



# INSTITUTE OF COGNITIVE SCIENCE ARPAC 2019 SELF-STUDY REPORT

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## Q.1 - UNIT OVERVIEW

*Task: Please provide an overview of the unit, including a summary of the resource requests justified elsewhere in the reporting.*

### MISSION AND HISTORY

Founded at the University of Colorado Boulder in 1968, the mission of the Institute of Cognitive Science is to **identify and address key questions in cognitive science**, building on our expertise in cognitive neuroscience and artificial intelligence. Over the last seven years, our research has contributed both basic and applied knowledge in cognitive development, brain health and wellness, cognitive modeling, emotion detection and processing, education and training, educational technology, and speech and language processing. The Institute operates in partnership with nine academic departments: Psychology and Neuroscience, Computer Science, Linguistics, Education, Philosophy, Integrative Physiology, Architecture and Planning, Information Science, and Speech, Hearing and Language Science (SLHS). The Institute's community is broad and intellectually diverse, encompassing nearly 240 faculty, students, staff and other research personnel, many from our partner departments and other units.

The Director of ICS is Professor Tamara Sumner (Department of Computer Science). Prof. Sumner is the third Director to serve since the Institute's inception; she began this position in July 2016. Prof. Sumner is working to strengthen the Institute's sustainability, and to expand our capacity in interdisciplinary collaborations, computational methods, and public impact and engagement. Prof. Marie Banich (Department of Psychology and Neuroscience) was the Institute's second Director (2004-2016). She led the incorporation of cognitive neuroscience into the Institute as well as the establishment of the Institute's neuroimaging and research laboratory facilities. Prior to this, Professor Walter Kintsch (Department of Psychology) served as the Institute's Director for over 30 years. He established the Institute's commitment to interdisciplinary approaches and the participation of affiliated faculty from other units, he oversaw the hiring of the Institute's first faculty in artificial

intelligence and human-computer interaction, and he established our strong research program in educational technology, blending psychology, computer science, and the learning sciences.

## CURRENT RESEARCH PORTFOLIO AND RESEARCH CENTERS

The Institute of Cognitive Science managed a rolling grant budget of \$24.7 million in FY 2018, with annual research expenditures averaging \$6.2 million per year between 2012 and 2018. These research expenditures are currently focused in three main areas:

- **Learning and Education:** Theories, interventions, and innovative applications supporting human learning, sometimes augmented by artificial intelligence and machine learning, across a wide variety of learning and working environments
- **Brain Health and Wellness:** Basic and applied research on the neural basis of emotions, pain, and addiction, combined with the development of innovative frameworks and applications supporting new wellness therapies and interventions
- **Cognition and Development:** Basic and applied research into adolescent brain development, language processing, and decision-making

Increasingly, we are using data-intensive research methods involving large quantities of data and/or multimodal data (brain, physiology, speech/text, performance), which provides rich opportunities for us to build on and expand our capacity in machine learning, natural language processing, and other computational methods.

Our research is carried out by faculty and students in individual labs, interdisciplinary project teams, and through four interdisciplinary research centers hosted by the Institute:

- The Intermountain Neuroimaging Consortium (INC)
- The Center for Research and Education Addressing Cannabis and Health (CU REACH)
- The Center for Research on Training
- Inquiry Hub: A Research + Practice Partnership with Denver Public Schools

ICS has an exceptionally strong track record in translational research and innovative ‘research + practice’ partnerships. Translational research emphasizes generating broader societal impacts and applications from basic science more quickly and more effectively than traditional basic versus applied approaches. Hallmarks of translational research include multidisciplinary teams, interdisciplinary perspectives and skills, iterative methodologies that interleave basic and applied research, and strong

partnerships with outside stakeholders such as doctors, teachers, learners, and businesses. ICS translational research and research + practice partnerships have generated educational interventions and technologies that have been used and studied in hundreds of schools and school districts, computational systems and algorithms that have been spun-off to new commercial applications and companies, and insights into cognitive impairments and disabilities that have led to new forms of treatment and interventions.

