Department of Health and Human Services
Public Health Services

Grant Application

Do not exceed character length restrictions indicated.

LEAVE BLANK—FOR PHS USE ONLY.

Type	Activity	Number
Review Group		Formerly
Council/Board (Month, Year)		Date Received

1. TITLE OF PROJECT *(Do not exceed 81 characters, including spaces and punctuation.)*

Neural mechanisms of stable and transient hierarchy on social decision making

2. RESPONSE TO SPECIFIC REQUEST FOR APPLICATIONS OR PROGRAM ANNOUNCEMENT OR SOLICITATION ☐ NO ☐ YES
(If "Yes," state number and title)

Number: RFA-NS-21-012 Title: NIH Blueprint Diversity Specialized Predoctoral to Postdoctoral Advanc

3. PROGRAM DIRECTOR/PRINCIPAL INVESTIGATOR

3a. NAME (Last, first, middle)	3b. DEGREE(S)	3h. eRA Commons User Name
Castrellon, Jaime, Jorge Fernando	BA, PhD	JCASTRELLON

3c. POSITION TITLE
Postdoctoral Researcher

3d. MAILING ADDRESS *(Street, city, state, zip code)*
D404 Richards Building, 3700 Hamilton Walk, Philadelphia, PA 19104

3e. DEPARTMENT, SERVICE, LABORATORY, OR EQUIVALENT
Department of Psychology

3f. MAJOR SUBDIVISION

3g. TELEPHONE AND FAX *(Area code, number and extension)*
TEL: (215) 746-4371 FAX:

E-MAIL ADDRESS:
jaimejfc@sas.upenn.edu

4. HUMAN SUBJECTS RESEARCH	4a. Research Exempt	If "Yes," Exemption No.
☐ No ■ Yes	■ No ☐ Yes	

4b. Federal-Wide Assurance No.	4c. Clinical Trial	4d. NIH-defined Phase III Clinical Trial
FWA00004028	■ No ☐ Yes	■ No ☐ Yes

5. VERTEBRATE ANIMALS ■ No ☐ Yes — 5a. Animal Welfare Assurance No.

6. DATES OF PROPOSED PERIOD OF SUPPORT *(month, day, year—MM/DD/YY)*		7. COSTS REQUESTED FOR INITIAL BUDGET PERIOD		8. COSTS REQUESTED FOR PROPOSED PERIOD OF SUPPORT	
From	Through	7a. Direct Costs ($)	7b. Total Costs ($)	8a. Direct Costs ($)	8b. Total Costs ($)
08/01/2022	07/31/2026	79690	6375	318760	25500

9. APPLICANT ORGANIZATION

Name The Trustees of the University of Pennsylvania

Address
Office of Research Services
3451 Walnut Street 5th Floor
Franklin Building
Philadelphia, PA 19104-6205

10. TYPE OF ORGANIZATION

Public: → ☐ Federal ☐ State ☐ Local

Private: → ■ Private Nonprofit

For-profit: → ☐ General ☐ Small Business

☐ Woman-owned ☐ Socially and Economically Disadvantaged

11. ENTITY IDENTIFICATION NUMBER
23-1352685

DUNS NO. 04-225-0712 Cong. District PA-003

12. ADMINISTRATIVE OFFICIAL TO BE NOTIFIED IF AWARD IS MADE

Name Elizabeth Peloso

Title Assoc. VP/Assoc Vice Provost, Research Svs

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E-Mail: epeloso@upenn.edu

13. OFFICIAL SIGNING FOR APPLICANT ORGANIZATION

Name Kyle Wolfe

Title Assistant Director, AOR Pre-Award

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Franklin Building

Tel: 215-746-2812 FAX:

E-Mail: wolfeky@upenn.edu

14. APPLICANT ORGANIZATION CERTIFICATION AND ACCEPTANCE: I certify that the statements herein are true, complete and accurate to the best of my knowledge, and accept the obligation to comply with Public Health Services terms and conditions if a grant is awarded as a result of this application. I am aware that any false, fictitious, or fraudulent statements or claims may subject me to criminal, civil, or administrative penalties.

SIGNATURE OF OFFICIAL NAMED IN 13. *(In ink. "Per" signature not acceptable.)*

Kyle Wolfe Digitally signed by Kyle Wolfe Date: 2022.12.19 16:27:31 -05'00'

DATE

Jaime J.F. Castrellon, Ph.D.
Postdoctoral Researcher
University of Pennsylvania
3700 Hamilton Walk
jaimejfc@sas.upenn.edu

Ashlee Van't Veer, Ph.D.
National Institute of Mental Health
Telephone: 301-443-3107
Email: ashlee.van'tveer@nih.gov

RE: Jaime. J. F. Castrellon K00 Application
December 13, 2022

Dear Dr. Van't Veer,

I write to submit my revised K00 application as a continuation of my F99 (F99 NS120412). My K00 application is entitled "Neural mechanisms of sustained and transient hierarchy on social decision making."

I have included a summary page that details the revisions made to the research and training plan and additional documents.

Thank you for your consideration. I look forward to the reviewer's comments. Please let me know if you need any additional information.

Sincerely,

Jaime J. F. Castrellon, Ph.D.
University of Pennsylvania
eRA: JCASTRELLON

INTRODUCTION TO APPLICATION

The reviewers of the previous application (1 K00 NS120412-01) pointed out concerns and generously offered suggestions for improvement. The following issues have been addressed in this revision (and line edits are marked in margins):

Revisions to Research Plan

The reviewers raised concerns about the details and suitability of the experimental tasks (in particular, the patent race game in Aim 2). The patent race game now includes citations to the game theory literature and its use in psychological and human neuroscience research. Additional text explains possible decisions in the task by participants as example scenarios. To further address the suitability of the experimental design in Aims 1 and 2, an additional section titled “Potential pitfalls” discusses potential challenges to the experimental design with a plan to ensure that perceptions about social hierarchy cannot be explained by other factors like stereotypes. Separately, a concern was raised about missing details regarding statistical power. To address this, a section in the research strategy details the justification for the sample size (35 participants) based on fMRI t-statistic values in brain regions of interest from a recently published study by the applicant’s sponsors that applied a similar approach to study how stereotypes influence social decision making (Kobayashi et al., 2022) and studies of the reproducibility of social cognition studies in human fMRI (Turner et al., 2018). An additional concern was raised about analysis plan details. Details have also been added to further explain the computational model will help test hypotheses about the integration of stable and transient social information. Added text includes the specific statistical tests and software to be used for Aims 1 and 2 and details about the experience sampling in Aim 3. Details about completion rates and missing data analysis have been added to the experience sampling analysis plan in Aim 3. The protocol for Aim 3 now explicitly justifies collecting experience sampling data after neuroimaging to prioritize completion of the main fMRI experiments in Aims 1 and 2.

Revisions to Training Plan

The career development plan has been updated to better integrate the roles of advisory committee members. The technical and conceptual training sections include bolded font sections detailing how advisory committee members will help advance the applicant’s goals. The long-term goals have been updated to reflect the applicant’s interest in applying for a K99/R00 award. To prioritize plans for this award, the text regarding applying to faculty jobs in year three has been removed.

Revisions to Responsible Conduct of Research

The Responsible Conduct of Research (RCR) training plan has completely revised and reformatted been to include details from the University of Pennsylvania Biomedical Postdoctoral RCR and specifically addresses the four components of in-person training (format, subject matter, faculty participation, and duration of instruction). The RCR includes 8 hours of in-person training that is led by faculty.

Revisions to Human Subjects Recruitment Plan

The initial application did not include documents for: (1) Inclusion of Women and Minorities, (2) Recruitment and Retention Plan, (3) Inclusion of Individuals Across the Lifespan, and (4) an Inclusion Enrollment Report. These documents have now been added including justification for the targeted age ranges for study (ages 18-40) and planned number of participants.

Duke UNIVERSITY

July 8, 2022

Dear committee,

Jaime Castrellon has successfully completed the F99 phase of the D-SPAN and is well-prepared for success in the K00 phase. As a graduate student here at Duke which ended with support by an F99, Jaime has become a star in every category. They're an award-winning researcher (well-published, poster winner at multiple conferences), award-winning grant writer (NSF GRFP, NINDS F99/K00, multiple internal Duke grants), award-winning mentor (two Duke campus-wide mentoring awards), and one of the best graduate teachers we've had in the Department of Psychology and Neuroscience. While supported by the F99, Jaime has essentially been running a lab within our lab, regularly supervising groups of undergraduate trainees. They are on an outstanding trajectory. Jaime is also a deeply committed advocate for equity in higher education and science. A resource guide they collaborated on to guide faculty in mentoring minoritized students collected thousands of views and was highlighted in Nature. Here at Duke Jaime has directly mentored a diverse group of undergraduates and post-baccs during the F99 phase who have each secured competitive jobs or enrollment in graduate programs.

During the F99, Jaime has been developing their own research program on social decision making. The transition from basic mechanisms to social aspects of value-based decision making in collaboration with Ming Hsu at Berkeley was the focus of the F99 and will continue to be the focus of the K00. While supported by the F99, in our lab Jaime has published one paper, has one under revision, and has two more in progress focused mostly on basic mechanisms of cost-benefit decision making and the role of dopamine in human and non-human animal decision behavior. Jaime also has a separate line of work here at Duke with John Pearson on juror decision making with two manuscripts under revision. During the F99, Jaime has developed a surprisingly vast methods skillset and a creative vision of how to piece together data to answer big picture research questions.

Jaime's dedication to science, teaching, and mentorship will serve the whole field well long term as they transition to the K00 phase and eventually to becoming an independent scientist. Jaime already has demonstrated excellence in all aspects of what it takes to be an outstanding independent scientist and professor. Jaime's excellence has already meaningfully made Duke a better place. As a post-doc at Penn, Jaime has assembled an outstanding team for the K00 phase. I look forward to following what comes out of that experience.

I hope it is clear from my letter that Jaime has been highly successful during the F99 phase and ideally positioned to take full advantage of the K00 phase at Penn. Jaime has a solid foundation of training with demonstrated excellence in every aspect of what it takes to be a star researcher, teacher, mentor, and campus community member. At this early career stage Jaime has demonstrated not only a deep commitment to basic and translational research but also a deep commitment to supporting fellow under-represented students and people at all levels. This foundation will set them on the path to great long-term success as a professor and scientist. We'll all miss Jaime dearly here at Duke and will be so proud to count them as an alum as they continue to advance in the academic ranks.

Sincerely,

Gregory R. Samanez-Larkin, Ph.D.
Jack H Neely Associate Professor, Department of Psychology & Neuroscience
Director of Graduate Studies, Cognitive Neuroscience Admitting Program
Core Faculty, Center for Cognitive Neuroscience, Duke Institute for Brain Science
Special Assistant to the Vice Provosts of Undergraduate Education & Student Affairs
Levitan Faculty Fellow
Faculty in Residence, Alspaugh
Duke University
(650) 799-5715
g.samanezlarkin@duke.edu

Final Progress Report for F99 Phase

Accomplishments

Major Activities

During this funding period, significant work and progress was made on Aims 1 and 2 and a postdoctoral position was successfully secured (Aim 3.)

Aim 1 – pre-F99 phase dissertation research. Aim 1 focused on using Positron Emission Tomography (PET) to quantify dopamine D2 receptors in humans and identify associations with value-based decisions. In the process, I completed four studies including: (1) a meta-analysis of rodent dopamine pharmacology effects on reward discounting, (2) a study comparing the relation between reward discounting and PET-derived measures of dopamine function in healthy and clinical populations, (3) a study identifying a correlation between dopamine D2 receptor levels and an fMRI-based neurocomputational value signal during intertemporal choices, and (4) a study evaluating whether individual variation in human dopamine D2 receptor levels can partially-explain self-control behaviors outside the laboratory. Three of these four studies were published in peer-reviewed journals and one is currently undergoing peer review.

Aim 2 – F99 phase dissertation research. Aim 2 focused on transitioning from non-social reward valuation to social reward valuation with a specific focus on the relationship between human dopamine, prosocial behavior, and social learning. The first major activity of Aim 2 was to learn about and design computational models of human social decisions. This was accomplished and used to examine whether theoretical models of altruism and affect (guilt and envy) relate to dopamine D2 receptor availability.

Aim 3 – Postdoctoral research direction (K00 phase). The major activities for Aim 3 included discussing potential mentor candidates with my F99 advisory team, and then contacting several potential labs. This was done between September and November of 2021. Through direct “cold” emails contacts, I narrowed down my options and scheduled talks at: (1) University of Pennsylvania, (2) Yale University, (3) Brown University. I gave additional practice talks at Harvard University and University of Texas at Dallas. As a result of the interviews, I was offered a position at all three institutions, and after discussing the pros and cons of each lab with my mentoring team, I accepted the position at University of Pennsylvania

Significant Results

Aim 1 – pre-F99 phase dissertation research. Existing studies in rats and non-human primates have identified associations beween transient fluctuations in dopamine release and neural computations of subjective value in regions like the prefrontal cortex (PFC) and ventral striatum (VS). While these studies focus on fine time-scales, it remains unknown whether trait-like variation in dopamine function (on the order of months to years) relates to individual differences in reward valuation. Importantly, existing studies in have largely focused on either healthy or clinical groups alone without strong consideration of group differences in correlations between behavior and brain measures. We found evidence that individual differences in dopamine D2 receptor levels related to discounting behavior in clinical groups (e.g. Parkinson’s Disease and ADHD) but not healthy groups. Nevertheless, we found evidence that while D2 receptors were unrelated to choice behavior, they were related to the subjective weighing of options. Evidence for this subjective value association was present in an fMRI signal associated with subjective value and behavioral sensitivity to long term benefits in self-control decisions outside the lab. These data urge caution when drawing comparisons between healthy and clinical groups and indicate that dopamine may be more strongly related to algorithmic-level antecedents of behavior but not observed choices.

Aim 2 – F99 phase dissertation research. To extend associations between dopamine and value-based decisions to social cognition, we needed to evaluate decisions where maximizing rewards comes with the cost of unfair giving to others and identifying how social learning influences valuation. To do this, I collected data and analyzed decisions in two tasks: (1) a modified dictator game and (2) a social strategy learning game. Decisions in these economic decision task were correlated with dopamine D2 receptor levels in two different studies. In the first study, among 81 healthy adults, we identified specific brain regions where dopamine

function related to prosocial choices. Specifically, greater D2 receptor levels in the amygdala and to a lesser-extent, the ventral striatum were associated with less fair giving in a position of strength (advantageous) and weakness (disadvantageous). Generally, these findings suggest that these dopamine function in these mesolimbic regions influences preferences for equity. Computational modelling suggested a moderate negative correlation between amygdala D2 receptor levels and model-predicted feelings of envy such that participants with greater D2 levels experienced no envy of other players' payoffs. This relationship wasnot present for the ventral striatum. Additional analyses evaluated whether reward maximization could explain decisions according to models of rational choice behavior. However, no associations between dopamine D2 levels and measures of rational decision making were identified, suggesting that observed correlations cannot be explained by simple reward-seeking alone. A manuscript describing these effects is in the final stages of preparation for submission to a peer-reviewed journal.

In the second study, among 35 healthy adults, I analyzed dopamine D2 receptor availability in relation to decisions in a social learning task. This experiment required participants to act strategically and compete with a computerized agent by investing endowed money on different goods. The goal is to investment more than their competitor without wasting their entire endowment. Preliminary findings indicate that participants with lower insula D2 receptor levels were more likely to change competing investments after experiencing regret in a prior investment. Overall, higher payoffs (indicative of greater adaptability to competition) were associated with lower D2 receptor levels in the amygdala. Ongoing analysis is evaluating computational measures of competitive learning and valuation. The preliminary have been accepted for a presentation at the Society for Neuroeconomics annual meeting in October 2022.

Aim 3 – Postdoctoral research direction (K00 phase). I interviewed in-person at the University of Pennsylvania and virtually at Yale University and Brown University. I was offered positions at all three institutions and accepted a position at University of Pennsylvania working jointly with the labs of Anna Jenkins and Joseph Kable. As proposed throughout this application, my postdoctoral research will focus on understanding the interrelationship between neural mechanisms of social decision making and social status/hierarchy. I will apply my current expertise in human neuroimaging to look at brain mechanisms that support social interactions with others who vary in status and power. I will further explore how individual differences in personal experiences with power, hierarchy, and discrimination shape these decisions. I will leverage the expertise gained during the K00 phase with my F99 phase expertise to mold a research program to support a lab investigating aspects of neural mechanisms of social decision making.

Training and Professional Development

Training

Technical training during this project period focused on expanding my skills in computational modelling as well as understanding of game theory and behavioral economics in the context of neural mechanisms of value-based decision making. To this end, I have learned how to design and implement complex models. This includes writing and running complex code in Python and R languages. This experience will help me answer future questions about how decisions with other agents who vary in status moderate brain mechanisms of learning and decision making.

Professional Development

My professional development during the F99 included mentoring three undergraduate students, attending Social area brown bag lecture series at Duke, and presenting findings in labs at Harvard University and University of Texas at Dallas. I also had the opportunity to practice postdoc job talks in the Motivated Cognition and Aging Brain lab at Duke. These skills have prepared me to succeed in academic job interviews and support future trainees/mentees in laboratory research.

Honors/Awards (2021 – Present)

- Dean's Award for Excellence in Mentoring (*Duke University's highest mentoring award*)

Conference Presentations (2021 – Present)

- Leong, J.K., Ellis, E., **Castrellon, J.J.,** Samanez-Larkin, G.R. Structural coherence of dopamine projections to the nucleus accumbens (NAcc) is associated with greater dopamine reception. Poster

presented at the annual meeting of the Social Affective Neuroscience Society. Virtual. May 2022. (*Poster with new collaborators and Sponsor Samanez-Larkin*)

- King, K., Ilsley, A., **Castrellon, J.J.,** Zald, D.H., Samanez-Larkin, G.R. Subjective responses to amphetamine are related to fMRI anticipatory responses to monetary rewards in the ventromedial prefrontal and orbitofrontal cortex. Poster presented at the annual meeting of the Social Affective Neuroscience Society. Virtual. May 2021. ****Best Poster Award Winner** (*Poster with 2 mentored undergraduate students and Sponsor Samanez-Larkin*)

Publications (2021 – Present)

- **Castrellon, J.J.,** Hakimi, S., Parelman, J.M., Lin, Y., Law, J.R., Skene, J.A.G., Ball, D.A., Malekpour, A., Beskind, D., Vidmar, N., Pearson, J.M., Carter, R.M., Skene, J.H.P (*In revision*). Neural support for contributions of utility and narrative processing of evidence in juror decision making. (*Preprint publicly available on BioRxiv*)
- **Castrellon, J.J.,** Hakimi, S., Parelman, J.M., Lin, Y., Law, J.R., Skene, J.A.G., Ball, D.A., Malekpour, A., Beskind, D., Vidmar, N., Pearson, J.M., Skene, J.H.P., Carter, R.M. (*In revision*). Social cognitive processes explain bias in juror decisions. (*Preprint publicly available on PsyArxiv*)
- **Castrellon, J.J.,** Young, J.S., Dang, L.C., Smith, C.T., Cowan, R.L., Zald, D.H., Samanez-Larkin, G.R. (*In revision*). Dopamine biases sensitivity to personal goals and social influence in self-control over everyday desires. (*Preprint publicly available on BioRxiv*)

Research Talks (2021 – Present)

- Center for Cognitive Neuroscience
  Duke University, Durham, NC (March 2022)
- Aging Well Lab
  The University of Texas at Dallas, Dallas TX (November 2021)
- Social and Affective Neuroscience Lab
  Brown University (Providence, RI) (October 2021)
- Neuroeconomics Forum
  Yale University, New Haven, CT (October 2021)
- Intergroup Neuroscience Lab
  Harvard University, Cambridge, MA (October 2021)
- Integrative INDecision Neuroscience Lab
  University of Pennsylvania, Philadelphia, PA (October 2021)

Project Summary/Project Abstract

This application seeks to understand how temporally-dynamic information is incorporated into social decisions by investigating the influence of social hierarchy on basic neural and cognitive processes engaged in valuation and learning. While some kinds of social information are stable, others can fluctuate in a way that can shift a social context. Hierarchy, or the organization of individuals according to power and status, is a common feature of most social animal species including humans and is a kind of social information that can exhibit both stable and transient qualities. Knowing a person's place in society may shape an individual's decisions to trust or learn from them. Critically, deficits in social decisions, broadly, are observed in psychopathologies ranging from autism to schizophrenia and potentially, such deficits might arise from maladaptive monitoring and integration of time-varying social features such as hierarchy. While stable hierarchical identities like socioeconomic status or gender could influence a person's decision to trust or learn from professionals like medical doctors or teachers, situational contexts can further transiently increase or decrease perceived differences in power or status (e.g., being at a hospital or in a classroom). The intersection between these stable and transient features of hierarchy are especially important because power dynamics may engage distinct or overlapping mental processes. For instance, patients might be more proactive in suggesting alternative therapies if they perceive healthcare providers to be of similar social status. These processes might further modulate different kinds of decisions depending on implicit goals. Affiliative and competitive goals might be under dissociable influence of hierarchy if the neural and cognitive processes involved in the decisions only partially overlap. While traditional psychological experiments have investigated human social decisions using anonymous or unknown partners (which offers important experimental control), this limitation is detached from real-world scenarios in which humans acquire dynamic information about the people with whom they are interacting. Studying the neural mechanisms involved in these decisions can provide information about the basic cognitive processes that contribute to maladaptive decision making. Specifically, computations in brain regions like the striatum, prefrontal cortex, and temporoparietal junction supporting reward maximization over costs, mentalizing, and learning abilities are important for interactions with others. Notably, the functional roles of these regions are consistently implicated in clinical disorders like schizophrenia and autism, which share common social behavior deficits. Therefore, understanding the brain mechanisms involved in the integration of social hierarchy with learning and decision making can provide transdiagnostic insight about social behavior. This examination of interactions between psychological constructs like reward valuation and learning with social processes achieves and extends the goals of the Research Domains Criteria (RDoC) Initiative by considering the temporal elements of social context at the neural and cognitive levels. **Aim 1** of this proposal will investigate how stable and transient social information is integrated in decisions with affiliative goals. Here, participants will make decisions about sharing rewards in a distribution game. Specific hypotheses will be tested by combining functional magnetic resonance imaging (fMRI) and computational modelling to test whether neural representations can distinguish costly sharing of rewards between oneself and others when information is provided about others' social status and power in both stable and transient domains. **Aim 2** will extend these mechanisms to a competitive social learning context. During fMRI, participants will perform a task that permits evaluation of complex belief learning from decisions made by opponents. Hypotheses will evaluate whether brain mechanisms supporting social learning depend on competitors' perceived status and power. Studying these processes in the same participants who complete the experiment in Aim 1 will further allow comparison of hierarchical identity representation. Specific test will evaluate whether humans form latent representations that change depending on the context across different dimensions: affiliative versus competitive goals, stable hierarchy position, and transient hierarchy position. Finally, **Aim 3** will investigate how these neural representations relate to daily social interactions and personal experiences with social inequality. When interacting with others whose perceived hierarchy is either ambiguous or different than one's own, humans tend to deploy emotion regulation strategies. Deficits in emotion regulation abilities, however, are symptomatic of a range of psychopathologies. Therefore, here we will identify whether neural representations of social hierarchy are related to daily life social-hierarchy related emotion regulation and abilities to mentalize the intentions of people who vary in social hierarchy. The correspondence of brain mechanisms to real-world decisions outside of the lab can inform potential future interventions that alleviate social decision-making deficits in psychopathology. Overall, this proposal has been designed to combine the candidate's expertise in functional neuroimaging and economic decision making to prepare the candidate for an independent research career focused on neural mechanisms of social decision making.

