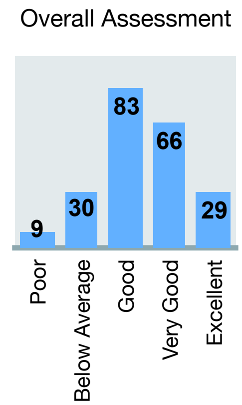


Enrollment: 178
Comments

- “great at giving the concepts to understand the theory behind statistical tests… You'll learn statistics like you'll actually use it, especially if you find yourself reading or writing research papers down the road.”
- “fantastic course. I felt that what we learned was interesting and so useful to not only my psych research and pre-med aspirations, but also just to everyday life. The course was also taught very well and lecture was a delight to attend!”
- “does an incredible job making statistics relevant and understandable.”
- “FANTASTIC instructor. He really cared about making his classes interesting, relatable, and learnable, which is a breath of fresh air.”
- “somehow made everyone feel appreciated and seen; it felt like he was invested in what each of us was getting out of the class.”
- “So great. Created a really nice vibe in such a huge lecture - knew people by name, welcomed comments and questions, etc. Very approachable.”
- “excellent professor! Imbued the class with humor and joy at every turn; thank you for making this potentially boring topic exciting”
- “Professor S-L is one of the best Yale has: you will love him”
- “If you'll believe it, this was actually my favorite class this semester. Statistics.”
- Full evaluation comments

Spring 2016





Enrollment: 258
Comments

- “balances application with theory behind the formulas”
- “Great class--was helpful to learn a more application-based side of statistics (lots of real world data type things).”
- “Professor SL is an incredible professor who makes lecture extremely interesting”
- “great course that I really enjoyed, with lots of class participation that made lectures engaging, and examples from the class population that made the rest of the material interesting.”
- “course is done really, really well. It was clear, responsive to the feedback of the students, and incredibly engaging. The focus on real issues/examples made it so interesting”
- “Great prof, really useful and practical class. I have used what I learned in stat this semester in the final project for another, unrelated course”
- “really enjoyed the exams in this class - they were fun and intriguing and worthwhile and I liked that I got to learn new things while proving what I had already learned”
- “Professor SL was one of the best professors I have encountered in my time at Yale thus far. He made the information very engaging and I appreciated his enthusiasm for the material.”
- “was very in-tune with the students' needs.”
- Full evaluation comments