## ACADEMIC PROGRAMS

The Institute of Cognitive Science offers two Combined PhD Programs and two Graduate Certificate Programs that provide exceptional breadth and depth of interdisciplinary training in the cognitive sciences:

- [Cognitive Science Combined PhD](#) <sup>1</sup>
- [Cognitive Neuroscience Combined Triple PhD](#) <sup>2</sup>
- [Cognitive Science Graduate Certificate](#) <sup>3</sup>
- [Human Language Technology Certificate](#) <sup>4</sup>

Students in good academic standing in the graduate programs of partner units are eligible to participate. Successful completion of an ICS program is acknowledged by a Certificate of Completion on the student's transcript. The PhD programs are noted on the student's diploma.

Undergraduates enrolled in programs offered by our partner units are eligible to participate in our interdisciplinary undergraduate studies:

- [Undergraduate Certificate in Cognitive Science](#) <sup>5</sup>

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<sup>1</sup> <https://www.colorado.edu/ics/graduate-programs/cognitive-science-combined-phd>

<sup>2</sup> <https://www.colorado.edu/ics/graduate-programs/cognitive-neuroscience-triple-phd>

<sup>3</sup> <https://www.colorado.edu/ics/graduate-programs/cognitive-science-graduate-certificate>

<sup>4</sup> <https://www.colorado.edu/ics/graduate-programs/human-language-technology-certificate>

<sup>5</sup> <https://www.colorado.edu/ics/graduate-programs/human-language-technology-certificate>

## ICS COMMUNITY

ICS currently has over 240 participants, including faculty, staff, fellows, and students (see Figure 1). The Institute has 8.5 Tenured and Tenure Track Faculty, including 3.5 professors with tenure homes in Psychology & Neuroscience and 5 with tenure homes in Computer Science. Our 9 Research Professors contribute additional expertise in learning sciences, speech and language processing, speech and hearing sciences, human-computer interaction, and clinical psychology. The Institute draws on the considerable interdisciplinary breadth of our affiliated faculty (46 Fellows) from over a dozen different departments and units across campus. In 2018, we employed 57 students, almost half of them as Graduate Research Assistants embedded in our research enterprise. We also have 63 students currently enrolled in our educational programs. Our community is supported by a small but dedicated staff (5.5 FTE) who perform grant management, facilities management, human resources, communication, and academic program administration.