Project Narrative

Making decisions involving others requires flexible integration of social information that can vary across timescales. While social decision making is disrupted in various psychopathologies like schizophrenia and autism, the mechanisms underlying these disruptions are unknown. Since one potential source of these disruptions is maladaptive integration of time-varying social attributes, this project uses functional neuroimaging in humans to investigate how temporally-structured information associated with social hierarchy modulates basic cognitive and neural mechanisms of social decision making.

FACILITIES

Human Behavioral Testing

Together, across the labs of Dr. Adrianna Jenkins and Dr. Joseph Kable, available testing suites are equipped with:

- Windows desktop computers with stimulus presentation software installed (including E-Prime 2.0 and Matlab);
- a Tobii T60XL eye-tracker running with a Windows desktop computer (Dell OptiPlex 9020 16GB MT, Windows 8);
- psychophysiology equipment for recording heart rate, respiration, and skin conductance, and for delivering electrical stimulation / "shocks" (BIOPAC, Inc.; MP150/MP36R and UIM100C for data acquisition; AcqKnowledge software; EL504-10 ECG electrode and ECG100C MRI for heart rate; TSD201 and RSP100C for respiration; EL507 EDA electrode and EDA100C MRI for skin conductance; STM100C power supply for electric stimulation; Elec-PAIN-4/S, Walther Graphtek, Lübeck, Germany);

Computing Resources

Center for Functional Neuroimaging Data Analysis Resources

The Center for Functional Neuroimaging (CfN) is a Type 1 Center within the Departments of Radiology and Neurology that provides infrastructure support for functional neuroimaging at the University of Pennsylvania. The CfN is comprised of investigators and staff with a broad range of expertise in neuroimaging including: regulatory affairs, MRI methods development, MRI physics and pulse programming, instrumentation, experimental design, computing, and image analysis procedures. The CfN makes use of distributed resources throughout the University of Pennsylvania, but also houses two data analysis facilities. The CfN HPC cluster consists of:

- 576 dedicated compute cores, from 21 compute nodes with dual 8-core Intel Xeon E5-2450 2.10GHz CPUs and 64GB RAM, and 30 compute nodes with dual 4-core Intel Xeon 2.83GHz E5-440 CPUs with 16GB RAM.
- A dedicated 16-core head node (running Rocks and SGE) manages cluster operations.
- Three dedicated file servers managing high-speed (6GB/s and 4GB/s) RAID-6 devices for over 200TB of formatted storage.
- A high-speed 10GbE internal network, and a Gigabit external network connection.
- A dedicated tape backup system with 100TB capacity.

The cluster is located in a University-run commercial-grade server room with redundant power supplies, UPS power backup systems, fire suppression system and 24-hour restricted access and security.

The labs have both public and private workstations and a 50-inch plasma screen for meetings and presentations.

Software and expertise to run a broad range of data analysis procedures is available, including SPM, fixed and random effects analyses, nonparametric analyses, time series extraction, both automated and manual segmentation into regions of interest, Brodmann areas, vascular distributions, BrainVoyager, FMRIB Software Library, MRIcro, AIR, AFNI, FSL, Free Surfer, SNAP, Matlab, and VoxBo (developed at Penn). The CfN also hosts and maintains an MRI scheduling calendar for all MRI research instrumentation.

The CfN receives additional support from the NINDS-funded Neuroscience Neuroimaging Center (P30 NS045839), the Human Brain Project-funded VoxBo software development project (R01 DA14418), and the Moss Rehabilitation Research Institute (R24 HD050836).

Office Resources

I have been assigned office space in the Center for Cognitive Neuroscience (CCN) near Dr. Kable's laboratory and in the lab of Dr. Jenkins in Solomon Building. The labs are within 5-minute walking distance on campus, allowing for easy communication between me and my Sponsors.

EQUIPMENT

MRI Scanning

The Center for Advanced Magnetic Resonance Imaging and Spectroscopy in the Department of Radiology at Penn currently operates two whole-body human MRI scanners fully dedicated for research protocols: a 1.5 Tesla Siemens Avanto and a 3.0 Tesla Siemens TIM Trio. Gradient coils are capable of imaging at 40 mT/m with slew rates in excess of 200 T/m/s. These scanners include standard capabilities for echoplanar imaging, arterial spin labeled perfusion imaging, diffusion imaging, angiography, spectroscopy, and spectroscopic imaging. BOLD fMRI sequences include automatic higher order shimming and both prospective and retrospective motion correction. Gradient performance allows for 4 mm isotropic voxels at TR=2 sec and 3mm isotropic voxels at TR=3 sec (3T). Both systems have integrated body RF coils and 8-channel and 12-channel head receiver arrays. The 1.5T system uses a receive-only head RF coil. The 3T system has several transmit/receive volume head coils and a multi-element receive only volume coil suitable for parallel acquisition schemes. Image data from these scanners can be ported directly to CD or a local workstation for back-up or onto DVD for larger data sets. Two additional Siemens 3.0 Tesla Tim Trio systems are available. One is on the main campus and is dedicated 50% to human research. The other is located at the Perelman School of Medicine facility in the newest building, the Translational Research Center, and is part of the Small Animal Imaging Facility.

The research scanners operated by the Center for Advanced Magnetic Resonance Imaging and Spectroscopy are located within the Hospital of the University of Pennsylvania and are staffed with MRI technologists skilled in imaging research protocols. Access to these scanners is available for approved protocols on an hourly basis at a nominal rate for government/research protocols (currently $500 per hour). In addition to these research personnel, an on-call radiologist is available and the scanners are equipped with full physiological monitoring capabilities and crash carts, and are accessible to hospital code teams. An on-site engineer is available to maintain the scanners in the event of technical malfunction. Extensive expertise in pulse programming, radiofrequency coil design, and pulse sequence design is available within the Center. An electronics/machine shop is also available on-site.

The Center for Functional Neuroimaging in conjunction with the new Neuroscience Neuroimaging Core also has two new MRI scanners located in the basement of the Stellar-Chance Building in the Perelman School of Medicine. There is a Siemens 7T and a Siemens 3.0 Prisma available for research projects.

fMRI Stimulus Presentation and Response Monitoring

Both 1.5T and 3T research scanners are equipped with stimulus delivery and monitoring systems for fMRI research. These include Sanyo-PLC-XT35-LCD projectors with Sanyo long-throw lenses for rearview/rear-projection onto Mylar screens. Video signals are carried into the magnet room using a Lightwave FiberLynx optical-fiber VGA connection. Both the projector and the FiberLynx units are housed in custom RF shield boxes with filtered power receptacles. Images are viewed through mirrors mounted on the head coils.

Audio stimuli may be presented via a pneumatic Avotec system which is equipped with two different styles of head phones to accommodate variance in patient head size on both the Siemens Sonata and Trio 1.5T and 3T systems. Alternatively, there is also a pair of electrodynamic headphones available. Pulse, pulse oximetry, EKG, ET CO2 and respiration can be monitored during fMRI scanning. Eye position can be monitored with an ASL Long Range Optics system. MRI-safe prescription glasses (which are compatible with all head coils) are available. Responses are monitored using FORP (fiber optic response pad) button boxes installed at the 1.5T and 3T systems. Low pass filters in the magnet room penetration panels allow for custom interfacing of other stimulus and monitoring equipment using DB-9 connectors.

DETAILED BUDGET FOR INITIAL BUDGET PERIOD
DIRECT COSTS ONLY

FROM 08/01/22 THROUGH 07/31/26

List PERSONNEL *(Applicant organization only)*
Use Cal, Acad, or Summer to Enter Months Devoted to Project
Enter Dollar Amounts Requested *(omit cents)* for Salary Requested and Fringe Benefits

NAME	ROLE ON PROJECT	Cal. Mnths	Acad. Mnths	Summer Mnths	INST.BASE SALARY	SALARY REQUESTED	FRINGE BENEFITS	TOTAL
Castrellon, Jaime J.	PD/PI	12			58000	58000	17690	75690
								0
								0
								0
								0
								0
								0
SUBTOTALS →						58000	17690	75690

CONSULTANT COSTS	
EQUIPMENT *(Itemize)*	
SUPPLIES *(Itemize by category)* Research Development supplies	3000
TRAVEL Domestic Travel	1000
INPATIENT CARE COSTS	
OUTPATIENT CARE COSTS	
ALTERATIONS AND RENOVATIONS *(Itemize by category)*	
OTHER EXPENSES *(Itemize by category)*	

CONSORTIUM/CONTRACTUAL COSTS	DIRECT COSTS	
SUBTOTAL DIRECT COSTS FOR INITIAL BUDGET PERIOD *(Item 7a, Face Page)*		$ 79690
CONSORTIUM/CONTRACTUAL COSTS	FACILITIES AND ADMINISTRATIVE COSTS	
TOTAL DIRECT COSTS FOR INITIAL BUDGET PERIOD		$ 79690

BUDGET FOR ENTIRE PROPOSED PROJECT PERIOD
DIRECT COSTS ONLY

BUDGET CATEGORY TOTALS	INITIAL BUDGET PERIOD *(from Form Page 4)*	2nd ADDITIONAL YEAR OF SUPPORT REQUESTED	3rd ADDITIONAL YEAR OF SUPPORT REQUESTED	4th ADDITIONAL YEAR OF SUPPORT REQUESTED	5th ADDITIONAL YEAR OF SUPPORT REQUESTED
PERSONNEL: *Salary and fringe benefits. Applicant organization only.*	75690	75690	75690	75690	
CONSULTANT COSTS					
EQUIPMENT					
SUPPLIES	3000	3000	3000	3000	
TRAVEL	1000	1000	1000	1000	
INPATIENT CARE COSTS					
OUTPATIENT CARE COSTS					
ALTERATIONS AND RENOVATIONS					
OTHER EXPENSES					
DIRECT CONSORTIUM/ CONTRACTUAL COSTS					
SUBTOTAL DIRECT COSTS *(Sum = Item 8a, Face Page)*	79690	79690	79690	79690	0
F&A CONSORTIUM/ CONTRACTUAL COSTS					
TOTAL DIRECT COSTS	79690	79690	79690	79690	0

TOTAL DIRECT COSTS FOR ENTIRE PROPOSED PROJECT PERIOD	**$** 318760

JUSTIFICATION. Follow the budget justification instructions exactly. Use continuation pages as needed.

BUDGET JUSTIFICATION
Senior/Key Personnel:
Jaime Castrellon, Ph.D., Principal Investigator (100%, $58,000 salary + fringe per year; 12 calendar months). Jaime is a postdoctoral fellow in the Jenkins and Kable labs beginning July 2022. Jaime will lead the
entirety of the proposed research with a consistent 100% devoted effort across all four funded years, split into
research (75%) and professional development (25%). His primary project will focus on the aims of this K00 application. Dr. Castrellon will commit the above listed calendar months to the K00 portion of this award. As PI
of this application, he will be responsible for the aims proposed in this grant.
Adrianna (Anna) Jenkins, Ph.D., K00 Mentor (no effort): Dr. Jenkins will serve as a mentor to Dr. Castrellon, helping to oversee all aspects of guidance, contribute to experimental design, and assist in manuscript preparation. She will provide necessary lab space, equipment, and resources for Dr. Castrellon to
complete the proposed work.

BUDGET JUSTIFICATION

Senior/Key Personnel:

Jaime Castrellon, Ph.D., Principal Investigator (100%, $58,000 salary + fringe per year; 12 calendar months). Jaime is a postdoctoral fellow in the Jenkins and Kable labs beginning July 2022. Jaime will lead the entirety of the proposed research with a consistent 100% devoted effort across all four funded years, split into research (75%) and professional development (25%). His primary project will focus on the aims of this K00 application. Dr. Castrellon will commit the above listed calendar months to the K00 portion of this award. As PI of this application, he will be responsible for the aims proposed in this grant.

Adrianna (Anna) Jenkins, Ph.D., K00 Mentor (no effort): Dr. Jenkins will serve as a mentor to Dr. Castrellon, helping to oversee all aspects of guidance, contribute to experimental design, and assist in manuscript preparation. She will provide necessary lab space, equipment, and resources for Dr. Castrellon to complete the proposed work.

Joseph Kable, Ph.D., K00 Mentor (no effort): Dr. Kable will serve as a mentor to Dr. Castrellon, helping to oversee all aspects of guidance, contribute to experimental design, and assist in manuscript preparation. She will provide necessary lab space, equipment, and resources for Dr. Castrellon to complete the proposed work.

Travel:

The budget includes $1,000/year (Years 1-4) for travel to the annual NIH Neuroscience Blueprint Conference.

Research Development:

The budget also includes an additional $3,000/year (Years 1-4) of research development funding for miscellaneous research supplies directly related to the conduct of the studies proposed. This would be used toward the cost of necessary equipment to be employed during data collection and analysis, such as brain imaging data acquisition and analysis software licenses, and the computers and components necessary to utilize the software.

Fringe Benefits:

The employee benefits rates are proposed at 9.0% for postdoctoral researchers until our rate agreement is amended. These rates are based on our federal rate agreement dated June 16, 2021. In lieu of full employee benefits, postdoctoral researchers receive single coverage health insurance which, is treated as a direct expense to the project. Postdoctoral researchers are also covered by FICA and Workers' Compensation.

Indirect Costs:

In accordance with the Program Announcement (RFA-NS-21-012), the indirect cost rate is 8.0%.

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors.
Follow this format for each person. **DO NOT EXCEED FIVE PAGES.**

NAME: Castrellon, Jaime Jorge Fernando

eRA COMMONS USER NAME (credential, e.g., agency login): JCASTRELLON

POSITION TITLE: Postdoctoral Research Fellow, University of Pennsylvania

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Start Date MM/YYYY	Completion Date MM/YYYY	FIELD OF STUDY
University of Southern California (USC), Los Angeles, CA	BA	08/2010	12/2013	Neuroscience/Political Science
Duke University, Durham, NC	PhD	08/2017	05/2022	Psychology and Neuroscience

A. Personal Statement

My long-term research interests involve the development of a comprehensive understanding of the neural mechanisms of social decision making. My academic training and research experience to date have provided me with an excellent background in social neuroscience and neuroeconomics. As an undergraduate at the University of Southern California, I conducted research with Dr. Mara Mather on socially-shared memory. At USC, I received several competitive internal research grants and fellowships to support an independent project under the umbrella of social cognition. My contributions resulted in a co-authored publication, as well as an opportunity to present a poster at the Western Psychological Association annual meeting. Importantly, this research experience grounded my interest in social cognition and social decision making. As a postbaccalaureate research analyst in Dr. David Zald's lab at Vanderbilt University, I gained skills collecting and analyzing fMRI, PET, genetic, and behavioral data in the context of reward-related decision making. During this time, I led analyses of fMRI data, PET measures of dopamine, genetics, social reward preferences, and impulsivity. I presented these findings with a poster at the Society for Neuroscience annual meeting and an oral presentation at the Interdisciplinary Symposium for Decision Neuroscience. This research experience allowed me to grow my technical knowledge and interest in applying molecular neuroimaging to study human decision making. Following this, I served as the inaugural lab manager for Dr. Katherine Karlsgodt's new group at UCLA where I helped build a team from the ground up while furthering my understanding of reward function in a clinical population. In particular, I contributed to a new line of research in the lab exploring neural mechanisms of social cognitive deficits in early-onset psychosis and schizophrenia. This experience helped me think critically about how basic social neuroscience research can translate into the clinic. For my graduate training at Duke University, I applied my prior experiences to study dopaminergic mechanisms of reward-related decision making under the mentorship of Dr. Gregory Samanez-Larkin. Along with developing new conceptual and technical training, my training included a set of career development activities and workshops – e.g. public speaking, literature analysis, project management, mentorship, and grant writing. My projects investigated whether individual differences in dopamine D2 receptor availability support reward discounting and neural representations of subjective value and later dopamine's relation to more social aspects of value-based decision making. As a Latinx scientist, I am the first in my family to graduate from college. I am looking forward to becoming an independent scientist and inspiring future young Latinx trainees to pursue careers in cognitive neuroscience. Overall, my choice of K00 sponsors, research project, and the training I will get from this fellowship will provide a solid foundation for my long-term goal to become an academic researcher.

B. Positions, Scientific Appointments and Honors

Positions and Employment

2022 - Present	Postdoctoral Researcher, University of Pennsylvania, PA
2018 - 2020	Teaching Assistant, Duke University, Durham, NC
2017 - 2022	Graduate Student Research Assistant, Duke University, Durham, NC
2016 - 2017	Lab Manager, Department of Psychology, UCLA, Los Angeles, CA
2014 - 2016	Research Assistant, Department of Psychology, Vanderbilt University, Nashville, TN
2012 - 2014	Undergraduate Research Assistant, Psychology Department, USC, Los Angeles, CA

Other Experience and Professional Memberships

2021 - Present	Society for Personality and Social Psychology
2017 - Present	Society for Neuroeconomics
2017 - Present	Association for Psychological Science
2017 - Present	Social Affective Neuroscience Society
2015 - Present	Society for Neuroscience
2013 - Present	Cognitive Neuroscience Society

Honors

2021	Dean's Award for Excellence in Mentoring, Duke University
2020	Bass Connections Outstanding Mentor Award, Duke University
2019	Best Poster Award, Society for Neuroeconomics
2019	Charles Lafitte Foundation Travel Award, Duke University
2019	Fellowship, Summer Institute for Cognitive Neuroscience, Kavli Foundation
2018	Best Poster Award, Society for Neuroeconomics
2018	Student Travel Award, Society for Neuroeconomics
2017 – 2022	National Science Foundation Graduate Research Fellowship
2017	Fellowship, Summer School in Social Neuroscience & Neuroeconomics, Duke University
2016	Summer Institute Fellowship, Sackler Institute for Developmental Psychobiology, Weil Cornell Medical College
2013	University Honors, University of Southern California
2013	Thematic Option Honors, University of Southern California
2013	Summer Undergraduate Research Fellowship, University of Southern California
2012	Summer Undergraduate Research Fellowship, University of Southern California
2012	Undergraduate Research Grant, University of Southern California
2011	Academic Achievement Award, University of Southern California
2011 - 2013	Scholarship, Rose Hills Foundation
2011	Scholarship, Xerox Hispanic Association for Professional Advancement
2010 - 2013	Scholarship, USC Latino Alumni Association
2010 - 2013	Scholarship, Congressional Hispanic Caucus Institute

C. Contributions to Science

1. **Undergraduate Research in Social Cognition:** Under the mentorship of Dr. Mara Mather at USC, I coordinated a series of studies that investigated mechanisms by which recall memory is susceptible to social influence. In the lab, I recruited study participants and collected and analyzed data from dyadic interactions to evaluate how age modulates the effects of collaborative recall and retrieval-induced forgetting. I applied for and received Summer fellowships and a research grant to support this line of research by developing, collecting data for, and analyzing an independent project to assess memory conformity. My involvement in these projects resulted in a publication in 2017 that identified conditions under which collaboration disrupts recall of emotional pictures.

Selected Publications and Presentations:
Barber, S.J., **Castrellon, J.J.**, Opitz, P., & Mather, M. (2017). Younger and older adults' collaborative recall of shared and unshared emotional pictures. *Memory & Cognition*. [PMC5500393]

2. **Post-baccalaureate Research in Human Dopamine Function**: As a full-time research analyst in Dr. David Zald's lab at Vanderbilt University, I was responsible for developing, collecting, and analyzing data from two large studies of dopamine function and decision making. For these studies, I recruited participants, collected and analyzed MRI, PET, genetic, and behavioral data. In addition to neuroimaging analysis skills, I gained experience in administering structured clinical interviews and coordinating interdisciplinary research across multiple departments (e.g., Psychology, Nuclear Medicine, Psychiatry, and Radiochemistry). I co-authored several publications on human PET measures of dopamine function and decision making across the adult life span. Notably, two of these publications challenge long-held assumptions about associations between dopamine, BMI, and physiological proxy measures of dopamine function. During my time in the lab, I presented a conference talk and a poster exploring neural correlations of impulsivity in aging as well as research combining dopamine PET imaging and genetic phenotypes to predict social reward valuation.