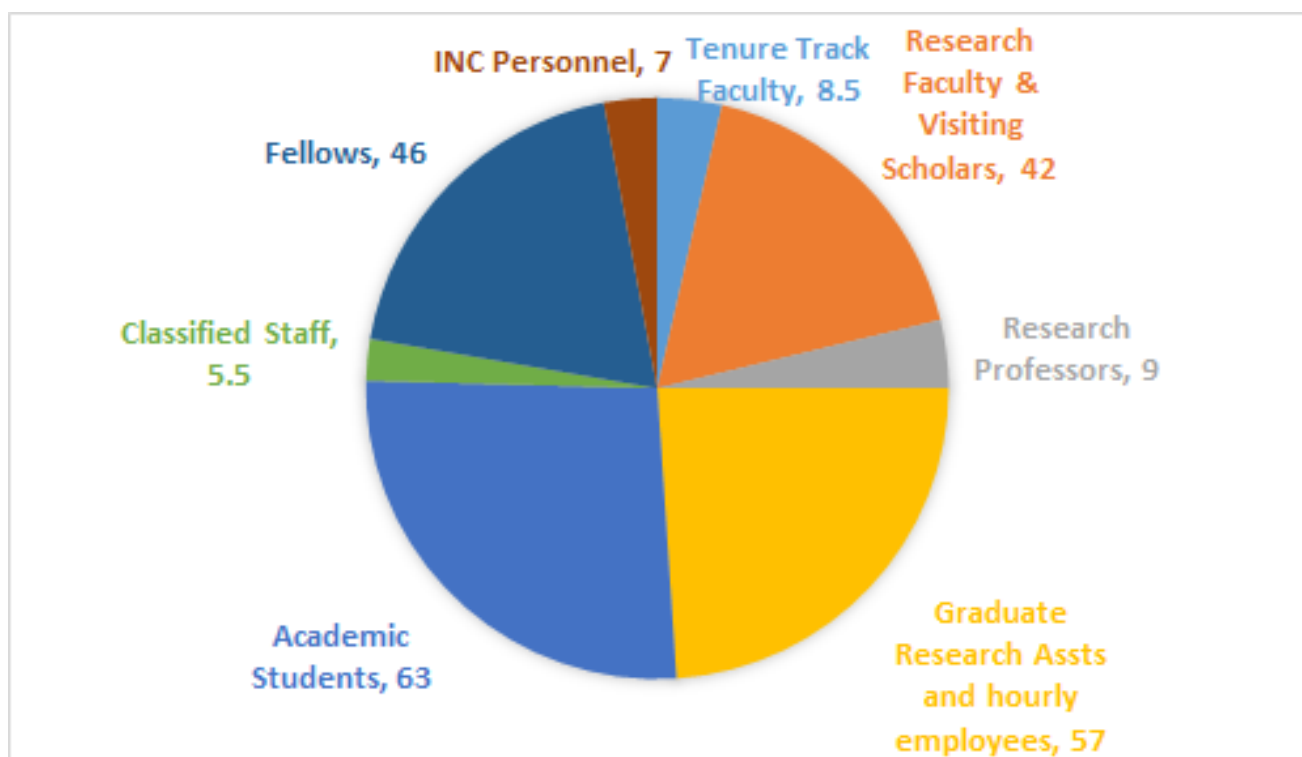


Figure 1. ICS Community Participants

## FACILITIES

The Institute's facilities include 4427 sq. ft. of office space, classroom facilities, and meeting rooms located in the Muenzinger Building on main campus, as well as 20,163 sq. ft. of research laboratory space in the Center for Innovation and Creativity (CINC) located on the east campus. Acquired by ICS in 2005, CINC provides office space, computer labs, neuroimaging facilities, experimentation rooms, conference rooms, server rooms, and networking facilities. ICS led an initiative, in partnership with the Department of Psychology and Neuroscience, to acquire a state-of-the-art Siemens 3 Tesla MRI scanner to support cutting edge neuroimaging research. This new research facility became operational in summer 2011, and the scanner was upgraded in 2016.

## INSTITUTES @ CU

The Institute of Cognitive Science is one of 11 Institutes on the CU Boulder campus. Institutes are the University's major engines for interdisciplinary research and are expected to be funded largely through their research programs and research partnerships. Combined, the 11 research institutes at CU account for more than half of all sponsored research dollars at the university (\$511 million in expenditures last year). Institutes differ from departments in important respects, which have implications for several of the areas reported on in this self-study:

- The tenure homes for Institute faculty reside in affiliated departments. Thus, our promotion and tenure policies, and as well as our faculty mentoring processes are designed to support and augment those in our affiliated units.
- Institutes cannot admit students. We partner with affiliated units to recruit students to the university and our programs, and we work with our affiliated units - who often have different processes and procedures - to manage students' overall academic progress through our educational programs.
- Institutes cannot directly list courses or offer standalone degrees. Our certificate and degree programs are designed to augment and extend those provided by our partner units. We partner with our affiliated units to cross-list and manage our courses, which has implications for how student credit hours and resulting tuition revenue is computed