   Selected Publications and Presentations:
   Dang, L.C., Samanez-Larkin, G.R., **Castrellon, J.J.**, Perkins, S.F., Cowan, R.L., Newhouse, P.A., Zald, D.H. (2017). Spontaneous eye blink rate (EBR) is uncorrelated with dopamine D2 receptor availability and unmodulated by dopamine agonism in healthy adults. *eNeuro*. [PMC5602106]

   Dang, L. C., **Castrellon, J.J.,** Perkins, S. F., Le, N. T., Cowan, R. L., Zald, D. H., & Samanez-Larkin, G. R. (2017). Reduced effects of age on dopamine D2 receptor levels in physically active adults. *NeuroImage, 148, 123-129.* [PMC5344739]

   Castrellon, J.J., Smith, C.T., Perkins, S.F., Samanez-Larkin, G.R., Zald, D.H., Monoamine oxidase A: a genetic marker of social reward preferences. Oral presentation at the annual Interdisciplinary Symposium on Decision Neuroscience. Temple University. Philadelphia, PA. June 2016.

   Castrellon, J.J., Dang, L.C., Perkins, S.F., Samanez-Larkin, G.R., Zald, D.H., Aging contributes to grey matter volume and attentional impulsivity correlates in frontoparietal functional connectivity. Poster presented at the annual meeting of the Society for Neuroscience. Chicago, IL. October 2015.

3. **Graduate Research in Decision Neuroscience**: My graduate research focuses on characterizing dopaminergic mechanisms of reward-related decision making in humans. Through research in the Samanez-Larkin lab, I have begun to unravel the complicated nature of individual differences in human reward discounting behavior and neural representations of subjective value. I have led several papers published and under review that challenge long-held assumptions about the role of dopamine receptors in reward discounting using PET measures of dopamine, fMRI, and a meta-analysis of rodent pharmacology. In work under peer review, I am extending this work to evaluate whether ecologically valid methods can capture the link between PET measures of dopamine and resistance of everyday desires. Notably, I gained recognition for my presentation of all this work twice in a row with the Best Poster Award and selection for a data blitz talk at the Society for Neuroeconomics annual meetings in 2018 and 2019.

   Selected Publications & Presentations:
   Castrellon, J.J., Young, J.S., Dang, L.C., Smith, C.T., Cowan, R.L., Zald, D.H., Samanez-Larkin, G.R. (Under review, Preprint available on BioRxiv). Dopamine biases sensitivity to personal goals and social influence in self-control over everyday desires.

   Castrellon, J.J., Meade, J., Greenwald, L., Hurst, K. (2020). Dopaminergic modulation of reward discounting in healthy rats: A systematic review and meta-analysis. *Psychopharmacology*. [PMID 33215269]

Castrellon, J.J., Young, J.S., Dang, L.C., Cowan, R.L., Zald, D.H., Samanez-Larkin, G.R., (2019). Mesolimbic dopamine D2 receptors and neural representations of subjective value. *Scientific Reports*. [PMC6934551]

Castrellon, J.J., Seaman K.L., Crawford, J.L., Young, J.S., Smith, C.T., Dang, L.C., Hsu, M., Cowan, R.L., Zald, D.H., Samanez-Larkin, G.R. (2019). Individual differences in dopamine are associated with reward discounting in clinical groups but not in healthy adults. *Journal of Neuroscience*. [PMC6325254]

Castrellon, J.J., Zald, D.H., Samanez-Larkin, G.R., Individual differences in dopamine predict self-control of everyday desires. Spotlight poster and talk presented at the annual meeting of the Society for Neuroeconomics. Dublin, Ireland. October 2019. ***Best Poster Award Winner**

Complete list of published work:
PubMed

D. Scholastic Performance
Duke University Graduate School courses are graded A-F scale. Some courses are graded CR (credit) or NC (no credit). **University of Southern California GPA:** 3.63/4.00; **Duke University GPA:** 4.00/4.00

University of Southern California	
Neuroscience Major Courses	*Political Science Major Courses*
Primate Social Behavior	Politics and Society I Honors Course
Statistics I	Writing Seminar I Honors Course
Introduction to Psychology	Culture and Values Honors Course
The Process of Change in Science Honors Course	Politics and Society II Honors Course
Minority Mental Health	Writing Seminar II Honors Course
Behavioral Neuroscience	Theory and Practice of American Democracy
Cell Biology and Physiology	Law, Politics, and Public Policy
Systems Neuroscience	Change and the Future Honors Course
Neurobiology of Aging	Symbols and Conceptual Systems Honors Course
Criminal Behavior	Politics and the Economy
Abnormal Psychology	American Political Thought
Psychology and Law	World Political Leadership
	Regulation of Elections and Political Finance
	Political Jurisprudence

Duke University		
YEAR	COURSE TITLE	GRADE
2017	First Year Seminar I	CR
2017	Principles in Cognitive Neuroscience I	A
2017	Research Practicum	A
2018	Firs Year Seminar II	CR
2018	Adult Psychopathology	A
2018	Principles in Cognitive Neuroscience II	A
2018	Research Practicum	A
2019	Foundations of Cognitive Psychology	A
2020	Functional Magnetic Resonance Imaging	A

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors.
Follow this format for each person. **DO NOT EXCEED FIVE PAGES.**

NAME: Joseph W. Kable

eRA COMMONS USER NAME (credential, e.g., agency login): JK1691.NYU

POSITION TITLE: Baird Term Professor of Psychology & Marketing

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
Emory University	B.S.	05/1996	Chemistry
University of Pennsylvania	Ph.D.	08/2004	Neuroscience

A. Personal Statement

My expertise is in the cognitive neuroscience of human decision making ("neuroeconomics"), as well as in computational analyses of behavior. My research investigates the neural mechanisms of human decision-making using a combination of techniques from experimental economics and cognitive and social neuroscience. Much of my work has focused on a particular kind of impulsive decision-making, choosing immediate rewards over delayed rewards, which is a behavioral tendency exacerbated in several mental illnesses. We have used fMRI to better characterize the properties of brain regions involved in valuing delayed rewards, linked differences in the activity and structure of these regions to differences in impulsivity, and studied how choices of delayed rewards were influenced by normative, contextual, and social factors. We have also studied not just one-off choices between immediate and delayed rewards, but also continued persistence in these choices over time, and discovered a critical role for uncertainty about the timing of future rewards in calibrating persistence. Another aspect of my work has been the identification and characterization of neural signals related to reward value during decision making. The current proposal builds on this work by testing how activity in the valuation system transient and stable characteristics of others, and the interactions between these characteristics and one's goals, during social decision making.

I am also committed to research training. In my lab, I have trained eleven pre-doctoral and eleven post-doctoral fellows, six of whom have won individual NRSAs or similar international fellowships. My trainees have continued in research-related careers in academia (six are now faculty), government (e.g., NIH) and industry (e.g., Johnson & Johnson). Anna Jenkins and I have a successful track record of collaboration and co-mentoring (e.g., Kenji Kobayashi) and we look forward to working with Jaime on the proposed research studies and training plan.

Relevant ongoing projects:

RF1 AG058065
Kable/Wolk (MPI)
09/15/17 – 08/31/22
Learning and decision-making in healthy aging and preclinical Alzheimer's Disease

AE Foundation
Kable (PI)
1/01/22-12/31/22

Enhancing the ability to build trust through excitatory transcranial magnetic stimulation to the temporal-parietal junction

Facebook Research
Kable (PI)
1/01/22-12/31/22
Who is most vulnerable to persistent negative effects of misinformation?

NSF
Kable/Schwarz (MPI)
05/01/21-04/30/24
Summer research experiences in mind and brain studies

Relevant publications:

Bartra, O., McGuire, J. T. & **Kable, J. W.** (2013). The valuation system: A coordinate-based meta-analysis of BOLD fMRI experiments examining neural correlates of subjective value. NeuroImage 76, 412–427. PMCID: PMC3756836.

Brethel-Haurwitz, K. M., Oathes, D. J., and **Kable, J. W.** (2021). Causal role of the right temporoparietal junction in selfishness depends on the social context. *Social, Cognitive and Affective Neuroscience,* nsab136.

Kiesow, H, Uddin, L. Q., Bernhardt, B. C., **Kable, J. W,** Bzdok, D. (2021). Dissecting the midlife crisis: Disentangling social, personality and demographic determinants in social brain anatomy. *Communications Biology,* **4**: 728. PMCID: PMC8211729.

Kobayashi, K., **Kable, J. W.**, Hsu, M., Jenkins, A. C. (2022). Neural representations of others' traits predict social decisions. *Proceedings of the National Academy of the Sciences*, **119**: e2116944119. PMCID: PMC9295729.

B. Positions and Honors

Positions and Employment

2018-present Baird Term Professor of Psychology, University of Pennsylvania
2017-present Secondary Appointment, Department of Marketing, Wharton School, University of Pennsylvania
2015-2018 Baird Term Associate Professor of Psychology, University of Pennsylvania
2012-2015 Baird Term Assistant Professor of Psychology, University of Pennsylvania
2008-2015 Assistant Professor, Department of Psychology, University of Pennsylvania
2004-2008 Postdoctoral Fellow, Center for Neural Science, New York University

Other Experience and Professional Memberships

2019-present Director, mindCORE
2017-present Editor, WIREs Cognitive Science
2017-2019 Associate Director for Research, mindCORE
2016-2019 President-Elect, President and Immediate Past President, Society for Neuroeconomics
2015-2016 Chair, Program Committee, Society for Neuroeconomics
2013-2016 Board Member, Society for Neuroeconomics
2013-present Co-chair of the Identity and Personality Network of the HCEO Global Working Group

Honors

2020 Fellow, Association for Psychological Science
2014 Early Career Award, Society for Neuroeconomics
2013 Best talk, Society for Neuroeconomics 10th Annual Meeting
2005-2007 Ruth L. Kirschstein National Research Service Award Individual Fellowship
2000-2003 National Science Foundation Graduate Fellowship
1996 Lucius Lamar McMullan Award, Emory University
($20,000 grant given to outstanding senior based on citizenship, leadership and service)
1992-1996 Charles and Anne Duncan Scholarship (full tuition), Emory University

C. Contribution to Science

1. The psychological and neural basis of delay discounting. Prominent economic and neural models stress how the discounting of delayed rewards arises from the competitive interaction of two systems—one that favors your immediate interests and another that is future-oriented. In contrast to this account, we have found evidence for a single set of brain regions, including the ventromedial prefrontal cortex and ventral striatum, where neural activity was related to the subjective value of both immediate and delayed rewards. Also in contrast to these prominent models, cognitive training does not reduce delay discounting – though we have identified two things that do: informing subjects who are unaware of certain normative considerations and prompting people to engage in prospection. Additionally, we have discovered structural and functional features of the ventromedial prefrontal cortex and ventral striatum that contribute to individual differences in discounting.

Kable, J. W. & Glimcher, P. W. (2007). The neural correlates of subjective value during intertemporal choice. Nature Neuroscience, 10, 1625–1633. PMCID: PMC2845395.

Cooper, N., **Kable, J. W.,** Kim, B. K. & Zauberman, G. (2013). Brain activity in valuation regions while thinking about the future predicts individual discount rates. Journal of Neuroscience, 33, 13150–13156. PMCID: PMC3735887.

Kable, J. W., Caulfield, M. K., Falcone, M., McConnell, M., Bernardo, L., Parthasarathi, T., Cooper, N., Ashare, R., Audrain-McGovern, J., Hornik, R., Diefenback, P., Lee, F., and Lerman, C. (2017). No effect of commercial cognitive training on brain activity, choice behavior or cognitive performance. Journal of Neuroscience, 37, 7390–7402. PMCID: PMC5546110.

Pehlivanova, M., Wolf, D. H., Sotiras, A., Kaczkurkin, A., Moore, T. M., Ciric, R., Cook, P. A., Garcia de La Garza, A. Rosen, A., Ruparel, K., Sharma, A., Shinohara, R. T., Roalf, D. R., Gur, R. C., Davatzikos, C., Gur, R. E., **Kable, J. W.**, and Satterthwaite, T. D. (JWK and TDS co-last authors). (2018) Diminished cortical thickness is associated with impulsive choice in adolescence. Journal of Neuroscience. PMCID: PMC5858592.

2. The psychological and neural basis of persistence. Future-oriented behavior and self-control involves not just choosing delayed rewards, but also persisting in that choice through the delay until the reward arrives. With colleagues, I have argued there are strong theoretical reasons to question one popular account, that failed persistence is evidence that self-control depends on a resource that depletes over time. In my lab, we have developed an alternative explanation of failed persistence that recognizes that in most cases – including the canonical delay of gratification paradigm – there is uncertainty about when the delayed reward will arrive. We have shown that many situations associated with failed persistence are characterized by exactly the kind of expectations for which limited persistence is rational, and that a simple version of our model can quantitatively account for behavior in the canonical delay-of-gratification experiments. In a parallel series of behavioral experiments, we demonstrated that people adjust their degree of persistence to the distribution of reward delays they experience, exhibiting more persistence failures when this is the optimal behavior given the reward-timing statistics. We have also found that medial prefrontal cortical activity evolves over the course of waiting, consistent with people dynamically reevaluating an awaited outcome, and that this activity differs depending on expectations learned from the reward-timing statistics in that context.

McGuire, J. T. & **Kable, J. W.** (2012). Decision makers calibrate behavioral persistence on the basis of time-interval experience. Cognition, 124, 216–226. PMCID: PMC3503451.

Kurzban, R., Duckworth, A., **Kable, J. W.** & Myers, J. (2013). An opportunity cost model of subjective effort and task performance. Behavioral & Brain Sciences, 36, 661–679. PMCID: PMC3856320.

McGuire, J. T. & **Kable, J. W.** (2013). Rational temporal predictions can underlie apparent failures to delay gratification. Psychological Review, 120, 395–410. PMCID: PMC3773987.

McGuire, J. T. & **Kable, J. W.** (2015). Medial prefrontal cortical activity reflects dynamic re-evaluation during voluntary persistence. Nature Neuroscience, 18, 760–766. PMCID: PMC4437670.

3. The neural basis of value maximization. We performed a comprehensive, quantitative meta-analysis of over 200 neuroimaging studies that confirmed that activity in ventromedial prefrontal cortex and ventral striatum reliably scales with subjective value across a variety of reward domains, both at the time that people make choices and when they receive the outcomes of their choices. We have also used functional imaging to ask more fine-grained questions about these signals that meta-analysis cannot answer, discriminating

subjective value signals in these regions from those associated with decision difficulty or confidence, showing that these signals adapt to the range of subjective values in the current context, and confirming that these signals are also present during aesthetic judgments. We have also done studies with individuals with damage to ventromedial prefrontal cortex that demonstrate that damage to this region causes individuals to behave less like value maximizers.

Camille, N., Griffiths, C. A., Vo, K., Fellows, L. K., **Kable, J. W.** (2011). Ventromedial frontal lobe damage disrupts value maximization in humans. Journal of Neuroscience, 31, 7527–7532. PMCID: PMC3122333.

Bartra, O., McGuire, J. T. & **Kable, J. W.** (2013). The valuation system: A coordinate-based meta-analysis of BOLD fMRI experiments examining neural correlates of subjective value. NeuroImage 76, 412–427. PMCID: PMC3756836.

Cox, K. & **Kable, J. W.** (2014). BOLD subjective value signals exhibit robust range adaptation. Journal of Neuroscience, 34, 16533–16543. PMCID: PMC4252558.

Pegors, T., **Kable, J. W.,** Chatterjee, A., & Epstein, R. A. (2015). Common and unique representations in prefrontal cortex for face and place attractiveness. Journal of Cognitive Neuroscience, 27, 959–973. PMCID: PMC4681394.

4. The neural basis of learning. People often construct evaluations based on their beliefs about the world and predictions generated from those beliefs. This view is broadly consistent with the idea that preferences are constructed at the time of choice, rather than simply revealed. However, this view leads to several important unanswered questions about the basic processes involved in constructing evaluations. For example, how are beliefs encoded in the brain? What determines how these beliefs are updated in the face of new evidence? In an ongoing collaboration with Josh Gold, we are exploring these questions. Our results include a normative account of how people should update their beliefs when the environment is noisy and can undergo abrupt changes, characterization of a fundamental tradeoff in the complexity of people's beliefs between bias and variance, and identification of multiple dissociable neural influences on this belief updating process.

McGuire, J. T., Nassar, M. R., Gold, J. I. & **Kable, J. W.** (2014). Functionally dissociable influences on learning rate in a dynamic environment. Neuron, 84, 870–881. PMCID: PMC4437663.

Nassar, M. N., McGuire, J. T., Ritz, H., and **Kable, J. W.** (2019) Dissociable forms of uncertainty-driven representational change across the human brain. Journal of Neuroscience, 39, 1688-1698. PMCID: PMC6391562.

Kao, C-H., Khambati, A. N., Bassett, D. S., Nassar, M. N., McGuire, J. T., Gold, J. I., and **Kable, J. W.** (2020) Functional brain network reconfiguration during learning in a dynamic environment. Nature Communications, 11, 1682. PMCID: PMC7125157.

Kao, C.-H., Lee, S., Gold, J. I., **Kable, J. W.** (2020) Neural encoding of task-dependent errors during adaptive learning. eLife, 9, e58809. PMCID: PMC7584453.

5. Computational psychiatry. Both the behaviors and the neural circuits I study are affected by several psychiatric conditions. Through a range of collaborations, I have used neuroeconomic experimental paradigms to shed light on the psychological and neural processes affected by affective disorders and psychosis. For example, my collaborators and I have shown that depressed individuals are impaired at basic learning from rewards and punishments, show reduced motivation to expend mental effort, and exhibit reduced ventral striatal responses to reward feedback and reduced connectivity within the basic reward network.

Mukherjee, D. & **Kable, J. W.** (2014). Value-Based Decision Making in Mental Illness: A Meta-Analysis. Clinical Psychological Science, 2, 767–782.

Satterthwaite, T. D., **Kable, J. W.,** Vandekar, L., Katchmar, N., Bassett, D. S., Baldassano, C. F., Ruparel, K., Elliott, M. A., Sheline, Y. I., Gur, R. C., Gur, R. E., Davatzikos, C., Leibenluft, E., Thase, M. E., and Wolf, D. (2015). Common and dissociable dysfunction of the value system in bipolar and unipolar depression. Neuropsychopharmacology, 40, 2258–2268. PMCID: PMC4613620.

Mukherjee, D., Filipowicz, A. L. S., Vo, K., Satterthwaite, T. S., and **Kable, J. W.** (2020) Reward and punishment reversal learning in major depressive disorder. Journal of Abnormal Psychology, 129, 810–823.

Mukherjee, D., Lee, S., Kazinka, R., and **Kable, J. W.** (2020) Multiple facets of value-based decision making in Major Depressive Disorder. Scientific Reports, 10, 3415. PMCID: PMC7042239.

Complete list of published work in MyBibliography:
http://www.ncbi.nlm.nih.gov/sites/myncbi/joseph.kable.1/bibliography/41558739/public/?sort=date&direction=descending

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors.
Follow this format for each person. **DO NOT EXCEED FIVE PAGES.**

NAME: Adrianna C. Jenkins

eRA COMMONS USER NAME (credential, e.g., agency login): ADRIANNA.JENKINS

POSITION TITLE: Assistant Professor

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
Dartmouth College, Hanover NH	B.A.	06/2005	Psychological & Brain Sciences; Government
Harvard University, Cambridge MA	M.A.	03/2009	Psychology
Harvard University, Cambridge MA	Ph.D.	05/2012	Psychology
UC Berkeley, Berkeley, CA	Postdoctoral	06/2018	Decision Neuroscience

A. Personal Statement

Research in my lab at the University of Pennsylvania uses a multi-method approach to investigate the processes in the mind and brain that support social thought and how they produce social behavior. My expertise is in psychology and cognitive neuroscience, with a particular focus on social cognition, and I have worked to integrate methodological and theoretical contributions from these areas with those of other disciplines, including neuro- and behavioral and economics. In these efforts, I have published productively with multiple methods, in multiple content areas, and with a variety of collaborators, including trainees, within and across institutions. My research has resulted in publications that have appeared in high-impact interdisciplinary and disciplinary journals (e.g., *PNAS*, *Nature Neuroscience*, *Psychological Science*), have been highly cited, and have attracted attention from a variety of mainstream media outlets. My young lab at the University of Pennsylvania has already begun to publish productively, with three papers out so far in 2022, revisions on two additional manuscripts currently invited, and three more under review. My expertise is directly pertinent to both the theoretical frameworks underlying the proposed research and the methodological approaches by which it will be carried out, including social cognitive frameworks, functional magnetic resonance imaging (fMRI), and computational modeling of social decision-making. Additionally, my productive collaboration with co-sponsor Joe Kable is reflected in a just-published paper in *PNAS* led by a postdoctoral fellow we jointly supervise (Kobayashi et al., 2022). Together, this experience has prepared me well to supervise and collaborate on the proposed research and training of Jaime Castrellon.

Jenkins, A.C., Macrae, C.N., & Mitchell, J.P. (2008). Repetition suppression of ventromedial prefrontal activity during judgments of self and others. *Proceedings of the National Academy of Sciences, USA, 105*(11), 4507-4512. PMCID: PMC2393803.

Jenkins, A.C., Zhu, L., & Hsu, M. (2016). Cognitive neuroscience of honesty and deception: A signaling framework. *Current Opinion in Behavioral Sciences, 11*, 130-137. PMCID: PMC5042136.

Jenkins, A.C., Karashchuk, P., Zhu, L., & Hsu, M. (2018). Predicting human behavior toward members of different social groups. *Proceedings of the National Academy of Sciences, USA, 115*(39), 9596-9701. PMCID: PMC6166817.

Kobayashi, K., Kable, J.W., Hsu, M. & Jenkins, A.C. (2022). Neural representations of others' traits predict social decisions. *Proceedings of the National Academy of Sciences, USA, 119*(22), e2116944119. PMCID: PMC9295729.

B. **Positions, Scientific Appointments, and Honors**

Positions

2018-	Assistant Professor, Department of Psychology, University of Pennsylvania
2018-	Faculty Affiliate, Neuroscience Graduate Group, University of Pennsylvania
2012-2018	Postdoctoral Scholar, Helen Wills Neuroscience Institute, UC Berkeley
2005-2006	Lab Coordinator & Research Assistant, Department of Brain and Cognitive Sciences, MIT
2005-2006	Research Assistant, Department of Psychology, Harvard University
2005	Research Assistant, Department of Psychological and Brain Sciences, Dartmouth College
2004-2005	Research Assistant, Pediatric Neuropsychology, Dartmouth Medical School

Honors

2021	F.J. McGuigan Early Career Investigator Award, American Psychological Foundation
2019	Elected Fellow, Society of Experimental Social Psychology
2018	Rising Star Award, Association for Psychological Science
2017	Graduate Society Dissertation Completion Fellowship, Harvard University
2010	George W. Goethals Teaching Prize, Harvard University
2010, -09, -07	Award for Distinction in Undergraduate Teaching, Harvard University
2010	Restricted Funds Large Research Grant, Harvard University
2009	Society for Personality and Social Psychology Graduate Student Travel Award
2007	Summer Institute in Cognitive Neuroscience Fellowship, Santa Barbara, CA

C. Contribution to Science

1. *Contextual flexibility in human social behavior: linking processes to outcomes and lab to field.* People flexibly adapt their behavior to different contexts, including interactions with different people. Rather than adopting a set of general rules that apply equally to every person across all situations (e.g., “give a dollar to everyone you meet”; “trust no one”), the mind instead brings to bear a complex set of cognitive processes that enable people to adapt their behavior across different contexts. By integrating approaches from psychology, cognitive neuroscience, behavioral economics, and other areas, a main contribution of my research is to scientific understanding of how the mind produces this flexibility in the context of the uncertainty that characterizes social contexts. We have developed a computational approach that makes it possible to forge a meaningful link between insights from our laboratory data and predictions of behavior in the complexity of the real world.

a. Jenkins, A.C., Karashchuk, P., Zhu, L., & Hsu, M. (2018). Predicting human behavior toward members of different social groups. *Proceedings of the National Academy of Sciences, USA, 115*(39), 9596-9701.
b. Kobayashi, K., Kable, J.W., Hsu, M. & Jenkins, A.C. (2022). Neural representations of others’ traits predict social decisions. *Proceedings of the National Academy of Sciences, USA, 119*(22), e2116944119. PMCID: PMC9295729.
c. Plate, R., Ham, H. & Jenkins, A.C. (2022). Exploration is higher in social contexts at the cost of rewards. *Proceedings of the Annual Meeting of the Cognitive Science Society, 44*, 2716-2723.
d. Zhu, L., Jenkins, A.C., Set, E., Scabini, D., Knight, R., Chiu, P., King-Casas, B., & Hsu, M. (2014). Damage to dorsolateral prefrontal cortex affects tradeoffs between honesty and self-interest. *Nature Neuroscience, 17*(10), 1319-1321. PMCID: PMC4177007.

2. *Cognitive processes supporting inferences about other minds.* How one person’s mind constructs predictions and inferences about the contents of other minds (i.e., accomplishes *theory-of-mind,* or mentalizing) is an enduring question in the mind sciences, both due to its fundamental role in human social life and due to its disruption in disorders of social functioning. My research has contributed to efforts to address this question by investigating the relationship between cognitive processes associated with thinking about oneself and thinking about others. We discovered that, despite the diversity of forms in which self-referential thinking can take place, thinking about oneself engages a common process associated with activation in the medial prefrontal cortex (MPFC). In turn, we found evidence that shared processes subserve self-referential thought and thinking about others to a greater degree when the target of understanding is presumed to be

similar to oneself than when the target is presumed to be dissimilar and that the recruitment of brain regions associated with self-referential thought during mentalizing about others can be promoted through a brief perspective-taking exercise.

a. Jenkins, A.C., Macrae, C.N., & Mitchell, J.P. (2008). Repetition suppression of ventromedial prefrontal activity during judgments of self and others. *Proceedings of the National Academy of Sciences, USA, 105*(11), 4507-4512. PMCID: PMC2393803.
b. Jenkins, A.C. & Mitchell, J.P. (2011). Medial prefrontal cortex subserves diverse forms of self-reflection. *Social Neuroscience, 6*(3), 211-218. PMID: 20711940.
c. Ames, D.L., Jenkins, A.C., Banaji, M.R., & Mitchell, J.P. (2008). Taking another person's perspective increases self-referential neural processing. *Psychological Science, 19*(7), 642-644. PMID: 18727776
d. Cikara, M., Jenkins, A.C., Dufour, N., & Saxe, R. (2014). Reduced self-referential neural response during intergroup competition predicts competitor harm. *NeuroImage, 96,* 36-43. PMCID: PMC4043933.

3. *The role of the medial prefrontal cortex (MPFC) and the default-mode network (DMN) in human social cognition.* My research and others' has shown that the MPFC tends to be more engaged when people think about themselves than when they think about other people. Yet this region is also consistently more engaged when thinking about people than when thinking about objects and is intriguingly engaged during a number of other activities, including episodic memory and decision-making. A key question accordingly arises regarding what process-level account of MPFC function can unify these findings. By characterizing circumstances under which MPFC and other DMN regions converge and dissociate, I have investigated (and continue to investigate) a set of hypotheses about the core functions of MPFC, its relationship to other DMN regions, and the fundamental nature of its role in social cognition.

a. Jenkins, A.C. & Mitchell, J.P. (2010). Mentalizing under uncertainty: Dissociated neural responses to ambiguous and unambiguous mental state inferences. *Cerebral Cortex, 20*(2), 404-410. PMCID: PMC2803737.
b. Jenkins, A.C. & Hsu, M. (2017). Dissociable contributions of imagination and willpower to the malleability of human patience. *Psychological Science*, *28*(7), 894-906. PMCID: PMC5507764.
c. Jenkins, A.C. (2019). Rethinking cognitive load: A default-mode network perspective. *Trends in Cognitive Sciences, 23*(7), 531-533. PMID:31176585.
d. Berkay, D. & Jenkins, A.C. (in press). A role for uncertainty in the neural distinction between social and nonsocial thought. *Perspectives on Psychological Science.*

Complete list of published work on Google Scholar:
https://scholar.google.com/citations?user=4oZkQKIAAAAJ&hl=en

A. DOCTORAL DISSERATION AND RESEARCH EXPERIENCE

Education

December 2013 – B.A., Neuroscience and Political Science; University of Southern California
May 2022 – Ph.D., Psychology and Neuroscience; Duke University

Research Experience

Emotion & Cognition Lab, University of Southern California January 2012 – May 2014, PI: Mara Mather: During my initial year, I contributed to ongoing studies of socially shared emotional memory and conducted an independent project to study mechanisms of social memory conformity. For these projects, I applied for and received two competitive research grants. During my second year, I advanced my skillset by learning psychophysiological and neuroimaging data collection and analysis for projects examining dietary effects on memory and fear conditioning responses. Once again, for these projects, I applied for and received a competitive research grant. My involvement in the lab culminated with a poster presentation demonstrating my knowledge of brain imaging analysis and a co-authored paper from my work examining social memory.

Barber, S.J., **Castrellon, J.J.**, Opitz, P., & Mather, M. (2017). Younger and older adults' collaborative recall of shared and unshared emotional pictures. *Memory & Cognition*. DOI: 10.3758/s13421-017- 0694-3

Castrellon, J., Ponzio, A., Faskowitz, J., Mather, M., The impact of caloric restriction on subcortical structures. Poster presented at the annual meeting of the Western Psychological Association. Portland, OR. April 2014.

Affective Neuroscience Lab, Vanderbilt University. June 2014 – October 2016, PI: David H. Zald: As a full-time research analyst, I contributed to two large-scale studies of dopamine function and decision making. For these projects, I was involved in the planning, coordination, collection, and analysis of behavioral, fMRI, PET, and pharmacological measures in humans across the adult life span. I also sought training in conducting structured clinical interviews (SCIDs) for mental disorders, optimized hospital-wide protocols for radiopharmaceutical safety during PET scans, and supervised several undergraduate students in data collection. To support my interest in connecting large-scale social issues with neuroscience research, I audited a course on Neuroscience and Law at the Vanderbilt Law School. In addition, I was selected for a competitive fellowship at the Sackler Summer Institute of Developmental Psychobiology whose topic that year was law and neuroscience. As a fellow, I met with, learned from, and debated researchers and leaders in this field. This experience allowed me to build a network of colleagues and mentors to whom I currently turn for mentorship. I presented a poster at the Society for Neuroscience on fMRI data analysis and presented a talk at the Interdisciplinary Symposium on Decision Neuroscience on the relation between social reward and dopamine function. I co-authored four publications of research that I collected and analyzed during that time.

Dang, L.C., Samanez-Larkin, G.R., Smith, C.T., **Castrellon, J.J.,** Perkins, S.F., Cowan, R.L., Claassen, D.O., Zald, D.H. (2018). FTO affects food cravings and interacts with age to influence age-related decline in food cravings. *Physiology & Behavior*. DOI: 10.1016/j.physbeh.2017.12.013

Dang, L.C., Samanez-Larkin, G.R., **Castrellon, J.J.**, Perkins, S.F., Cowan, R.L., Newhouse, P.A., Zald, D.H. (2017). Spontaneous eye blink rate (EBR) is uncorrelated with dopamine D2 receptor availability and unmodulated by dopamine agonism in healthy adults. *eNeuro*. DOI: 10.1523/ENEURO.0211- 17.2017

Dang, L. C., **Castrellon, J.J.,** Perkins, S. F., Le, N. T., Cowan, R. L., Zald, D. H., & Samanez-Larkin, G.R. (2017). Reduced effects of age on dopamine D2 receptor levels in physically active adults. *NeuroImage, 148, 123-129.* DOI: 10.1016/j.neuroimage.2017.01.018

Dang, L.C., Samanez-Larkin, G.R., **Castrellon, J.J.**, Perkins, S.F., Cowan, R.L., Zald, D.H. (2016). Associations between dopamine D2 receptor availability and BMI depend on age. *NeuroImage, 138,* 176-183. DOI: 10.1016/j.neuroimage.2016.05.044

Castrellon, J.J., Smith, C.T., Perkins, S.F., Samanez-Larkin, G.R., Zald, D.H., Monoamine oxidase

A: a genetic marker of social reward preferences. Oral presentation at the annual Interdisciplinary Symposium on Decision Neuroscience. Temple University. Philadelphia, PA. June 2016.

Castrellon, J.J., Dang, L.C., Perkins, S.F., Samanez-Larkin, G.R., Zald, D.H., Aging contributes to grey matter volume and attentional impulsivity correlates in frontoparietal functional connectivity. Poster presented at the annual meeting of the Society for Neuroscience. Chicago, IL. October 2015.

Cognitive & Clinical Neuroscience Lab, UCLA October 2016 – August 2017 PI: Katherine H. Karlsgodt: As the lab's first member, I helped coordinate and establish the lab's behavioral and neuroimaging data analysis pipelines and protocols, staff and undergraduate hiring and training, and day-to-day operations. I oversaw the development of a large-scale project to characterize social cognition and reinforcement learning in adolescents with psychosis. To do this, I developed novel tasks and coordinated data-sharing with collaborators across campus and institutions. I also developed a novel analytic plan for brain imaging that estimated cellular and myelin composition from MRI scans. I presented this ongoing novel work at the Society for Neuroscience annual meeting in 2017. While at UCLA, I attended lectures, job talks, and colloquiums to familiarize myself with research at the intersection of social cognition and psychopathology.

Castrellon, J.J., Karlsgodt, K.H., Diffusion-imaging derived cell density in the nucleus accumbens core predicts delay discounting in humans. Poster presented at the annual meeting of the Society for Neuroscience. Washington, D.C. November 2017.

Motivated Cognition & Aging Brain Lab, Duke. September 2017 – June 2022, PI: GR Samanez-Larkin: I entered my PhD program at Duke with an NSF Graduate Research Fellowship. During my time in the lab, I developed statistical skills in multilevel modeling, blind source separation, basic univariate fMRI analysis, and meta-analysis. During this time, I investigated associations between dopamine function and impulsive decision making in humans using an individual differences approach. This included quantification of dopamine receptor availability and release with PET and estimation of responsivity to the psychostimulant d-amphetamine.
Specifically, my work sought to identify links between delay discounting, subjective valuation, and dopaminergic mechanisms with pharmacology, fMRI, PET, and experience sampling in everyday life. I also received funding to conduct a pilot study to test whether fMRI-related brain activation patterns can predict real- world changes in physical activity in response to socially motivating messages. I trained and mentored 10 undergraduate students in data analysis, writing of results, and conference presentations. Nearly all of these students received competitive funding to support their research. My mentorship was recognized in 2020 with the Duke Bass Connections Outstanding Mentor Award and in 2021 with the Dean's Award for Excellence in Mentoring. I presented my research at the Cognitive Neuroscience Society, Society for Neuroeconomics, the Social Affective Neuroscience Society, and the Organization for Human Brain Mapping. For two years in a row, I won the Best Poster Award from the Society for Neuroeconomics. My travel to some of these conferences was supported by competitive awards from the Lafitte Foundation and the Society for Neuroeconomics. Each summer, I participated in competitive programs like the Summer School in Social Neuroscience and Neuroeconomics and the Kavli Summer Institute for Cognitive Neuroscience. At these summer schools, I expanded my knowledge of social decision-making and developed a network of potential collaborators for future research. As part of my graduate training, I served as an instructor for introductory statistics, cognitive neuroscience, neurobiology research methods, and developmental psychology. Thus far, I authored/co- authored seven manuscripts and personally delivered six conference presentations.

Castrellon, J.J., Young, J.S., Dang, L.C., Smith, C.T., Cowan, R.L., Zald, D.H., Samanez-Larkin, G.R., Individual differences in dopamine support self-control of everyday desires. *In revision.*

Castrellon, J.J., Meade, J., Greenwald, L., Hurst, K., Samanez-Larkin, G.R. (2021). Dopaminergic modulation of reward discounting in healthy rats: A systematic review and meta-analysis. *Psychopharmacology*. DOI: 10.1007/s00213-020-05723-5

Botvinik-Nezer, R., Holzmeister, F., Camerer, C.F.,…**Castrellon, J.J.**,…Samanez-Larkin, G.R., …, Nichols, T., Poldrack R., Schonberg, T. (2020). Variability in the analysis of a single neuroimaging dataset by many teams. *Nature*. DOI: 10.1038/s41586-020-2314-9

Burr, D.A., **Castrellon, J.J.,** Zald, D.H., Samanez-Larkin, G.R. (2020). Emotion dynamics across

adulthood in everyday life: older adults are more stable in their affective experiences and better at regulating desires. *Emotion*. DOI: 10.1037/emo0000734

Castrellon, J.J., Young, J.S., Dang, L.C., Cowan, R.L., Zald, D.H., Samanez-Larkin, G.R., (2019). Mesolimbic dopamine D2 receptors and neural representations of subjective value. *Scientific Reports*. DOI: 10.1038/s41598-019-56858-1

Castrellon, J.J., Seaman K.L., Crawford, J.L., Young, J.S., Smith, C.T., Dang, L.C., Hsu, M., Cowan, R.L., Zald, D.H., Samanez-Larkin, G.R. (2019). Individual differences in dopamine are associated with reward discounting in clinical groups but not in healthy adults. *Journal of Neuroscience*. DOI: 10.1523/JNEUROSCI.1984-18.2018

Castrellon, J.J., Zald, D.H., Samanez-Larkin, G.R., Individual differences in dopamine predict self-control of everyday desires. Spotlight poster and talk presented at the annual meeting of the Society for Neuroeconomics. Dublin, Ireland. October 2019. ***Best Poster Award Winner**

Castrellon, J.J., Dang, L.C., Smith, C.T., Cowan, R.L., Zald, D.H., Samanez-Larkin, G.R., Latent organization of dopamine D2 receptors. Poster presented at the annual meeting of the Organization for Human Brain Mapping. Rome, Italy. June 2019.

Castrellon, J.J., Samanez-Larkin, G.R., Parsing the role of dopamine in reward discounting and subjective valuation. Spotlight poster and talk presented at the annual meeting of the Society for Neuroeconomics. Philadelphia, PA. October 2018. ***Best Poster Award Winner**

Castrellon, J.J., Dang, L.C., Young, J.S., Zald, D.H., Samanez-Larkin, G.R., Individual differences in dopamine D2 receptors and neural representations of subjective reward value. Poster presented at the annual meeting of the Cognitive Neuroscience Society. Boston, MA. March 2018.

Brains & Computation Lab, Duke University January 2018 – May 2022, PI: John M. Pearson: My involvement in the Pearson lab grew from a practicum rotation to learn online survey programming methods. I was involved with leading an ongoing project on neuroimaging juror decision making. By studying social decisions under an ecologically-valid context, the results shed light on neural mechanisms that account for biased juror decisions. Through personal meetings with Dr. Pearson and collaborators at the Duke University School of Law and the University of Colorado, I enhanced my skillset in multilevel statistical models of complex social behavior and fMRI analysis. I presented preliminary findings from this work at the Society for Neuroeconomics and published 2 manuscripts of the results.

Castrellon, J.J., Hakimi, S., Parelman, J.M., Yin, L., Law, J.R., Skene, J.A.G., Ball, D., Malekpour, A., Pearson, J.M., Carter, R.M., Skene, J.H.P. (2022). Neural support for contributions of utility and narrative processing of evidence in juror decision making. *Journal of Neuroscience*. DOI: 10.1523/JNEUROSCI.2434-21.2022

Castrellon, J.J., Hakimi, S., Parelman, J.M., Yin, L., Law, J.R., Skene, J.A.G., Ball, D., Malekpour, A., Pearson, J.M., Skene, J.H.P., Carter, R.M. (2022). Social cognitive processes explain bias in juror decisions. *Social Cognitive and Affective Neuroscience*. DOI: 10.1093/scan/nsac057

B. GOALS FOR FELLOWSHIP TRAINING AND CAREER

My ultimate goal is to lead a research lab that focuses on characterizing neurobiological mechanisms of motivated social decision making in humans. Thus far, my research has supported this goal by using neuroimaging to study the role of dopamine in human decisions for personal and social rewards. **My proposed research under the K00 examines how dynamic social information such as hierarchy modulates basic neural and cognitive mechanisms of decision making and learning. This project's transdiagnostic approach is consistent with the RDoC framework because it seeks to use neuroimaging with economic games that approximate behaviors under the Positive Valence and Social Processes domains.** This line of research would place me in a position to lead as an interdisciplinary scientist by combining tools from neuroscience, behavioral economics, and psychiatry to probe social decision making. Together with my sponsors Dr. Joseph Kable and Dr. Adrianna Jenkins and the advisory team that I have assembled (Dr. Emily Falk, Dr. Michael Platt, and Dr. Ted Brodkin), I will have unique access, exposure, and preparation for a successful scientific career. All advisory team members are experts in social cognition with specialized focus on neurobiology (Platt), clinical disorders (Brodkin), and applications to real-world settings (Falk). As an independent researcher in a faculty position, I will build an

inclusive environment for future trainees to conduct interdisciplinary science while fostering practices that promote "open science" and accelerate discoveries. **The goal of the K00 portion of this fellowship is to advance my intellectual, technical, and professional skills to succeed in the next step of my career. My immediate broad goals are to (1) gain technical training in multivariate fMRI analysis, (2) acquire and expand my conceptual knowledge about social cognition, and (3) further develop my professional skills in mentoring, communication, grant writing, networking, and future job preparation.**

Technical Training: During my time as a postdoctoral researcher in the Jenkins and Kable labs, I will receive in-depth training on multivariate neuroimaging analysis such as those implemented in voxel pattern analysis, representational similarity analysis, and neural decoding. Since the data associated with the proposed project will need to be collected first, I will immediately begin training in analytical methods using pre-existing datasets in both labs. The datasets available are focused on different aspects of social decision making, so they are highly relevant for my training. I will then write up results from analyses of these pre-existing datasets and will submit at least one manuscript for peer-review. Both labs have expertise in multivariate fMRI analysis, including in joint projects between the two labs[12], and will provide informal training through weekly meetings with Dr. Kable and Dr. Jenkins along with experienced fellow postdoctoral researchers. To support this informal training, I will audit Dr. Russell Epstein's advanced functional MRI methods course. Dr. Epstein is an expert in advanced statistical analysis of fMRI data, including different multivariate techniques, and his course will provide helpful structured training in these methods. **Involvement of Advisory Committee:** I will seek advice from Dr. Emily Falk and members of her lab to optimize the experience sampling protocol proposed in Aim 3 since her lab has years of experience designing experiments linking experience sampling measures to fMRI brain activation. **Benchmark(s):** During the first year of the award, as I am collecting data to support my specific aims, I will publish at least one manuscript related to the analysis of a pre-existing social decision-making fMRI dataset. In the second year, I will analyze data and draft results from Aims 1 and 2. In the third year of the award I will submit at least 2 manuscripts for peer review on the results of Aims 1 and 2 and begin analyzing data and drafting results associated with Aim 3. Aim 3 results will be submitted for peer-review in the fourth year of the award.