## SELF-STUDY PROCESS

This self-study reflects the period from 2012 to 2018. Professors Tamara Sumner, Donna Caccamise, and James Martin chaired the self-study process and were assisted by the ICS Executive Committee, ICS staff, other ICS faculty and fellows. The self-study collected information from community members through a variety of processes and forums: a university-administered climate survey, an institute-administered space survey, strategic planning sessions, a student town hall, and faculty meetings. Over the last year, the ICS Executive Committee led important changes and updates to our policies and procedures: leading a major revision of our bylaws, establishing a new inclusiveness policy, and developing new procedures and rubrics supporting tenure track and research professor merit review. Members of the ICS Executive Committee also organized and convened strategic planning sessions and student town halls. A broad and diverse group of Institute faculty, staff, and members contributed to leading discussions, gathering data, and authoring the many sections of this self-study: Alaa Ahmed, Marie Banich, Cinnamon Bidwell, Jean Bowen, Christine Brennan, Donna Caccamise, Sidney D'Mello, Alan Dale, Yasko Endo, Peter Foltz, Alice Healy, Jennifer Jacobs, Matt Jones, Catherine Latzer, James Martin, Shannon McKnight, Robert Rupert, Steve Sommer, Tamara Sumner, Katie Van Horne, and Karli Watson. The first version of the self-study was made public for a 10 day period of open review and community commentary, followed by a formal review by the ICS faculty at a specially convened faculty meeting. Documents requiring significant revision were made available for a second round of community review. After additional revisions, the resulting self-study documents were reviewed and approved by the ICS Executive Committee prior to final submission. Specifically, the Executive Committee voted unanimously (Vote: Yes - 8; No - 0; Abstain - 0) to endorse the following statement:

*This self-study report was generated through a transparent community process whereby meetings were held to obtain specific input and ideas from stakeholders, various ICS members and writing teams produced multiple drafts that were available for comment by the entire ICS membership for several weeks, and the final version reflects all of these inputs. We, the ICS Executive Committee, endorse this process and its outcome: ARPAC 2019 ICS Self-Study Report.*

## SUMMARY OF REQUESTS TO THE UNIVERSITY OF COLORADO BOULDER

The enactment of our strategic plan is a joint responsibility shared by ICS leadership, the ICS community, the Office of Research and Innovation, and relevant university leadership. Enacting this plan will require additional resources to be jointly contributed by responsible parties. Table 1 lists our requests with suggestions for cost sharing across responsible parties. Detailed rationale for these

requests, including measures, are provided in Q2. Strategic Plan as well as other sections in the self-study.

Resource	ICS	RIO/University
Educational Program Administration & Learning Outcomes Assessment	0.5 FTE	0.5 FTE
Inclusion, Diversity and Equity Coordinator		0.25 FTE
Marketing, Communications and Outreach Specialist	0.25 FTE (ICS) 0.25 FTE (INC/Inquiry Hub)	0.25 FTE
Faculty Growth Plan	Develop, fund and execute plan that includes new tenure track faculty lines in partnership	
CINC Space Remodel and Growth Plan	Develop, fund and execute plan in partnership, which needs to include provisions for reliable transportation between CINC and main campus.	
Other items outlined in the strategic plan such as seed funding for research or course development	ICS leadership will work with faculty and the executive committee to identify opportunities for self-funding these items, finances permitting	

**Table 1. Resource Requests**

## ADDITIONAL REQUEST RATIONALE

Since our inception over 50 years ago, the University has provided the Institute with support for 1.6 administrative FTEs. Base level of support for administration has not changed during this period, while at the same time the Institute has grown, the university is asking more of administrative staff and processes, and we have added educational programs to meet student demand. There have been vast increases in the scope and complexity of CU's administrative and compliance processes for human resources, grant management, and other functions over the past 50 years. Additionally, the university is asking units to take on new tasks important for student success, such as learning outcomes assessment, as well as cultural transformation activities to promote inclusion, diversity and equity. To comply with



new administrative processes and to support these new activities, we are requesting RIO/University to provide the Institute with additional annual support for a staff FTE to be deployed across the categories shown in Table 1.