Conceptual Training: In concert with the technical training, I will receive extensive conceptual and theoretical training on social cognition. Dr. Adrianna Jenkins is an expert in social cognition and decision making and will therefore help lead my training in this area. Dr. Jenkins teaches an undergraduate course on social cognition— from this course, she will provide me with a reading list to begin orienting me toward foundational research. To contribute and extend to the field's theoretical knowledge, I will lead the writing of a review paper on interactions between social cognition and decision making. To discuss the emerging literature on social cognition, I will attend weekly lab meetings and journal clubs in the Jenkins lab where new findings are regularly discussed and research by my lab members is presented for feedback. Outside of the lab, I will attend the psychology department colloquium and seminars through mindCORE (Penn's center for the cognitive and brain sciences). Attending presentations here by researchers at Penn and invited talks will further enhance my conceptual knowledge of more cutting-edge perspectives and ideas. To understand the broad impacts of social cognition on behavior, I will also attend talks hosted by the Center for Neuroscience and Society, which focuses on legal, ethical, and social implications of neuroscience research. **Involvement of Advisory Committee:** To enhance my conceptual understanding of the relevant topics, I will meet with Dr. Ted Brodkin to consider the clinical implications of disruptions to social cognition on the ability to integrate dynamic social information in decision making. Dr. Brodkin's expertise on social cognitive deficits in clinical groups (schizophrenia and autism) will be especially important here. I will meet with Dr. Michael Platt to discuss the neurobiological significance of brain regions in the use of social hierarchy information for social decisions. Dr. Platt can provide specific advice based on expertise in neurobiology of social decision making in non-human primates. I will meet with Dr. Emily Falk to discuss experience sampling methods as a means of studying social cognition and how to best link brain function with real-world behaviors examined using experience sampling. Dr. Falk's expertise in experience sampling methods and social cognition will be most relevant to the proposed research in Aim 3. **Benchmark(s):** In the first year of the award, I will begin drafting a review article on neural mechanisms of social decision making and submit the manuscript for peer review in the subsequent 1-2 years.

Mentoring: Mentoring has always been central to my identity as a scientist and so my professional

development will include specific training in mentoring trainees. My training in mentorship will include advising at least one junior research associate/lab manager/undergraduate student in the first two years of the award. In subsequent years, I will mentor at least one graduate student. Informal training in mentorship will include meetings with my mentors and advisory team and formal training will include mentoring workshops supported by mindCORE's Step-Ahead Mentorship Program. Through mindCORE, I will also participate in the postdoc- led Diversity and Equity Initiative in the Mind Sciences (DivE In) program which provides mentorship to underrepresented minorities with interest in psychology and neuroscience. This includes hosting graduate student diversity recruitment events and participating in outreach events in the Philadelphia area.
Benchmark(s): I will have first-hand mentoring experience by aiding in the supervision of research associates/undergraduate students/graduate students and the direct supervision of at least one of these trainees per year.

Communication: In addition to communicating the impacts of research to the local community, I will develop my public speaking skills by delivering a lecture in courses on social cognition taught by Dr. Jenkins and on neuroeconomics taught by Dr. Kable. Outside my home labs, I will also give talks in the labs of Dr. Emily Falk and Dr. Ted Brodkin. These interactions with scholars with different expertise will help strengthen my communication abilities. There are regular meetings of the social and decision neuroscience labs across Philadelphia (including both Penn and Temple University), and I will deliver practice job talks at these gatherings. **Benchmark(s):** I will deliver 1-2 undergraduate course lectures per semester as well as deliver at least one research talk outside my home lab once per semester.

Grantsmanship: To sharpen my grant-writing skills, I will aide Dr. Jenkins and Dr. Kable in the writing of an R21 NIH or similar development grant. While I will not lead the writing, my involvement (observing/assisting) will prepare me to apply for a K99/R00 award to facilitate the transition to independence. In addition to these federal grants, I will seek opportunities to apply for smaller grants to support the proposed K00 research. Preparing these grants will equip me with the skills to independently run a lab. **Benchmark(s):** During the award period, my sponsors will submit an NIH R21 or similar award that I aided through writing and other preparation. Between my third and fourth year of the K00, I will submit a K99/R00 application.

Networking: During the K00, I will seek opportunities to give oral presentations at conferences. To achieve this, I will organize a mini or nano symposium at the Society for Neuroscience annual meeting. This will help me network with fellow scientists addressing similar questions. As part of the award, I will attend the NIH Blueprint-sponsored conference to network with fellow D-SPAN F99/K00 awardees. To specifically engage with scholars on the neurobiology of social decision making, I will attend and deliver presentations (poster and oral) at annual conferences for the Society for Neuroeconomics, Social Affective Neuroscience Society, Society for Personality and Social Psychology, and the Society of Biological Psychiatry.
Benchmark(s): I will present findings from my specific aims at 2-3 research conferences per year and will organize a mini or nano symposium in the second year of the award.

Transition to Independence: During the K00 award period, I will apply for a K99/R00. During the K99, I anticipate transitioning to independence by preparing to apply for faculty positions. First, during the K00 phase, I will prepare for this process by developing a project that I can propose in the K99/R00 application. For the K99 application, I will seek advice and feedback on materials from prior mentors (F99 mentors) and K00 sponsors and members of my advisory committee. My committee members including my sponsors have a solid track record of advising and supporting postdocs in the transition to independence.
Benchmark(s): I will meet with advisory committee members and give talks in lab meetings to gain feedback on potential project aims and future research directions in support of a K99 application.

Year	Research (75% Effort)	Mentoring (10%)	Professional Development (15%)	Milestones
K00 Year 1	Aims 1, 2, and 3: Design behavioral experiments for fMRI (Aims 1 and 2) and	Supervise a research associate	Attend weekly MindCORE	Publish 4 PhD manuscripts (2 currently

	experience sampling surveys (Aim 3), recruit participants, collect data <u>Technical skills</u>: analyze a pre-existing dataset on social decisions from the Jenkins lab using multivariate fMRI methods <u>Writing</u>: Dedicate 1 day per week to drafting a review article on interactions between social cognition and decision making and begin drafting report (1 day per week) on results from analysis of pre-existing dataset. To support writing of the review paper on social cognition and decision making, I will attend talks hosted by Penn's Center for Neuroscience and Society	Discuss mentoring strategies in weekly meetings with Sponsors (Dr. Kable and Dr. Jenkins) Attend MindCORE mentoring workshops Participate in/help lead MindCORE DivE In program	colloquium series. Attend MindCORE grant writing and professional development workshops Present PhD work at SNE conference and analysis of pre-existing dataset on social decisions at SANS conference Meet with Postdoctoral Advisory Committee (minimum 2 times) Network with fellow D-SPAN fellows at NIH Blueprint conference	in revision
K00 Year 2	<u>Aims 1 and 2</u>: Implement computational models for behavioral data (cooperative trust game and competitive patent race game) and analyze multivariate fMRI data <u>Writing</u>: Dedicate 2.5 days per week to drafting 2 manuscripts (Aims 1 and 2)	Continue supervising research associate(s) or mentor a PhD or undergraduate student Continue to discuss mentoring strategies in weekly meetings with Sponsors Attend MindCORE mentoring workshops Participate in DivE In program	Continue attending colloquium and MindCORE workshops Solicit and lead a nano- or mini-symposium at SfN to present Aims 1 and 2 Give talks at Penn in labs of Dr. Falk and Dr. Brodkin to share ideas from review article on social cognition and decision making Meet with Postdoctoral Advisory Committee (minimum 2 times)	Submit 2 articles for peer review (review article and pre-existing dataset analysis)
K00 Year 3	Aim 3: Analyze experience sampling data in relation to fMRI data (collected in Aims 1	Continue supervising research associate(s) or mentor a PhD or undergraduate student	Present Aim 3 results at SPSP conference and SOBP conference	Submit 2 manuscripts (Aims 1 and 2) for peer review

	and 2) using mixed-effects modeling. Writing: Draft manuscript of Aim 3 results	Continue to discuss mentoring strategies in weekly meetings with Sponsors Help lead DivE In program Attend Penn MindCORE mentoring workshops	Meet with Postdoctoral Advisory Committee (minimum 2 times) Contribute to writing, preparation of an R21 grant with Sponsors Network with fellow D-SPAN fellows at NIH Blueprint conference	
K00 Year 4	Writing: Dedicate 2.5 days per week to drafting and revising application for K99/R00 grant Future: Organize ideas for follow-up experiments and collect pilot data for R00 grant	Continue supervising research associate(s) or mentor a PhD or undergraduate student Continue to discuss mentoring strategies in weekly meetings with Sponsors Help lead DivE In program Attend MindCORE mentoring workshops	Network with fellow D-SPAN fellows at NIH Blueprint conference Solicit feedback on K99 project aims through lab meeting presentations and meetings with advisory committee members	Submit 1 manuscript (Aim 3) for peer review

SfN: Society for Neuroscience; SANS: Social Affective Neuroscience Society; SNE: Society for Neuroeconomics; SPSP: Society for Personality and Social Psychology; SOBP: Society of Biological Psychiatry; DivE In: Diversity and Equity Initiative in the Mind Sciences

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Specific Aims

The ability to flexibly incorporate social information into decisions is central to successful social behavior and may be a locus of disruption in disorders of social function. While some kinds of social information are stable across time, others fluctuate dynamically. One important aspect of social context that has both stable and transient temporal features of social context is social hierarchy, which could affect whether one trusts and learns from others[1] and how one regulates emotions. Social hierarchy, or the organization of individuals in a community relative to others according to status and power[2], is a prominent feature of most societies. Critically, hierarchy can vary across timescales, forming temporally-defined stable and transient contexts for decisions in ways that increase or decrease one's power and status over others[3]. Whereas relatively stable attributes could include factors like age, gender, or occupation, transient attributes can be defined by the relation between people (e.g., parent-child, employer-employee, doctor-patient, etc.,).

In addition to the characteristics of others, one also must dynamically integrate one's own goals with the goals of others when making social decisions. In the case of social hierarchy, humans may need to consider someone's hierarchical position differently depending on whether their goal is cooperative or competitive. For example, in cooperative environments, asking an employer for advice may depend on how one represents the employer's power and status in the community according to stable features like gender and age along with transient features like status and power as a manager in the workplace. In competitive contexts, seeking a promotion at work may demand specific monitoring of co-workers' behaviors and outcomes according to different stable features like socioeconomic status and transient features like job performance. Learning and valuation across these cooperative and competitive goals, therefore, may shift or remain unchanged. Behavioral work indicates that social decisions and perceptions about others[4] are disrupted in psychopathology[5]. Yet, the mechanisms by which these disruptions arise are unknown. One potential source is the integration of both stable and transient social information with valuation and learning processes in ongoing decisions with cooperative versus competitive goals. Thus, examining social hierarchy as a modulator of the neural systems involved in decision making can provide a broader, transdiagnostic understanding of the brain's ability to integrate dynamic social information in everyday/real-world decisions.

Social hierarchy has generally been linked to neural circuits that converge on the reward system[6–9]. In fact, across species, striatal dopamine is an important modulator of social status and dominance[10,11]. Inferences about others' traits, however, have been predominantly linked to the temporoparietal junction (TPJ)[12] and learning about hierarchies engages the anterior insula (AI)[13,14]. However, it is not known how or where temporal dimensions of social information are integrated with goals to modulate preferences and learning. In addition to testing the influence of neural representations of hierarchy on trust and social learning, we also test whether humans flexibly reconfigure these neural representations of hierarchy across cooperative and competitive environments since it may be adaptive to adjust representations when goals change. Finally, to ecologically validate this work, we will test for links between neural patterns and social behavior in daily life.

Specific Aim 1: *Stable and transient characteristics of others*. Humans will undergo a function MRI (fMRI) scan while they make decisions about trusting others with rewards. Identifying information about others provides cues about stable hierarchy (e.g., occupation, age, gender, etc.) and task-manipulated costly giving manipulates transient hierarchy. Using computational modelling (to isolate independent contributions of stable and transient hierarchy) and multivariate analysis of fMRI data, we will investigate how the brain represents perceived hierarchy and the extent to which these representations explain trust behavior. We hypothesize that the TPJ will specifically track multivariate representations of stable hierarchy and that the striatum will track transient hierarchy. We also hypothesize that interactions between these cortical and the striatal regions will predict differences in distributions between oneself and others according to transient hierarchical position.

Specific Aim 2: *Modulation of decision making by social goals*. To test whether humans flexibly update representations according to social goals, participants from Aim 1 will also perform an fMRI task in which they compete with and learn the strategies of others whose hierarchical position is cued as in Aim 1. Here, we hypothesize that striatal and AI activation will be associated with greater learning from others whose stable and transient hierarchical position are high. We also hypothesize that these greater learning abilities will be associated with flexible updating of neural representations of hierarchy in the TPJ (and dissimilar from representations in the cooperative context in Aim 1). From data collected in Aims 1 and 2, we will evaluate the extent to which representations of status and power are distinct or overlap.

Specific Aim 3: *Linking modulatory mechanisms of hierarchy to everyday social behavior.* By sampling from a diverse community, we can evaluate whether neural representations relate to daily social behavior. We hypothesize that activation patterns predicting social preferences in the distribution task will correspond to social affective experiences outside the lab.

BACKGROUND AND SIGNIFICANCE

To successfully navigate complex social relationships, humans must be able to flexibly integrate their mental representations of others into ongoing decisions. This ability requires understanding that certain attributes of others are relatively more stable (e.g., gender, age, occupation) and others are relatively more transient or context dependent (e.g., parent, employee, friend, mentor). One kind of attribute that exhibits these dynamic temporal characteristics is social hierarchy, or the organization of individuals in a community relative to others according to status and power. Social hierarchies are present across different animal species[1,2]. In human societies, status and power can manifest from factors like access and/or control of resources, influence and respect, privilege, or expertise to name a few[15]. The representation and use of dynamic social information may depend on the ability to flexibly reconfigure how hierarchy is represented because of specific goals. In the case of social hierarchy, humans may need to consider someone's hierarchical position differently depending on whether their goal is cooperative or competitive.

While behavioral studies indicate that social decision making is generally disrupted in psychopathology[5], the mechanisms by which these disruptions arise are unknown. Potentially, one factor contributing to deficits in social decisions is the ability to monitor and integrate temporally-defined social attributes with basic decision making processes like reward valuation and strategic learning. These processes are especially important since temporally-varying social attributes might differentially influence decisions to trust others or learn and optimize one's behavior based on observations of others' experiences. Social decisions to trust and learn from other people engage a network of brain regions that coordinate mentalizing and reward valuation [16] (**Figure 1**). Notably, the use of information related to social hierarchy has generally been linked to neural circuits that converge on these same brain regions[6–9].

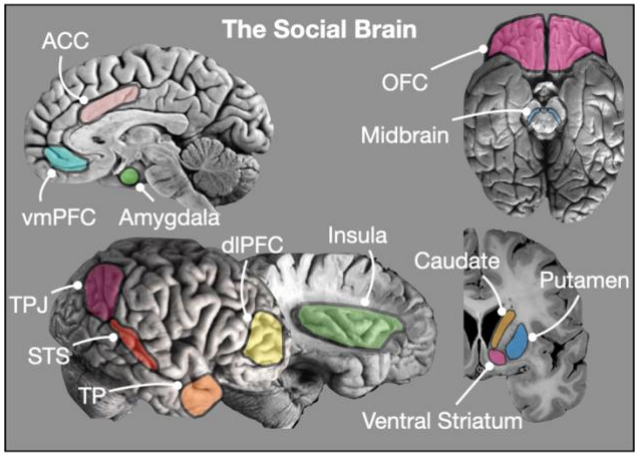

Figure 1. Brain regions involved in social decision making functions including social cognition, learning, and motivation. The coordination of activity between these regions will be tested using functional brain imaging and multivariate pattern analyses. TPJ: temporoparietal junction; STS: superior temporal sulcus; TP: temporal pole; PFC: prefrontal cortex ; vm: ventromedial; dl: dorsolateral; OFC: orbitofrontal cortex; ACC: anterior cingulate cortex.

It has been proposed that reward processing regions like the striatum (and the midbrain from which reward-sensitive dopamine neurons project) are sensitive to social hierarchy because of the incentive value associated with benefits from higher social status[17]. Taken together with the striatum's well-characterized role in updating and representing the subjective value of rewards[18,19], the integration of transient hierarchy with social decisions may be expected to elicit striatal activity. Likewise, given the role of theory-of-mind processing regions like the temporoparietal junction (TPJ) and the superior temporal sulcus (STS) in evaluating global social attributes like traits[12], these same regions may be more dedicated to integrating stable hierarchy information in decisions. While stable and transient hierarchy may be independently evaluated by specific brain regions, the interaction between them raises the possibility of dedicated processing to incorporating both temporal aspects with an ongoing decision. The integration of values has been largely ascribed to the functions of the ventromedial prefrontal cortex (vmPFC)[20]. Thus, the vmPFC may be similarly involved in the integration of stable and transient hierarchy.

Research into these mechanisms can provide transdiagnostic insight about social behavior and emotion regulation. For instance, prior work has shown that symptoms of anhedonia in psychosis predict lower trust behavior, potentially indicating a motivational/reward processing deficit[21], and in autism, reduced mentalizing abilities are attributed to disrupted trusting behavior[22]. These decisions may be further disrupted for hierarchical interactions requiring mentalizing since autism and schizophrenia have been linked to under- and over-perception of agency[4]. Interacting with others whose perceived hierarchical position is different than one's own can contribute to negative emotions and the deployment of emotion regulation strategies like suppression[23]. Deficits in emotion regulation abilities, therefore, may amplify perceived negative outcomes from interactions involving asymmetric hierarchy. Using neuroimaging, this project seeks to resolve the specific mechanisms that might contribute to these social processing deficits.

Whereas traditional fMRI analyses are limited to identifying unidimensional contributions to brain activation, the multivariate analyses proposed here will allow us to identify the joint contributions of stable and transient hierarchy to learning and decision making. Representational similarity analysis (**Figure 2**) can help identify the specific mapping between neural and cognitive representations of multidimensional constructs like

social hierarchy. This application seeks to understand how the brain integrates and adapts to dynamic social information and goals by examining how social hierarchy modulates neural mechanisms of cooperative and competitive decision making. The proposed studies here fulfill this goal with multivariate analysis of functional magnetic resonance imaging (fMRI) data and computational modeling of behavior from economic interpersonal tasks with 3 primary aims. Aim 1 tests how the human brain integrates stable and transient social hierarchy with decisions to trust others. Aim 2 uses a strategic learning task to resolve whether competitive goals here and cooperative goals in Aim 1 differentially influence neural representations of dynamic social information. Finally, Aim 3 broadens this research to study how integration of dynamic social information in the lab relates to actual behavior and emotional experiences recorded in daily life using experience sampling methods.

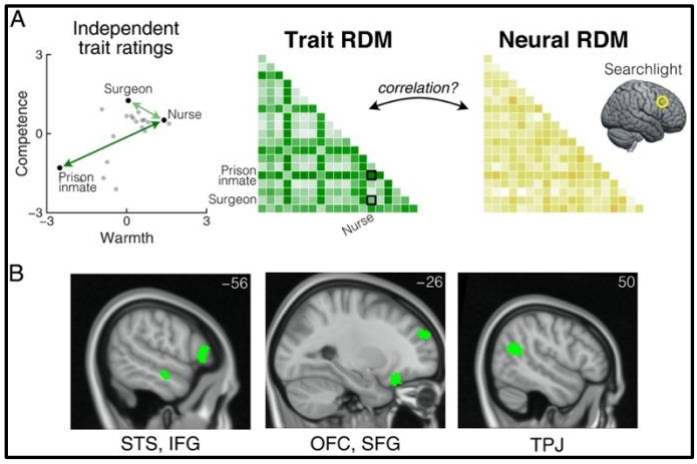

Figure 2. Multivariate fMRI analysis can identify the degree to which specific brain regions track and represent multidimensional cognitive constructs. In this example, our labs have used this approach to identify multivariate patterns of others' traits during prosocial choices.

EXPERIMENTAL APPROACH

Aim 1 Stable and transient characteristics of others:

Rationale: This Aim is designed to evaluate how humans represent and integrate temporally-varying social hierarchy in decisions that have a cooperative goal. Cooperation and the formation of alliances is foundational to the survival of social animals and emerges in concert with the establishment of a social hierarchy in a community[24]. One kind of cooperative decision, trusting others, involves attaining rewards at the cost of some uncertainty that others may or may not cooperate. As a result, these decisions engage mentalizing and motivational cognitive processes. In daily life, humans regularly face situations that momentarily place them in higher or lower status/power with others whom they perceive to have more or less power/status, generally. For example, trusting the advice of a healthcare provider might depend on whether one is feeling ill. Despite the number of studies that have examined trust behavior generally, no study has tested how variation in social standing along temporal dimensions modulate basic neural and cognitive processes involved in cooperation. Using functional brain imaging and multivariate analysis, I will test whether, how, and in which brain areas that stable and transient hierarchy are integrated. Specific hypotheses speculate on the involvement of reward valuation and mentalizing brain regions.