- ICS currently provides 0.5 FTE administrative support for our educational programs and will continue to do so. However, our educational programs need to be staffed to the level of an entire FTE to ensure student success, comply with university mandates such as learning outcomes assessment, and to expand access to our programs. We cannot self-fund to this level as we don't receive tuition revenue from our courses. We request that the university match our support (0.5 FTE) for these interdisciplinary educational programs that serve students across nine departments and four colleges.
- ICS is ready to contribute to the CU IDEA plan and to transform the Institute into a campus leader supporting inclusion, diversity and equity. As detailed in Q14 (Inclusiveness), we have identified activities to be performed, the coordination support needed, as well as a highly skilled individual to lead this effort. To move forward, we need financial support for a 25% FTE administrative position for someone with a graduate degree, leadership and management experience, and experience working with a broad range of individuals and building collaborations across campus.
- Over the past two years, RIO has established industry and community outreach and collaboration to be an important activity across campus. Academic Futures discusses our positioning as a public university with a responsibility for creating and sharing knowledge with the public. To support these new campus-level strategic objectives, the Institute needs to expand our science communication and outreach capacity. We have recently developed a cost sharing arrangement between ICS and two of our Centers to support a 0.5 FTE marketing, communications and outreach specialist. We request that the university match these contributions (0.25 FTE) to enable us to expand our capacity to 0.75 FTE.

We are requesting to develop a faculty growth plan with RIO/University that includes support for two tenure track faculty positions to be phased in over the next three years in strategic growth areas. As detailed in Q3 (Interdisciplinary Research and Scholarship), our track record and evidence suggests that each faculty line would yield robust research expenditures: our per capita FTE productivity by active grant dollars over the last seven years was \$807,942. This succession planning timetable is also necessary to ensure vitality and sustainability as many of our faculty head towards retirement.

We are requesting to develop a plan for expanding and remodeling our CINC facility (excluding the neuroimaging facility) over the next 2-4 years in partnership with our landlords, RIO/University and Facilities. This plan is necessary to support continued growth in our research personnel and lab facilities, as well as to make the existing space more useful and usable for our changing needs and

changing technologies. Our CINC facilities have not been updated since 2005. And, as detailed in Q9 (Space), since the reprogramming of the RTD Stampede bus route in Fall 2018, there are no bus services supporting transportation between CINC and main campus. This is hindering our ability to recruit students, to teach courses on campus, to participate in campus-based events, and to provide equitable access to our facilities to all our community members.

- *Prepared by Prof. Tamara Sumner on behalf of the Institute of Cognitive Science*



## Q.2 - STRATEGIC PLANNING

*Task: Please describe the unit's strategic goals and aspirations, linking them to the priorities set by the chancellor and the provost.*

### MISSION

Our mission is to identify and address key questions in cognitive science. Through interdisciplinary research and education, we explore the nexus of humans and machines as we seek to understand and extend human cognition, machine intelligence, and fruitful collaborations between the two. Our research builds on artificial intelligence, cognitive neuroscience, human learning, and emotional processing to tackle some of society's most pressing challenges: understanding brain health and wellness, developing personalized therapies and interventions, enhancing and deepening human learning, and optimizing complex cognitive processes to improve human performance and collaboration.

### VISION

Our vision for the coming period is to:

- Be a campus leader in innovative, interdisciplinary research
- Be a campus leader in inclusiveness, diversity, and equity
- Reimagine our interdisciplinary educational programs
- Develop a robust resource engine to support future growth

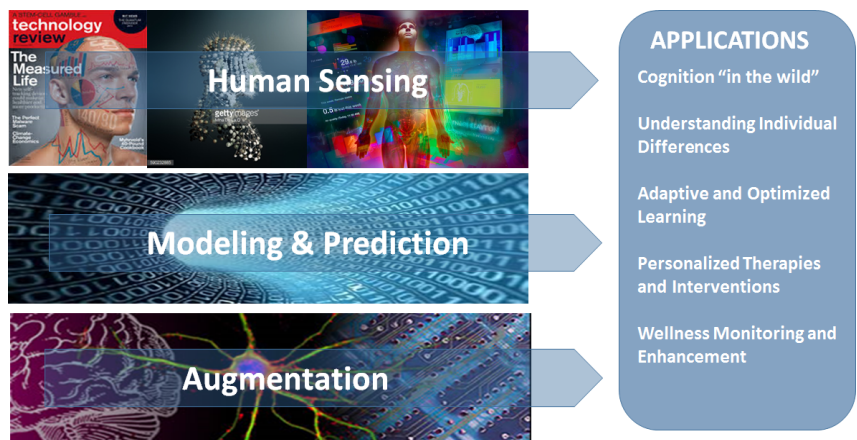
## INTERDISCIPLINARY COGNITIVE SCIENCE @ CU: OUR NEXT CHAPTER

We have identified several opportunities for building on our current expertise, computational skills, and technological trends:

**Cognition in the Wild.** Cognition in the wild refers to the complex and realistic mental activities that people engage in every day: at work, in school, at home, and when pursuing health and wellness. These activities are embedded in rich, and increasingly technologically-augmented, physical and social environments. Our cognitive processes are embodied in the sense that they are deeply situated within, and influenced by, the people, tools, and technologies available in these environments. Increasingly, people will expect learning, health, and wellness applications to be dynamically tailored to their individual needs and their social and environmental contexts.

One driver of these profound changes is the Internet of Things, whereby the majority of objects in our environment are enriched with sensors and computation, and interconnected for real-time sensing and communication. One of the objects that is increasingly enriched with sensors is the human body, through smartphones, wearable devices, smart fabrics, ingestible sensors, programmable tattoos, and functional skin. These technologies generate a constant stream of language, environmental, physiological, and behavioral data. New technologies for sensing brain signals and other mental phenomena are increasingly available.

These technologies will rapidly accelerate the shift to data-driven cognitive science, by providing unprecedented access to a rich variety of data streams capturing a broad range of human cognition, learning, and behaviors (Figure 1). Capitalizing on these data streams will require significant advances in our ability to computationally analyze, synthesize and model multimodal data streams spanning a variety of temporal and spatial scales. Neuroimaging studies will perform an important validation role by ensuring that data collected in the wild correspond in a principled and scientifically valid way to the brain regions and mental constructs identified in the laboratory. Our community has discussed various ways to increase our capacity in this area, including professional development for faculty, fostering new partnerships with other campus units and/or industry, and recruiting new faculty and fellows working in this space.



**Figure 1. Studying and enhancing cognition enabled by new forms of data**

**Neuroscience.** Neuroimaging is a crucial tool for brain mapping and understanding. With the recent upgrade to our neuroimaging facility, we now operate a state-of-the-art facility that is one of a handful in the country with similar capabilities. Our strength in neuroimaging - fMRI, EEG, and fNIRS - can extend and enhance our other areas of research. Avenues for building on our neuroimaging facility and expertise include bringing education and neuroscience together to expand our understanding of learning and cognition, bringing our expertise in neuroimaging and machine learning together to expand our understanding of brain functioning and brain health, and bringing together our neuroscience and computational expertise in emotions to expand understanding of affect and cognition. As we continue to push for translational impact, we will need to expand our partnerships with clinical researchers from Psychology and Integrated Physiology. One challenge we will face is the substantial learning curve associated with fMRI studies; we identified several options for mitigating this obstacle such as focusing on senior hires in this area and/or developing the capacity of our Intermountain Neuroimaging Center to offer turnkey research services.

**Interdisciplinary Partnerships.** The above two areas are not an exhaustive list of our planned research, rather, they describe two pillars of our expertise. Our community recognizes that the third pillar of our expertise is interdisciplinary breadth, and we have a stunning range of expertise and experience across our membership to draw on. We will continue to enhance our capacity to draw on our membership as we build interdisciplinary teams capable of addressing problems that require “deep integration across disciplines”, one of the two hallmarks of convergence research as defined by the National Science Foundation<sup>1</sup>. The other hallmark is solving vexing research problems, in particular, complex problems focusing on societal needs. The following questions illustrate the ‘convergence research’ challenges our interdisciplinary teams can address:

- How does the adolescent brain develop and how is development influenced by genetic and environmental factors?
- How can we combine AI with advances in our understanding of the brain, and innovations in human sensing, to provide early detection, customized treatments, and cognitive augmentation to enhance human mental health and well-being?
- How can we design more engaging, effective, and equitable learning environments? How can AI be used effectively to support and enhance human learning?