Experimental Design: We will recruit 35 healthy adults between the ages of 18 and 40 from the Philadelphia community and the University of Pennsylvania to participate in an fMRI experiment. We will design an experiment that extends prior implementations of the trust game[25]. In the trust game (**Figure 3**), participants are instructed that they will make a series of decisions across trials in which they entrust all, part, or none of an endowed monetary reward with a partner (trustee). The entrusted reward amount is then multiplied (typically by 2 or 3) before being sent to the trustee, who then can decide to share all, none, or a part of the multiplied investment with the participant. As in many versions of the task, our implementation will use computerized, programmed trustees with actual decisions by past participants

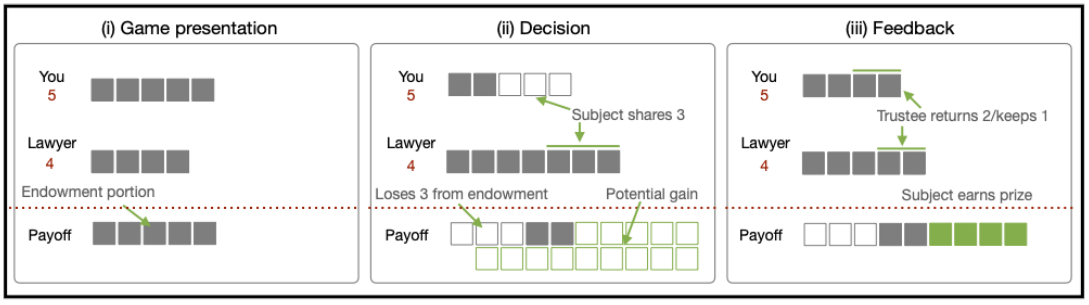

Figure 3. Illustration of the modified trust game with asymmetric endowments: Participants cooperate with others by trusting them to increase an invested prize. On each round, the participant receives an endowment that is either higher or lower than their trustee. The participant first decides whether to share none, all, or a portion of the endowment with a trustee (3 in the example above). When the endowment is sent to the trustee, it is multiplied by 2. In this example, the potential payoff is 14 since the trustee could share this entire new endowment of 7 multiplied by 2. The trustee will then either return none, a portion, or all of the endowment back to the participant. In the example above, 2 are sent back and 1 is kept by the trustee, resulting in a prize of 5 for the trustee and 6 for the subject (2 from the subject's original unshared endowment plus the 2 multiplied by 2 from the trustee).

completing the task so that participants know that trustee decisions are real. To simulate the experience of stable hierarchical differences, participants will be provided a written cue that signals an attribute of the trustee on each round (e.g., "doctor", "police officer"). Whereas typical implementations of the experiment initialize each round with equal reward endowments to the participant and trustee, we will implement a design tested by others that uses asymmetric endowments[26,27]. This simulates the experience of transient hierarchy because on some trials, participants will be endowed more or less than their trustee (whose stable hierarchical attribute can independently vary). Differences in the starting endowment gives one of the players the advantage because a player with more resources can more easily guarantee themselves a minimum by sharing some and keeping some than someone with fewer resources. Importantly, these are "single-shot" decisions, meaning that each round is a new decision with a new trustee. The rounds in the task will be distributed across runs with a short break between runs for participant comfort in the fMRI scanner. Once scanning is complete, participants will provide ratings for the trustees based on perceived hierarchical features like power and status in the community. To account for other factors that participants may be considering, participants will also provide ratings that capture stereotypes acquired from past experience and knowledge related to warmth and competence. These two aspects of stereotypes have been shown to explain a substantial amount of variability in social percepts like trustworthiness, friendliness, intelligence, etc[28]. Inclusion of warmth and competence ratings in behavioral and fMRI models will help isolate the independent contribution of social hierarchy to the explained variance in decision making. We note that prior to any fMRI data collection, online data will be collected from a large representative sample of the U.S. population to identify optimal stimuli for the task. Specifically, we will collect ratings on aspects of hierarchy for each potential trustee identity. This will enable us to optimize our stimuli so that high versus low social hierarchy position, as well as differential power and status, are maximally distinguishable.

Analysis plan: I will analyze behavior using computational models that can test for the presence of independent and interactive contributions of stable and transient hierarchy defined by the ratings provided by participants. Our lab has developed and tested a social-perception weighted (SPW) model of social valuation that can explain decisions with partners with who vary in rated warmth and competence[29]. Here we will apply the SPW model to assess how humans weigh stable and transient aspects of hierarchy as additive or multiplicative weights. Parameter estimates will be compared using mixed effects linear modelling to test whether participants are more trusting of individuals according to hierarchy that is: (1) stable, (2) transient, and (3) if both dimensions, whether they combine additively or multiplicatively. Evidence for integration of both dimensions will be probed by testing whether multiplicative or additive weights in the SPW model better explain behavior. Neuroimaging data will undergo standard preprocessing using fMRIPrep[30] before univariate and multivariate analysis using open-source Python-based tools (nilearn[31], nltools[32], and rsatoolbox[33]) and FMRIB software library [34]. Univariate patterns will help describe overall simple activations associated with dimensions of hierarchy and multivariate analyses will test whether a pattern in the cognitive representation of hierarchy from ratings is similarly represented in the fMRI data during trust decisions. Representational similarity analysis will be used to (1) construct adjacency matrices based on ratings of perceived hierarchy and (2) identify which brain region's multivariate neural activity is most similar to the adjacency matrix. Specifically, two matrices will be constructed that represent the (dis)similarity between social cues' (1) stable hierarchy and (2) transient hierarchy based on the Euclidean distance between hierarchy ratings. A searchlight analysis will test for the similarity (via spearman rho) of each matrix to activation in the brain in a voxelwise manner. A permutation test in FMRIB software will be used to evaluate the statistical significance of effects with 5,000 permutations against the null that no correlation exists.

Expected and competing hypotheses: Valuation of social hierarchy will be operationalized by the extent to which participants entrust a greater proportion of their endowment to trustees whose stable hierarchy is rated higher **and** trustees who have equal or larger endowments. From the regression coefficients of a linear model predicting amount entrusted to trustees from stable and transient hierarchy ratings, I hypothesize that if regression weights are equal, then participants value both stable and transient hierarchy dimensions. Alternatively, participants may place a greater weight on stable hierarchy alone or transient hierarchy alone. This would be concluded from unequal regression coefficients in the linear model (stable>transient or transient>stable). These alternatives would suggest that these temporal dimensions are not integrated in decision making. From the behavioral data, I hypothesize that if participants integrate different aspects of hierarchy, then the SPW model of social valuation with multiplicative weights will fit the data better than an additive model—providing evidence of interactions between stable and transient hierarchy. I hypothesize that the cognitive mapping of participants choices for trustees across stable and transient hierarchy will be best explained by regional voxel activations in social

cognitive and reward processing regions. If stable and transient hierarchy are independent, then the neural representations will be non-overlapping. Specifically, stable hierarchy will be represented in the mentalizing regions such as the TPJ, STS, and dmPFC while transient hierarchy will be represented in the striatum (with activation centered on the ventral striatum). I hypothesize that if stable and transient hierarchy are integrated, then their joint representation will be localized in the vmPFC. Alternatively, the absence of a joint representational activation profile would suggest that stable and transient hierarchy are not integrated in decisions.

Potential pitfalls: A primary concern for this experiment and the experiment proposed in Aim 2 below pertains to the design of the task. Specifically, if the social hierarchy position associated with identity cues are not maximally distant or unambiguous, then we may not be able to capture brain signals that scale with variation in hierarchy. For example, participants may not meaningfully distinguish a doctor from a lawyer with respect to their perceived social hierarchy position. To overcome this challenge, we will select identity cues that can capture a wide range of possible social hierarchy positions (e.g., politician, janitor, flight attendant, etc.). Ratings from an independent online sample will be used to identify those identities that are most consistently (low standard deviation across raters) rated as having high, average, or low social hierarchy positions. This will reduce the potential for noise in the data from interindividual variability. An additional concern is whether participants' decisions are influenced by factors beyond social hierarchy like attractiveness or stereotypes. To overcome this possibility, the social cues selected for use in the tasks here will be selected from a larger sample of cues that will not only be rated on aspects of social hierarchy but also traits like warmth and competence which can capture a substantial portion of variability in stereotypes for traits like trustworthiness, friendliness, capability, envy, etc.. Our team has adopted this approach in the past to show that warmth and competence can capture a sizeable portion of variance that could overlap with aspects of social hierarchy[12,29]. We will then select the cues which are most independent or unrelated to warmth and competence. In particular, since perceptions about competence are related to perceptions about status[35], identifying stable hierarchy cues with a lower competence-status correlation across raters will be essential to the experimental design.. Further, we will only provide participants with written cues because images might bias perceptions of hierarchy related to facial appearance or clothing.

Aim 2: Modulation of decision making by social goals

Rationale: This Aim is designed to evaluate (1.) how humans represent and integrate temporally-varying social hierarchy in decisions with a competitive goal and (2.) whether the representation and integration in this competitive goal context and the cooperative goal context in Aim 1 are distinct or overlapping. Whereas cooperative situations present the opportunity to share rewards, competitive decisions are often zero-sum, with one individual earning a reward at the expense of another (and vice-versa). Although cooperative and competitive decisions both engage mentalizing (TPJ and STS) and motivation (striatum) processes[16], the heightened conflict in competition engages cognitive control in the anterior cingulate cortex (ACC) and anterior insula (AI) to help track beliefs about opponents potential strategies[14]. Notably, these regions are also engaged in learning[36]. These belief-based processes support complex learning about the consequences of others' actions to help guide one's own future actions. Updating one's own behavior from the strategies of others is adaptive and self-preserving. These functions are particularly important since many competitive decisions are made with others who are higher or lower in perceived social hierarchy. For example, it may be advantageous to learn how one's manager behaves if it can inform future negotiations about salary and promotion. Deficits in this belief learning ability might arise if individuals solely monitor their own behavior and not the behavior of an opponent. The integration of time-varying dimensions of hierarchy may uniquely impact learning abilities if people place a greater weight on the status or power of others. One possibility is that participants place a greater learning weight on stable characteristics like age, socioeconomic status, or occupation as indicators of success to emulate[9]. Alternatively, participants may pay more attention to immediate, transient hierarchical differences for more rapid learning, or the combination of both stable and transient hierarchy. Flexible decision making across different goal contexts may demand reconfiguration of brain networks[37–39]. Whether and how, precisely, animals update their representations of social information across contexts is unknown. This question is important because maladaptive reconfiguration could result in treating others in ways that are inconsistent with social or cultural norms[40]. For example, while it may be beneficial to learn and emulate the financial decisions of a wealthy person who claims to be similar to oneself, trusting based on these characteristics alone could potentially lead to negative consequences like fraud victimization[41]. Thus, reconfiguring neural representations of hierarchy may be adaptive. In neuroimaging experiments that probe basic cognitive functions, reconfiguration based on task elements can be quantified using multivariate tools. Some evidence indicates a role of the dorsolateral prefrontal cortex (dlPFC) in this flexible reconfiguration[42,43]. As a result, if the representations of social hierarchies are

dissimilar across cooperative and competitive goal contexts, then the neural patterns associated with them should be distinguishable using multivariate analyses.

Experimental Design**:** After completing the fMRI trust game described in Aim 1, the same 35 participants will remain in the scanner while they perform the patent race task, an experiment like the trust game that is well-known in the behavioral economics literature[44–46] and has been used to assess competitive interactions in healthy and clinical groups[47]. During the patent race (**Figure 4**), participants will be instructed that on each of several trials, their decisions will be paired with those made by different past participants. However unlike the trust game in Aim 1, here their partner does not share the same goal but is instead is an opponent. The participant and their opponent compete to develop a new product worth money. At the start of a trial, the participant and their opponent are each endowed with money with one competitor endowed with more than the other. The goal is to invest the minimum amount of money to win the prize. The competitor with the larger endowment could guarantee winning the prize by investing their entire endowment; however, if they believe their opponent may not invest their full endowment because they do not expect to win, they can maximize their earnings by keeping some of their endowment and trying to win the prize with a smaller investment. Knowing this, the lower endowment opponent may be more likely to try and win the prize by investing their full endowment. Participants thus may adjust their strategy based on the strategies they see opponents implementing; one of the things we will test is whether participants pay attention to and learn from the strategies of some opponents more than others To ensure that participants care about their decisions, they are paid from 20% of the trials. As a result, if participants simply invested all of their endowment on each trial, they would miss out on a potentially large actual payout so dynamically changing one's investment makes most sense to ensure the participant earns the highest possible amount of money. Importantly, the look and structure of the task will be like the modified trust game to facilitate comparisons between tasks. After participants indicate how much they wish to spend, their opponent's choices (pre-programmed) are revealed. If the participant spends more money than their opponent, they win the prize and if they spend less money than their opponent, they lose the prize to the opponent. In both scenarios, the participant lost their initial investment. Participants received real payouts from 40 trials. As in the trust game in Aim 1, here asymmetric endowments control transient hierarchy since the player with a larger endowment effectively has more power in the form of an investment advantage over their opponent. Whereas prior iterations of this task paired participants with anonymous opponents, here, participants will be provided with cues as in Aim 1 that signal stable hierarchy. Stable (text cues) and transient (endowments) will independently vary across trials. Importantly, although each decision with a specific opponent is "single-shot" and not repeated, the task can evaluate learning over time from aggregated interactions with high/low stable and high/low transient hierarchy opponents.

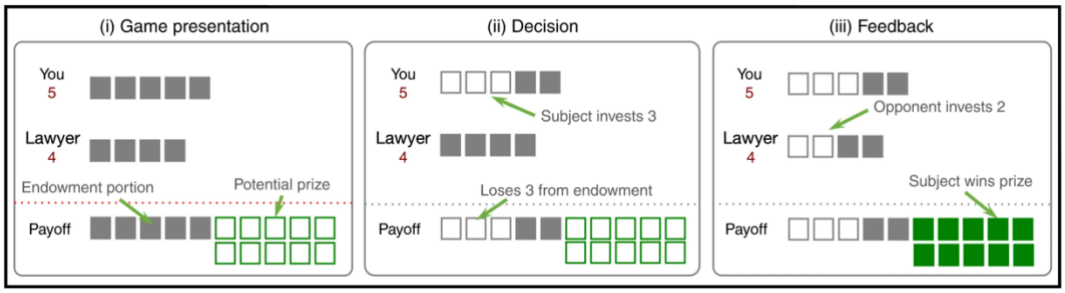

Figure 4. Illustration of the patent race game. Participants compete with others to develop a new product worth a certain amount of money. If the participant spends more than their competitor, the participant wins the product and their remaining endowment and vice-versa with the competitor. If the participant and the competitor invest the same amount, then neither player wins the product. Participants always lose their investment but are instructed that 20% of rounds will be actually paid to incentive them to invest the minimum amount they believe is required to win the prize.

Statistical Power: The fMRI tasks proposed are variants of trust and patent race experiments that have been used by our group[12] and colleagues[14]. In Kobayashi et al., 2022, our lab observed fMRI activation related to traits like warmth and competence during the dictator game in the TPJ (t-statistic = 4.71) and OFC (t-statistic = 4.64) in a sample of 32 adults. Our proposed modified trust game will similarly expose participants to cues about social partners (here, social hierarchy position). In Zhu et al., 2019, our colleagues observed robust fMRI activation associated with learning during the patent race in the striatum (t-statistic = 7.71 bilateral averaged) and mPFC (t-statistic = 5.30) in a sample of 35 healthy adults. Our proposed sample size (N=35) was determined based on those prior effect sizes in equal and smaller samples and is therefore expected to yield similar effect sizes in the trust and patent race games. In fact, social cognition tasks in fMRI experiments show a high level of reproducibility in neural signal at the sample size of N=35 (Pearson r ~ 0.80). Equivalent reproducibility in other

kinds of tasks (e.g., working memory, language, etc.,) require much larger sample sizes (average N>72 across 11 tasks from the Human Connectome Project)[48]. We are therefore confident that a sample of 35 healthy adults is sufficient for the social decision making experiments used in Aims 1 and 2.

Analysis plan: To identify the extent to which participants rely on complex belief learning mechanisms, I will use a variation of the SPW model implemented in Aim 1 to compare the contributions of stable and transient social hierarchy information to learning strategies. Specific tests will evaluate whether participants update their strategies in response to opponents according to stable, transient or a combination of both aspects of hierarchy by evaluating the regression coefficient from a linear model with SPW weights as in Aim 1. Neuroimaging data will undergo the same standard preprocessing before univariate and multivariate analysis used in Aim 1. Univariate patterns will help describe overall simple activations associated with dimensions of hierarchy and multivariate analyses will test whether a pattern in the cognitive representation of hierarchy from ratings is similarly represented in the fMRI data during social learning. Using the same preprocessing and analytical steps for functional MRI in Aim 1, here, representational similarity analysis will be used to identify which brain regions support a multivariate signal that is most like the cognitive representation of hierarchy in an adjacency matrix. Central to this Aim, multivariate decoding will also be used to evaluate whether functional brain patterns across social goals for cooperation versus competition are overlapping or dissociable. Specifically, this will require concatenating the data in Aim 1 with the data here which can then be compared to a hypothesis-based adjacency matrix (sometimes called a conceptual matrix)[49]. Variations of the conceptual matrix can test whether social information related to hierarchy will be the same or different according to the social goal (cooperative or competitive). This analysis will test whether specific brain regions represent social information similarly across goals. We will use another analysis to test whether the entire brain pattern can distinguish experience with hierarchy across the tasks. Specifically, since participants will have completed the trust game with the same structure and trustee/opponent attributes, a within-subject classification analysis will be used to test whether the cooperation and competition can be decoded or separated from the whole brain activation patterns associated with hierarchy in general. Decoding will be implemented using a support vector machine with 10-fold cross validation of the data.

Expected and competing hypotheses: I hypothesize that if humans integrate dynamic social information, then stable and transient dimensions of hierarchy will **both** contribute to learning in a multiplicative/interactive form, applying an extension of the SPW model tested in Aim 1. I also hypothesize that if humans place incentive value on higher status, then, on average, participants will exhibit preferential learning from opponents whose stable hierarchy is rated higher **and** that participants will prefer to learn the strategies of opponents who have equal or larger endowments. Alternatively, participants may place a greater weight on stable hierarchy alone or transient hierarchy alone. These alternatives would suggest that these temporal dimensions are not integrated in social learning and that humans may apply other basic heuristics for social learning. I hypothesize that the cognitive mapping of opponents' status across stable and transient hierarchy will be best explained by regional voxel activations in social cognitive and reward processing regions. If stable and transient hierarchy are independent, then the neural representations will be non-overlapping. Specifically, stable hierarchy will be represented in the mentalizing regions such as the TPJ, STS, and dmPFC while transient hierarchy will be represented in the striatum (with activation centered on the ventral striatum) with contributions from activation in the ACC (due to its role in conflict monitoring) and AI (due to its role in learning about hierarchical differences). I hypothesize that if stable and transient hierarchy are integrated, then their joint representation will be localized in the vmPFC. Alternatively, the absence of a joint representational activation profile would suggest that stable and transient hierarchy are not integrated in decisions. I hypothesize that if participants flexibly update their neural representations of dynamic social information according to social goals, then their representations of social hierarchy from their partners (trustees/opponents) will be dissimilar. Exploratory analyses will test whether this dissimilarity is restricted to the stable or transient hierarchy dimension alone or the joint integration of both temporal dimensions. If evidence in support of flexible updating of neural representations across social goals is present, then the dissimilarity of representations between goals will correlate with activation of the dlPFC due to its role in task switching and flexible reconfiguration.

Aim 3: Linking modulatory mechanisms of hierarchy to everyday social behavior

Rationale: Advancing our understanding of the use of dynamic social information in daily life requires studying decisions outside the laboratory. This Aim is designed to test the relationship between neural mechanisms of social hierarchy integration and everyday social behavior. Experience sampling methods, such as delivery of daily surveys to participants, can allow researchers to test for the ecological validity of experiments and link

neural mechanisms to measurable mental health outcomes[50,51]. These kinds of associations can identify the specific conditions that might elicit negative affective experiences and poor social functioning. Prior work using experience sampling indicates that emotion regulation strategies (like the suppression of negative feelings) are central to social interactions with asymmetric hierarchy[23]. However, it is unknown what accounts for variation in these affective states. One possibility is that ambiguity in perceived social hierarchy differences might contribute to negative feelings[52]. Here, we will probe the quality of social interactions and emotional experiences associated with them from participants who completed tasks in Aims 1 and 2. Statistical tests will examine the correspondence of neural activation for specific behaviors (e.g. trust in the lab/trust in the real world) and the relationship between interaction-related affect and neural representations of hierarchy.

Experimental design:
The 35 participants who completed the fMRI experiments in Aims 1 and 2 will be enrolled in an experience sampling survey using the daily diary method. Data collection will occur after neuroimaging to prioritize completion of the fMRI tasks. Participants will provide a mobile number to which survey links will be delivered via text message. Over the course of 30 days, participants will receive a text message once per day with a link to a mobile survey. The survey will ask participants to retrospectively indicate whether they had any social interactions that day. If so, they will answer several questions about (1.) the quality of the interaction (positive/negative/cooperative/competitive, etc.,), (2.) the hierarchical identity of the person(s) with whom they interacted relative to their own identity (e.g., employee-employer, etc.,), (3.) their own emotional experience and decisions to suppress negative feelings, (4.) their beliefs about the goals and emotional state of the person(s) with whom they interacted, and (5.) the extent to which they wish to emulate or learn from the behaviors of the person(s) with whom they interacted. Geolocation data will also be collected from smartphones to identify locations and points of interest with high social activity (e.g., parks, grocery stores, etc.,). Participants without a smartphone will be provided with one to answer the mobile surveys. When completing the mobile survey, participants will enter a unique identifier code (provided by the researcher) that will automatically link all of their survey responses online so that data can be combined automatically. We have previously used this method successfully in studies that include a neuroimaging component [53,54].

Analysis plan: Mixed effects regression models will be used to explore associations between fMRI activation and daily social interactions. A region of interest (ROI) approach will be carried out by extracting task-related activation magnitudes from ROIs centered on regions responsible for social cognition (TPJ, STS, and dmPFC), reward valuation (striatum), integration (vmPFC), and flexible switching between goals (dlPFC). Models will test contributions of activation during trust and strategy learning to the self-reported quality of social interactions outside the lab including one's own emotional states and perception of others' emotional states. Initial behavior-only models will test whether specific interaction quality and emotion ratings are related. Interaction models will then test whether activation from ROIs mediate the relationship between interactions with others who vary in social hierarchy and the use of emotion regulation strategies to suppress negative feelings. Typical completion rates for experience sampling studies are around 70 to 80%[55,56]. Although it is common for participants to miss or skip surveys in this design, missing data is not problematic for mixed effects regression analyses[56]. We can therefore anticipate similar statistical results with an average of 21 to 24 (out of 30) responses per participant compared to no missing data.

Expected and competing hypotheses: I hypothesize that if participants believe they are accurate at inferring the emotional and mental state of others, then regions supporting these functions (TPJ and striatum) will be recruited during cooperative and competitive decisions. Specifically, activation from the striatum and social cognition ROIs will be positively correlated with perceived accuracy of one's ratings for others emotional states in daily life. I also hypothesize that if interactions with asymmetric hierarchy increase the likelihood of experiencing negative emotions, then then participants will report using emotion-regulation strategies in their interactions. Further, if participants perceive the hierarchical identity of others to be ambiguous, then their neural representations of hierarchy will be less linear/unambiguous. Here, the degree of ambiguity from neural representations may be related to how well participants regulate their emotions during daily social interactions. Specifically, participants whose neural representations are more linear/unambigious will be better at regulating negative emotions than participants who perceive hierarchies as less clearly defined. If these hypotheses are unsupported, then follow-up hierarchical regressions will test the extent to which task-related neural or behavioral measures alone or together best explain everyday decisions. This will increase our understanding of fMRI measures in ecological validity of social decision making.

PLANS AND STATEMENT OF CO-SPONSORS

A. STATEMENT OF SUPPORT

We are both delighted to serve as mentors for K00 phase of Jaime Castrellon's F99/K00 award. We have been impressed with Jaime's talent and productivity as a scholar for several years now. His burgeoning research program in the neural basis of social decision-making sits at an intersection between the expertise of our two labs that has already led to fruitful collaborations between us. Jaime has the skills, abilities and motivation to successfully complete the outlined training and research plans and move on to an independent faculty position at the highest level, and we are extremely excited to work with him to reach this goal.

As a graduate student at Duke, Jaime started out investigating the relationship between the dopaminergic system and the discounting of rewards according to their associated delay, risk or effort. He began examining dopaminergic function with positron emission tomography (PET), and developed expertise in analyzing PET data and relating it to behavioral and other brain measures. For example, in one elegant study, Jaime demonstrated that D2-receptor availability in the striatum was associated with an enhanced representation of the subjective value of delayed rewards in the ventromedial prefrontal cortex (vmPFC), though not with overall levels of time discounting. One reason this association is of interest is that one of us (Joe) has found that amotivation reduces the fidelity of subjective value signals in the vmPFC during decisions about delayed rewards, without affecting overall discounting rates. In a separate paper published in the *Journal of Neuroscience*, Jaime replicated the lack of association between D2-receptors and behavioral levels of time discounting in a larger sample, but also showed through meta-analysis that there were associations in clinical populations, though in different directions depending on the form of psychopathology. Showing his breadth of thinking, Jaime also undertook and published a meta-analysis of dopaminergic pharmacological experiments in rats, which showed that DAT-blockers reduced while D1- and D2-anatagonists increased discounting of time, risk and effort costs. Overall, leading up to his Ph.D., Jaime has been extraordinarily productive, publishing fourteen papers in total, including three as first author and four as second author. His accomplishments have also led to numerous awards, including an NSF graduate research fellowship, multiple awards from Duke for mentoring, and the best poster award at the Society for Neuroeconomics for two years running (!).

Now, Jaime would like to build on the skills he has acquired in brain imaging and the quantitative modeling of behavior and apply these skills to understand decisions in the social realm. He already started moving in this direction during the latter stages of his Ph.D.; for example, he has two additional first author manuscripts in revision that concern juror decision-making. At Penn, his research plan builds on an area of fruitful collaboration between his two Penn mentors. In a recent study published in *PNAS*, we showed that areas involved in social cognition (e.g., the temporal-parietal junction and superior temporal sulcus) and decision-making (e.g., orbitofrontal cortex, OFC) both represented the perceived traits of others during resource allocation decisions about those others, but that only the latter (i.e., OFC representations) additionally predicted resource allocation decisions. Jaime seeks to build on this work by examining how the neural representation of others' traits during social decisions incorporates both stable and transient characteristics, as well as how these representations are shaped by one's social goals (e.g., cooperation versus competition). This an ambitious and creative, but tractable, set of questions, with a strong potential to move the field forward in an impactful way.

We are confident that we can work together seamlessly to co-mentor Jaime, given that we have already co-mentored a joint postdoc together, Kenji Kobayashi (the first author of the recent *PNAS* study). We will serve complementary roles in Jaime's training. Anna will provide key expertise in the application of computational cognitive neuroscience approaches to social cognition and decision-making, and particularly towards questions concerning the cognitive processes that produce contextual flexibility in social behavior. Joe, having a longer track record of previous trainees moving on to tenure-track faculty positions (six are now faculty), will provide key perspective on the broader professional skills Jaime will need to develop to navigate this transition successfully. Both of our labs provide fertile training ground for advanced functional MRI analysis methods, including representational similarity analysis. We will both meet with Jaime regularly to provide mentorship and guide his research and training, and he will attend both of our lab meetings. Jaime has developed a training plan with concrete, detailed, and easily measurable benchmarks that will guide us together over the next several years. Beyond our labs, Jaime will be able to access rich resources for his professional development;

Penn is a growing hub for interdisciplinary neuroscience research, especially in the domain of decision making, including a new center for the cognitive and brain sciences, mindCORE.

Jaime will have the full support of the resources of both of our laboratories in pursuing this work. In addition to the external funding listed below, as well as pending and planned joint and individual submissions, we both have unrestricted funds from the University of Pennsylvania that can be used to cover Jaime's research costs that are not covered elsewhere. As Jaime's proposed research sits at the intersection of his two mentors, his research program is also clearly unique from ours, and therefore he will be able to continue on this track as an independent investigator with a clear and independent identity and without competition from his mentors.

Jaime has put together a tremendous proposal that will build upon his existing strengths to expand his expertise into new areas critical to his future success as an independent investigator. In our interactions with Jaime, we have found him to be an exceptionally smart, thoughtful, and humble scientist, and he has already amassed an extraordinary record of productivity. For these reasons, we have every expectation that Jaime will use his training not only to the benefit of his own career but for the benefit of scientific progress more generally, and we look forward to contributing actively to this process.

B. RESEARCH SUPPORT AVAILABLE

The co-mentors both run active labs with institutional and external support. The existing funding is sufficient to support the training of Jaime Castrellon.

KABLE LAB

Current

Source	Number	Title	PI	Dates	Amount
NIH/NIA	RF1AG058065	Learning and decision-making in healthy aging and preclinical Alzheimer's Disease	JK & Wolk (MPI)	2017-2022	$1,250,000
Facebook Research		Who is most vulnerable to the persistent negative effects of derogatory misinformation?	JK	2022	$45,000
AE Foundation		Enhancing the ability to build trust through excitatory transcranial magnetic stimulation to the temporal-parietal junction	JK	2022	$272,148
NIH/NIMH	R01MH113565-02	Adolescent neurodevelopment and impaired intrinsic motivation in psychosis risk	Dan Wolf	2018-2023	$2,012,500

JENKINS LAB

Current

Source	Number	Title	PI	Dates	Amount
NSF	n/a	An Interdisciplinary Approach to Predicting Unequal Treatment	Jenkins	2019-2022	$416,718

Pending

Source	Number	Title	PI	Dates	Amount
NSF	n/a	Motives and Mechanisms of Social Information Seeking	Jenkins	2022-2027	$665,530
NIH	n/a	Social Perception and Stress in Intergroup Dyads: Repeated Interactions in a Naturalistic Setting	Jenkins	2023-2028	$1,254,439
Russell Sage Foundation	n/a	Cognitive Load and Mental Simulation in Social Decision-Making	Jenkins	2023-2025	$134,000

B. SPONSORS' PREVIOUS FELLOWS / TRAINEES

KABLE LAB

Previous Fellows/Trainees (Total: 11 postdoctoral, 9 predoctoral; Current: 5 postdoctoral, 3 predoctoral)

Name	Stage	Employing Organization	Position
Joseph McGuire	Postdoctoral	Boston University	Assistant Professor of Psychological and Brain Sciences
Wi Hoon Jung	Postdoctoral	Daegu University	Assistant Professor of Psychology
Matthew Nassar	Postdoctoral	Brown University	Assistant Professor of Neuroscience
Dahlia Mukherjee	Predoctoral	Pennsylvania State University	Assistant Professor of Psychiatry
Nicole Cooper	Predoctoral	University of Pennsylvania	Research Director, Communication Neuroscience Lab

JENKINS LAB

Across my career so far, I have personally mentored 36 trainees, ranging from undergraduates to co-mentorship of postdoctoral fellows, many of whom have gone on to pursue independent research careers. The Jenkins Lab at Penn, which launched in 2018, is currently home to a vibrant group of 1 research technician, 3 Ph.D. students, and 3 postdoctoral fellows, and it shares a 4th postdoctoral fellow with the Kable Lab. We anticipate the graduation of 2 Ph.D. students in the next two years. In my four years as a PI, I have additionally mentored 2 other full-time Research Technicians, both of whom are now enrolled in Psychology Ph.D. programs, and 9 undergraduate independent study or honors thesis students.

C. TRAINING PLAN AND ENVIRONMENT

We have worked together with Jaime to develop a cohesive, well-rounded training plan that is designed to further Jaime's career goal of becoming an independent researcher in social decision neuroscience. This training plan for Jaime's K00 training period aims to broaden and deepen his intellectual, technical, and professional expertise, with three main areas of focus: 1) applying multivariate approaches to the analysis of fMRI data from social decision-making, 2) developing expertise in social cognitive processes and how they interface with social decision making across different social contexts, and 3) his professional repertoire, including mentorship, grant writing, research dissemination, and the academic job search process. The training plan will provide Jaime with opportunities to develop a well-rounded set of skills that prepare him to lead his own research group. With this addition to his current research skill set, Jaime will have a burgeoning research program examining potentially transdiagnostic neurocognitive mechanisms underlying social behavior, and he will have the skills to apply advanced behavioral and brain imaging methods to extend this research program independently. This training plan will also set up him to have an independent research program that is clearly distinct from all of his previous mentors while incorporating some of the strengths from their (our) research.

Mentored acquisition of expertise

1. Technical training in multivariate fMRI analysis. To investigate how transient and stable aspects of social context affect social decisions, Jaime needs to acquire the skills to empirically characterize the representations of social counterparts underlying social decision making. Multivariate fMRI analysis provides a powerful approach to investigate these representations. In Year 1, Jaime will perform new analyses on an existing dataset in the Jenkins Lab that lends itself to multivariate analysis. Dr. Kable and Dr. Jenkins will collaborate to mentor Jaime in this area. We will meet at least biweekly with Jaime to assist him in constructing and implementing Representational Similarity Analyses on this existing data set and, ultimately, in designing and implementing similar analyses in his own studies. Jaime will also have ample opportunities to present his

projects at all stages of development in our lab meetings and receive feedback from members experienced in multivariate fMRI analysis.

To complement our individual mentoring, Jaime will also audit Russell Epstein's advanced fMRI methods course, as well as participate in the monthly joint lab meetings the Jenkins and Kable labs have with several other social neuroscience and neuroeconomics groups using similar methods at Penn and at Temple University, including members of his postdoc mentoring committee Michael Platt and Emily Falk.

2. Conceptual training in social cognitive processes and their interaction with social decision making
Another important goal of the training plan is for Jaime to build his expertise in social cognition. As Jaime aims to examine how transient and stable aspects of social contexts are integrated into social decisions, he needs to develop understanding of the neurocognitive processes of social cognition, including the process through which people make inferences about other people's personality traits and mental states (*mentalizing*) and the ways in which these processes and their outputs impact social behavior. Dr. Jenkins will provide Jaime with mentorship and training in social cognition. Dr. Jenkins is an expert in social cognition and has conducted a number of fMRI studies that lie at the intersection of social cognition and decision making (e.g., Jenkins et al., 2018; Kobayashi et al., 2022; Plate et al., 2022). Throughout his K00 training period, Dr. Jenkins will see Jaime at least biweekly to discuss details of experimental design, data analysis, and data interpretation. Jaime will also present his ideas and projects to post-docs and graduate students in the Jenkins Lab with a strong expertise in social cognition. He will participate in the Jenkins Lab journal roundup to deepen his expertise in the social cognition and social cognitive neuroscience literature, and Dr. Jenkins will work with Jaime to adapt a syllabus through which she has overseen multiple Ph.D.-level mentored independent studies in social cognitive neuroscience so that it is tailored to provide Jaime with a strong foundation in this area. After developing this foundation, Jaime will undertake the writing of a review and synthesis paper that will consolidate his learning and start him on the path of further contributing to the development of knowledge in this field.

Jaime will also be encouraged to attend external workshops and conferences to gain exposure to latest developments and develop a network with colleagues in the social neuroscience field. He will also attend conferences such as SfN and Social & Affective Neuroscience Society (SANS). Dr. Jenkins will provide feedback as he prepares his talks and presentations for these conferences so that he develops the skills necessary to communicate with the broad audience of social cognitive neuroscience. Through these opportunities, Jaime will gain exposure to best ongoing research on social cognition and social neuroscience.

3. Professional development
While the primary focus of Jaime's K00 period will be research, we will also provide him with opportunities to advance his professional development. Drs. Kable and Jenkins will meet with him at least biweekly. While individual meetings largely focus on specific research plans, we will also have biannual meetings specifically to develop, review, and modify Jaime's Individual Development Plan (IDP).

We will also aim to further Jaime's professional development through:

- *Mentoring and Collaboration.* Jaime will mentor at least two undergraduate researchers and/or research coordinators under our supervision. Jaime will also be encouraged to collaborate with graduate students in our labs on topics directly related to the current proposal. Jaime will receive mentorship training through the MindCORE Step-Ahead mentorship training program, and he will participate in the Mind DiVE-IN (Diversity and Equity) program that brings interested students from groups typically underrepresented in science to the Penn campus to learn about Ph.D. programs in the mind sciences.
- *Manuscript Preparation.* The process of preparing results for publication, starting with a review paper in Year 1, will be used to refine Jaime's written communication skills.
- *Oral communication.* Jaime will present his research regularly in his sponsors' lab meetings and give talks in the labs of each of the members of his mentoring committee. He will also be encouraged to present at various opportunities at Penn, including the Penn-Temple Social Neuroscience & Neuroeconomics Meetings, as well as at conferences (especially SfN, SNE, SANS, & SPSP) to develop his communication abilities with broader audiences. Jaime will also attend the D-SPAN conference sponsored by the NIH.

- *Grant-writing.* We will provide Jaime with opportunities to contribute to the grant-writing process, including in the writing of an R21 or similar award within the first three years of his K00 and mentor him through the preparation and submission of a K99/R00 proposal in his third K00 year.
- *Participating in Peer Review.* Jaime will have opportunities to assist his sponsors in reviewing manuscripts, with full attribution, so that he becomes more knowledgeable about the peer review process.

We will also ensure that Jaime is in a position to take advantage of the numerous resources available to postdocs at Penn for training in the responsible conducts of research preparation for the transition into successful independent research careers, including:

- *Responsible Conduct of Research.* As part of the annual training organized by the Neuroscience Graduate Group, the Kable and Jenkins Labs dedicate two lab meetings per year to the discussion of the responsible conduct of research.
- *Ethical Research Practices.* Regular talks and seminars at the Penn campus are offered by the Center for Neuroscience and Society, led by cognitive neuroscience faculty member Dr. Martha Farah. Recent events have focused on the implications of neuroscience for law, ethics, politics, economics and education.
- *MindCORE Professional Development Series*. Jaime will attend professional development workshops series hosted by MindCORE, an interdisciplinary program established to catalyze new research on the mind and foster innovative collaborations between departments at Penn (directed by Dr. Kable and of which Dr. Jenkins is a faculty affiliate). Recent topics include navigating the academic job market, negotiating a job offer and starting a lab, and grantsmanship.
- *Biomedical Postdoctoral Programs (BPP) Career Workshop Series*. Professional development workshops are also offered through the BPP, which is supported by the Perelman School of Medicine. Topics covered in these workshops include academic job searches and applications, scientific writing and peer-review, applying for grants, and laboratory management.

Jaime is not expected to teach any courses, nor have any clinical or administrative obligations, during his K00 training phase. To help develop his mentoring skills, he will be provided with opportunities to mentor junior researchers in projects directly related to the current proposal, but the majority of his training time will be protected for the proposed research.

Timeline and transition to independent research

Given the need for training, Jaime's first K00 year will be primarily dedicated to mastering new techniques of multivariate fMRI analysis and developing expertise in social cognition, which he will accomplish by performing new multivariate analysis on an existing fMRI dataset and writing a review paper, which he will submit in Year 2. In Years 2 and 3, Jaime will carry out the proposed new data collections and apply computational modeling and multivariate fMRI analysis, resulting in two additional manuscript submissions (one each for Aims 1 and 2). Between Years 3 and 4, Jaime will prepare job application materials and a K99/R00 proposal. In Year 4, he will submit the final manuscript resulting from the proposed work for consideration for publication. We have no doubt that these efforts will have a strong impact on the fields of cognitive, decision, and social neuroscience. Jaime is fully licensed to take with him all aspects of the projects described in the proposal to his own lab. He will also be permitted to take copies of the data that he has collected during the K00 period and use them as pilot data in his independent grant applications.

Job market preparation. By the end of the K00, Jaime will have developed a strong set of skills and knowledge in social decision making, social cognition, and multivariate fMRI analysis, with a strong foundation of professional skills. We are confident that this broad skill set, coupled with his already highly productive record, will make him a competitive applicant for tenure-track research position at top research institutions. To further that cause, we will assist Jaime in the preparation of this job application materials, and help prepare for interviews by providing him with opportunities to sit in on presentations and chalk talks from prospective job candidates at Penn. He will also have the opportunity to practice his job talk in different environments (e.g., Psychology, Neuroscience, Psychiatry, and the Business school). This will help prepare him for the interview processes and strengthen his ability to find a tenure-track academic research position. As he approaches the job market cycle, we will also provide him with opportunities for conference presentations to help him promote his work to a broad audience.

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University of Pennsylvania
3620 Walnut Street
Philadelphia, PA 19104-6220
215-898-7041

Emily Falk, Ph.D.
Director, Communication Neuroscience Lab, University of Pennsylvania
Associate Dean for Research, Annenberg School for Communication
Professor of Communication, Psychology, Marketing, and Operations, Information and Decisions
falk@asc.upenn.edu
Phone: 215-869-8873

July 18, 2022

Dear K00 Review Committee,

I write in enthusiastic support of Jaime Castrellon's NIH Blueprint D-SPAN K00 application. I plan to be part of his advisory committee member for his project titled "Neural mechanisms of sustained and transient hierarchy on social decision making."

My laboratory is focused on investigating social, cognitive, emotional and neural mechanisms of behavior change. Much of our work has specifically investigated interactions between social cognition and decision making using functional neuroimaging and experience sampling methods—all of which are central aspects of Jaime's proposed project. Since my lab is in a shared space with his sponsor Dr. Joseph Kable, and since I serve on multiple committees with with other primary mentor Anna Jenkins, interactions between Jaime and members of our team will be natural, facilitating our ability to communicate and advise on aspects of his project. We look forward to having Jaime give research talks in our lab to gain feedback from our expertise as he progresses through the K00 fellowship.

Further, I am happy to provide Jaime with the career advice and professional support necessary for him to become a successful, independent research and tenure track faculty member. as part of his Advisory Committee.

Sincerely,

Emily Falk, Ph.D.
Director, Communication Neuroscience Lab, University of Pennsylvania
Associate Dean for Research, Annenberg School for Communication

Professor of Communication, Psychology, Marketing, and Operations, Information and Decisions

Michael Platt, Ph.D.
Director, Wharton Neuroscience Initiative
James S. Riepe University Professor
Department of Neuroscience, Perelman School of Medicine
Department of Psychology, School of Arts and Sciences
Marketing Department, the Wharton School
University of Pennsylvania
mplatt@pennmedicine.upenn.edu

Dear Jaime,

I am delighted to provide a letter of support for your F99/K00 D-SPAN fellowship from NINDS, which extends the support you received in your last year in grad school at Duke working with my former colleagues Greg Samanez-Larkin, John Pearson, and Pate Skene to a postdoctoral research fellowship to work with my current colleagues Joe Kable and Anna Jenkins at Penn. I work closely with both Joe, as a colleague and collaborator, and Anna, as a mentor.

As you know, my own work focuses on the neurobiology of social decision making, in both nonhuman primates and humans. Your proposed project, titled "*Neural mechanisms of transient and sustained hierarchy on social decision making,*" which uses fMRI in combination with social learning and decision making experiments in humans to study how perceived dimensions of social hierarchy modulate basic processes that drive preferences for fairness and competitive learning strategies, aligns nicely with multiple NIMH-funded research projects in my lab. These projects use a combination of fMRI and EEG in humans and intracranial recordings in monkeys to uncover the neural mechanisms that integrate information about social hierarchy into computations that drive social decisions. This consilience will synergize our respective projects and help to create a broader intellectual community around the themes of social status and decision making, with important potential impacts on health and society.

I will be happy to serve on an informal postdoctoral advisory committee to lend my experience as a scientist, mentor, and administrator. I can advise on the delicate arts of professional development, including applying faculty positions, and negotiating a startup package. As a faculty member, I have mentored scientists for 22 years, and 18 of my prior trainees have successfully advanced into faculty positions and manage their own labs. Based on my experience, I fully anticipate that you will achieve the same success.

Best wishes,

Michael L. Platt, Ph.D.
James S. Riepe University Professor
University of Pennsylvania

Perelman School of Medicine
University of Pennsylvania

July 18, 2022

Dear K00 Review Committee,

I am pleased to write in support of Jaime Castrellon's NIH Blueprint D-SPAN K00 application and to highlight my role as an advisory committee member on his project titled "Neural mechanisms of sustained and transient hierarchy on social decision making."

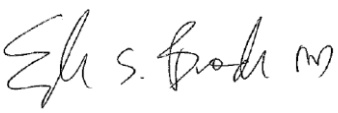
My laboratory is focused on investigating the neurobiology of social behavior. Much of our work has specifically examined disruptions to social cognition and affiliative social behavior across psychopathologies including autism spectrum disorder and schizophrenia. To achieve this, my lab uses behavioral and genetic tools in both humans and mice to identify specific circuits involved in adaptive social functioning. In addition, I direct the Autism Spectrum Program of Excellence and the Adult Autism Spectrum Program (both in the Perelman School of Medicine here at Penn).

Jaime's proposed K00 research program focuses on understanding how temporally-defined aspects of social hierarchy can modulate neural and cognitive mechanisms of social preferences and strategic learning. I am particularly interested in this proposal because of the potential to extend the investigations in clinical groups. In this area, especially, I will be able to provide expertise and guidance as he seeks to characterize neural circuits supporting the ability to integrate complex social information with learning and decision making. Since this project aligns with my lab's goals, Jaime is also welcome to share this research through talks in our lab to gain feedback from our expertise as the project evolves.

Further, I am enthusiastic to provide Jaime with career advice and professional support as part of his Advisory Committee. Jaime has high potential to become a successful, independent tenure-track research faculty member.

I wish Jaime all the best with this exciting application!

Sincerely,



Edward S. Brodkin, M.D.
Associate Professor of Psychiatry
Director of the Adult Autism Spectrum Program
Perelman School of Medicine at the University of Pennsylvania

Daniel Swingley, PhD
Professor of Psychology
Chair, Department of Psychology

July 19, 2022

Dear K00 review committee:

As the chair of the department of Psychology at the University of Pennsylvania, I am pleased to write this letter in support of Jaime Castrellon's application for the NIH Blueprint Diversity Specialized Predoctoral to Postdoctoral Advancement in Neuroscience (D-SPAN) Award (F99/K00). Jaime joins us in the Department of Psychology after receiving his Ph.D. in Psychology and Neuroscience from Duke University. He will complete his postdoctoral training (K00 phase) in the labs of Dr. Joseph Kable and Dr. Adrianna Jenkins. His research will focus on how social hierarchy modulates basic neural and cognitive processes engaged in decision making.

Dr. Kable and Dr. Jenkins have unparalleled combined expertise in decision making, neuroeconomics, and social cognition. Both mentors have the resources and expertise required to guide Jaime on his project, and a dedication to mentorship that will provide Jaime with excellent scientific and professional training. In addition, the Department of Psychology will provide Dr. Castrellon with the facilities, equipment, laboratory/office space, administrative support, and other resources that he will require for the successful completion of his training and research at Penn. Beyond these resources, the University of Pennsylvania is an intellectually rich environment for young scientists. Jaime will benefit from the numerous scientific talks and workshops that occur on campus regularly, including many in the area of his proposed research. During his training as a full-time postdoctoral fellow in the labs of Dr. Kable and Dr. Jenkins, Jaime will be released of all non-research activities, including teaching and administrative duties, for the duration of the K00 award. He will commit a minimum of 75% of his time to research and the remaining time to professional development and career advancement. Jaime will have access to the numerous education and professional development resources offered at Penn. In addition to the travel to the Society for Neuroscience conference funded through the D-SPAN fellowship, funding to support other conference trips will be available through Dr. Kable's and Dr. Jenkins' faculty research funds and innovation funds sponsored by the University of Pennsylvania.

Together with his mentors, Jaime has developed a detailed research and professional development plan for the K00 phase of his award. Based on his successful research and publication record thus far, I am confident that Jaime will be able to complete the work proposed

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in his application. I am pleased to offer Jaime the full support of the Department of Psychology during his time as a postdoctoral researcher at the University of Pennsylvania. If you have any further questions, please don't hesitate to reach out to me.

Sincerely,

_____

Daniel Swingley
Chair, Department of Psychology
University of Pennsylvania

RESPECTIVE CONTRIBUTIONS

The ideas and general research program have been developed primarily by the applicant in collaboration with sponsors Dr. Joe Kable and Dr. Adrianna Jenkins. The research proposal was developed through an iterative process between the applicant and the sponsors. The applicant developed the initial draft of the proposal and subsequently made revisions according to suggestions from the mentorship team. The training and mentorship plan was developed collaboratively between the applicant and sponsors. Together we have prepared a training plan that will allow me to accomplish my research goals while acquiring the necessary technical and conceptual knowledge and engaging in professional development.

Mentorship Team	Role and Objectives
Joseph Kable (University of Pennsylvania, School of Arts and Sciences)	**Sponsor,** will provide mentorship in human neuroimaging methods and statistical analysis, overall project management, access to the research population and data, career advisement, mentorship training, manuscript and grant preparation, and will meet weekly with the applicant. The applicant will also meet with Dr. Kable and Dr. Jenkins together at least bi-weekly to discuss specific progress on the proposed research.
Adrianna Jenkins (University of Pennsylvania, School of Arts and Sciences)	**Sponsor**, will provide mentorship in conceptual knowledge of social cognition and social neuroscience, experimental design, access to research population, manuscript and grant preparation, career advisement, and will meet weekly with the applicant. The applicant will also meet with Dr. Kable and Dr. Jenkins together at least bi-weekly to discuss specific progress on the proposed research.
Dr. Emily Falk (University of Pennsylvania, School of Arts and Sciences, Annenberg School for Communication)	**Advisory Committee Member** on K00 phase studies of social decision making, will provide consultation on the implementation of experience sampling tools and integrated fMRI analysis. The applicant will consult with Dr. Falk in preparation for identifying tenure-track faculty positions to ensure that the institutional environment is optimal for interdisciplinary research. The applicant will meet with Dr. Falk as needed and will convene a meeting with all postdoctoral advisory committee members together at least twice per year.
Dr. Edward (Ted) Brodkin (University of Pennsylvania, Perelman School of Medicine)	**Advisory Committee Member** on K00 phase studies of social decision making, will provide consultation on the optimization of studies for potential expansion in clinical populations. The applicant will consult with Dr. Brodkin in preparation for identifying tenure-track faculty positions to ensure that the institutional environment is optimal for potential clinical research. The applicant will meet with Dr. Brodkin as needed and will convene a meeting with all postdoctoral advisory committee members together at least twice per year.
Dr. Michael Platt (University of Pennsylvania, Perelman School of Medicine and Wharton School of Business)	**Advisory Committee Member** on K00 phase studies of social decision making, will provide consultation on the conceptual interpretation of research findings in light of his experience studying the neurobiology of social decision making in non-human primates. The applicant will consult with Dr. Platt in preparation for identifying tenure-track faculty positions to ensure that the institutional environment is optimal for neurobiology research. The applicant will meet with Dr. Platt as needed and will convene a meeting with all postdoctoral advisory committee members together at least twice per year.

RESPONSIBLE CONDUCT OF RESEARCH

Proposed Training

RCR training requirements will be fulfilled at Penn through online training and single- and multi-session lectures/seminars (face-to-face). Of relevance are the courses offered through Penn's Knowledge Link and seminar series offered through the Perelman School of Medicine. The seminar series offered through the School of Medicine occur monthly. The online courses offered through Knowledge Link are instructor led courses. I plan to participate in face-to-face seminars and online courses on RCR each semester.

Format:

Formal: Formal RCR instruction includes the online Collaborative Institutional Training Initiative (CITI) program in RCR and face-to-face RCR educational sessions 1 and 2 (**8 contact hours**). The online CITI RCR course is completed once. The face-to-face programs (which are led by faculty members) must be completed during each career stage (i.e., postdoctoral) at a minimum of once every four years. The RCR formal courses will be completed during the first year of the K00 award period. The online CITI RCR course is to be completed during the first year of fellowship appointment. RCR sessions 1 and 2 can be completed in any order during the first or second year.

- RCR Session 1: Responsible Authorship and Publication Practices, Collaborative Science, Peer Review, Mentoring, and Current Topics (**4 hours**)
- RCR Session 2: Researcher in Society, Research Misconduct, Conflicts of Interest, Data Management: Acquisition, Sharing and Owneershop, Intellectual Property, and Research Safety (**4 hours**)

Informal: Informal RCR is continuous learning about research that occurs in the course of daily research team interactions, mentored and peer discussions, and in other scholarly interactions throughout training experience. This includes lab meetings, seminars, journal clubs, and conferences. The Office of Academic Training and Outreach Programs offers guidance and additional resources to support research faculty and trainees in the development of informal RCR educational experiences.

Subject Matter: Course material covers the following topics:

- Review of Authorship, Publications, and the Peer Review Process
- Collaborative Science
- Conflicts of Interest and Commitment
- Data Acquisition, Management, Sharing, and Ownership
- Mentor and Trainee Responsibilities
- Peer Review
- Research Involving Animal Subjects
- Research Involving Human Subjects
- Research Misconduct
- Researcher in Society
- Safe Laboratory Practices
- Unconscious Bias

MRI Safety. I will be trained in the safe and responsible use of MRI in human subjects research by Dr. Kable and Dr. Jenkins. Both labs have standard operating procedures for minimizing risks and properly responding to any potential adverse events. This is relevant to the protection of human subjects in the proposed research.

Faculty Participation:

My proposed training in the responsible conduct of research will occur mostly in the form of one--on-one and small group discussions with my faculty mentors Dr. Kable and Dr. Jenkins. Through weekly meetings (in addition to lab meetings), we will discuss best practices in data collection, management, and ethical publication practices, and minimization of bias in the research process. On average, I expect to have at least one hour of training in the responsible conduct of research per week, throughout the entire award period.

DESCRITION OF INSTITUTIONAL ENVIRONMENT AND COMMITMENT TO TRAINING

The University of Pennsylvania will provide the ideal institutional environment for Jaime to pursue the research and training goals outlined in this K00. Specifically, the Center for Cognitive Neuroscience (CCN) is home to world--renowned faculty, plentiful educational and professional development opportunities, and state-of-the-art facilities and resources. Penn is committed to fostering Jaime's mentored training.

Center for Cognitive Neuroscience

As detailed in the Facilities & Other Resources attachment, the Center for Functional Neuroimaging (CfN) within the CCN at Penn is a state-of-the-art neuroimaging center, which provides administrative and technical support to all users of the MRI scanning facilities. The CfN is comprised of investigators and staff with broad range of expertise in neuroimaging including regulatory affairs, MRI methods development, MRI physics and pulse programming, instrumentation, experimental design, computing, and image analysis procedures. Jaime has full access to the resources of the CfN.

The CfN also runs a high-performance computing cluster. The two CfN data analysis clusters house a total of 12 public workstations connected to 40+ CPUs running 32--bit x 86 (Linux) gigabit networking within each lab with a high-speed fiber connection between the two labs. There is 21.5 terabyte online disk storage in 3 RAID arrays, with backup via a 24--slot LTO Ultrium--3 tape library for periodic full backups and nightly incremental backups. There is also a 10--slot SDLT tape library. This allows researchers to perform intensive data analysis efficiently. Given Jaime's interest in the computationally intensive MRI analyses outlined in this proposal, this cluster—and all the software that is available on it—will be a very valuable resource.

For the behavioral testing outlined in this proposal, both Dr. Kable's (Sponsor) and Dr. Jenkins' (Co-Sponsor) lab suites are equipped with several experiment rooms and computers with stimulus presentation software installed.

Jaime has already been given two office spaces. One office is shared with another postdoctoral researcher, at the CCN (located within Richards Medical Research Laboratories building). This office neighbors the offices of Dr. Kable. Another office is a private space within Dr. Jenkins' lab (and next to her office) located within the Solomon building, home to the Department of Psychology. Dr. Jenkins is an expert in social cognition and social decision making and has a lab funded by the University of Pennsylvania and the NSF. These offices are a short walk from each other. At the CCN, Jaime is also surrounded by other cognitive neuroscience faculty, with research interests that overlap with his, including:

- Dr. Joseph Kable (Sponsor) is an expert in the cognitive neuroscience of decision-making and has an excellent record of publication, teaching, and mentorship. He has a well-funded lab, with grants from NIH and NSF.
- Dr. Emily Falk studies the neuroscience behind how messaging can be used to instill behavior change. She and Dr. Kable host a social neuroscience journal club monthly, which Jaime will participate in.
- Dr. Michael Platt, a professor at the Wharton School of Business whose lab space is at the CCN, has started the Wharton Neuroscience Initiative, which will provide an array of new resources and training opportunities in this research area. For example, there is a lecture series featuring visiting professors (e.g., MacArthur Fellow Dr. Colin Camerer), and a conference on the intersection of neuroscience and marketing.

PROTECTION OF HUMAN SUBJECTS

Risks to Human Subjects

A. Human subjects involvement, characteristics, and design

For the experiments described in this proposal, we will recruit approximately 35 participants for neuroimaging and 300 participants for online surveys to supplement analyses. Neuroimaging participants will be recruited from the Philadelphia community and online participants will be recruited from the nationally representative Amazon Mechanical Turk (mTurk) workforce, without regard to gender, ethnicity, or race. In previous neuroimaging research at the Center for Cognitive Neuroscience (CCN) at Penn, 50-60% of subjects have been women and 30-40% of subjects have belonged to an ethnic or racial minority group. Subjects may be excluded from fMRI if they (a) have metal or other implants in their body that are contraindications for MRI, (b) might be pregnant, or (c) are claustrophobic. Individuals may also be excluded from the study if they have a prior history of major psychiatric disorder or any history of neurological disorder, such as stroke, epilepsy, or multiple sclerosis.

B. Source of materials

Behavioral data consisting of choice and reaction time measures will be obtained from all subjects across all the proposed research studies (trust game and patent race game). Self-report questionnaire data will also be collected (Social Dominance Orientation, MacArthur Scale of Subjective Social Status, Economic System Justification, General System Justification, SPARQ Perceived Discrimination) along with basic demographic information (age, gender, race/ethnicity, income, etc.,). For the experiments in Aims 1 and 2, functional MRI data will be obtained. For the experience sampling surveys in Aim 3, mobile surveys and geolocation data (if available on mobile device) will be collected. All paper forms will be kept in a locked filing cabinet in the Sponsor (Dr. Joseph Kable's) laboratory. All digital data from behavioral, fMRI, and mobile experience sampling studies will be kept on password-protected computers. Digital data will also be backed up on to CD or DVD, and these backup media will be stored in a locked cabinet in the Sponsor's laboratory. Only the PI, Sponsors (Dr. Joseph Kable and Dr. Adrianna Jenkins), and study personnel will have access to the data. All paper and digital data will be labeled with ID numbers and made anonymous. The key linking ID numbers with identifiers (name and contact information) will be kept separately from participants' data, with access restricted only to the PI and study personnel.

C. Potential risks

MRI: The known risks associated with MRI are minimal. The radio waves and magnetic fields, at the strengths used, fall within the FDA guidelines and are judged to be without harm. Because the magnetic field of the fMRI scanner attracts metal, the greatest risk is a metallic object flying through the air toward the magnet and hitting the participant. Most people do not find an MRI scan uncomfortable. However, on occasion some subjects have reported mild discomfort. The MRI machine is noisy, because of the knocking and beeping sounds that resonate when the magnetic gradients are pulsed. Also, some people have reported feeling claustrophobic in the MRI machine. Finally, due to the rapid rate of change of the magnetic gradients during imaging, the possibility exists for peripheral nerve stimulation. If this happens, subjects may feel a tingling or twitching sensation, typically along their arms or legs. This sensation is temporary and stops when the scan ends. Although there are no known risks of MRI on pregnant women or a fetus, there is a possibility of yet undiscovered pregnancy--related risks. Since pregnant women receive no direct benefit from participating, we will exclude pregnant women from this study.

INCLUSION OF WOMEN AND MINORITIES

Our subject population will include women and minorities. Young and middle-aged adult participants will be recruited from the University of Pennsylvania community and the greater Philadelphia region. Since we will recruit without regard to gender, race or ethnicity, the composition of our subject population will reflect the demographics of these communities. Historically, our subject population has included approximately 50-60% women and 30-40% minorities. We feel that the diversity of Philadelphia will make it possible to include both women and minorities in the numbers listed in the planned enrollment table. In fMRI studies, women who are or who may be pregnant are excluded. Generally, this does not compromise our ability to enroll 50% or more women in fMRI studies.

INCLUSION OF INDIVIDUALS ACROSS THE LIFESPAN

At present, we do not have plans to include subjects younger than 18, for the following reasons:

1) Some experiments in the current proposal involve collecting fMRI data. Subjects in these experiments must maintain concentration for an extended period of time, while lying still in an extremely small space without moving their head. Although young children have been studied with fMRI, there are a number of practical difficulties in scanning small children (e.g., excessive motion, inattention) that are particularly problematic with longer scanning sessions.

2) There are developmental differences between younger children and young adults in flexible decision-making. The functions of prefrontal cortex (PFC) and temporoparietal junction (TPJ) may likely be quite different in young children, who are still undergoing connectivity and myelination changes in the frontal lobe.

Although the inclusion of young children is beyond the scope and feasibility of the current proposal, several promising lines of investigation involving children could follow from this research. Subsequent proposals could compare the function of the PFC and TPJ in the integration and representation of social information in decision making in young adults, adolescents and younger children.

At present, we also do not have plans to include subjects older than 40. Since aging is well-known to alter both the circuits involved in reward sensitivity, learning, and positive affect related to decision making, we will limit our inclusion to only younger and middle-aged adults to reduce inter-subject variability and increase statistical power. Future iterations of the project can potentially evaluate age-related differences as older adults are likely to differ from younger adults in the use and integration of complex social information in decision making.

RECRUITMENT AND RETENTION PLAN

We will recruit participants through an online system for paid human subject experiments maintained by MindCORE (Mind Center for Outreach, Research and Education) at the University of Pennsylvania. We have been using this system (and its predecessors) for over a decade to successfully recruit diverse samples of young and middle age adults, and hundreds of employees and students of the University of Pennsylvania and members of the surrounding community are aware of and participate in the system. If necessary, recruitment will be supplemented by posters around the local community or print or online advertisements. Younger adult participants may also be recruited through the Psychology Department's subject pool of undergraduate students.

Since experiments in Aims 1 and 2 are collected in a single testing session, we do not anticipate any issues with retention between neuroimaging experiments. Aim 3 data collection does not require an in-person visit and can be set up remotely since the goal is to capture natural daily behaviors.

PHS Inclusion Enrollment Report

OMB Number: 0925-0001 and 0925-0002
Expiration Date: 10/31/2018

This report format should NOT be used for collecting data from study participants.

***Study Title (must be unique):** Neural mechanisms of sustained and transient hierarchy on social decision making

* Delayed Onset Study? ☐ Yes ☒ No

If study is not delayed onset, the following selections are required:

Enrollment Type ☒ Planned ☐ Cumulative (Actual)

Using an Existing Dataset or Resource ☐ Yes ☒ No

Enrollment Location ☒ Domestic ☐ Foreign

Clinical Trial ☐ Yes ☒ No **NIH-Defined Phase III Clinical Trial** ☐ Yes ☒ No

Comments:

Racial Categories	Ethnic Categories									
	Not Hispanic or Latino			Hispanic or Latino			Unknown/Not Reported Ethnicity			Total
	Female	Male	Unknown/ Not Reported	Female	Male	Unknown/ Not Reported	Female	Male	Unknown/ Not Reported	
American Indian/ Alaska Native	0	0		0	0					0
Asian	2	1		0	0					3
Native Hawaiian or Other Pacific Islander	0	0		0	0					0
Black or African American	6	6		1	1					14
White	6	6		2	2					16
More than One Race	1	1		0	0					2
Unknown or Not Reported										
Total	15	14		3	3					35

To ensure proper performance, please save frequently.

RESOURCE SHARING PLAN

The proposed research will include behavioral and MRI data from healthy adults. For the sake of reproducibility and transparency we will publicly share all deidentified data and analysis code for the proposed studies on the Open Science Framework (OSF). The applicant has a well-documented history of sharing data and code on OSF (osf.io/582bx). Our brain imaging data will be in BIDS format for easy sharing to public repositories (e.g., OpenNeuro). The labs of sponsors Dr. Joseph Kable and Dr. Adrianna Jenkins have a history together of publicly sharing raw neuroimaging data this way (OpenNeuro Dataset ID: ds004128).