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<sup>1</sup> <https://www.nsf.gov/od/oia/convergence/index.jsp>; retrieved Oct. 9, 2018

- What are the neural processes underlying skilled reading? How can adaptive training models be used to teach advanced reading comprehension?
- What brain pathways underlie the generation and regulation of emotion and pain? How does affect and emotion influence our learning and decision-making? Can we develop machines that can reliably detect and characterize human affect and emotions?
- What cognitive factors influence high performance human-human and human-agent collaboration and teaming? How can we design learning and working environments to facilitate effective collaboration and teaming?

## SWOT ANALYSIS

### Strengths

- Built up critical expertise in key areas
- Created the necessary infrastructures

### Weaknesses

- Brittle resource engine based primarily on indirect cost returns

### Opportunities

- New campus initiatives supporting inclusiveness and diversity
- Education opportunities and partners

### Threats

- Retention and growth challenges for faculty and staff in high demand fields

**Strengths.** While the Institute is small in size, we have built up *critical expertise* in key areas and created the *necessary infrastructures*. ICS has a track record in developing and utilizing advanced computational approaches – machine learning, natural language processing, and data mining – to analyze and model structured and unstructured data in order to understand human cognition. Thus, we are already ahead of the curve in terms of preparation and skills for data-driven cognitive science. We have also recently recruited two additional faculty members (D’Mello and Hirshfield) whose expertise in affect detection, non-invasive brain-computer interfaces, adaptive user interfaces, and learning analytics will further enhance our capabilities in this area. We also host the Intermountain Neuroimaging facility which includes a state-of-the-art imaging facility as well as a strong community of researchers.

The Institute of Cognitive Science has also laid the groundwork for transformative future growth through developing significant human, technological, and capital infrastructure over the past decade. We have a suite of talented and creative interdisciplinary tenure track and research faculty, a broad range of faculty fellows from participating units, and a productive and well-functioning staff (*human*).



Our research has advanced science in learning, cognition, and brain health and wellness, with a core emphasis on developing and using innovative computational approaches and neuroimaging to study, model, and support human cognition (*technological*). This research is made possible through our ongoing operation of a state-of-the-art neuroimaging facility and the CINC laboratory facility (*capital*).

**Weaknesses.** A persistent weakness is our *brittle resource engine*. In non-profit organizations, the term ‘resource engine’ refers to a combination of money, time and energy (typically volunteered) that is needed to generate and sustain a robust organization (Collins, 2001). The Institute has relied on indirect cost returns from grant expenditures as our primary source of revenue for the past two decades. Even though the Institute offers courses, certificates, and degree programs, we receive no tuition-derived revenue for these offerings. These programs are supported through our indirect cost returns, which limits our ability to sustain them, much less scale them to meet rising student demand. While our grant expenditures are strong and growing, recent experiences highlight the potential vulnerabilities of relying on this sole income stream. One issue is our dependence on federal research awards; our financial health can be significantly and negatively impacted by a decline in federal research expenditures. A second vulnerability is our dependence on a modest number of highly productive contributors. As a small unit, our finances can be negatively impacted by the departure of a single contributor, particularly if this position goes unfilled for multiple years. Three years ago, these vulnerabilities occurred at the same time and the Institute required a small “bail-out” from the University to support continued operations. While we have since returned to profitability, underlying causes contributing to this fiscal exposure are still present and need to be addressed.

**Threats.** We will need to work closely with the University to *retain our outstanding faculty and staff* in this increasingly competitive employment environment. Our tenure track and research professors are working in cutting edge and high demand areas such as deep learning, emotion detection, brain-computer interfaces, adaptive learning, cannabis and health, neuroscience of pain, etc. Their knowledge and skills make them highly sought after in both academic and industry environments. Timely and competitive retention packages will be critical. We also need to create a productive and welcoming work environment that people are reluctant to leave. This will necessitate a remodel of our CINC research facility in the coming period.

Hiring great talent in high demand areas will also be challenging in this competitive environment. We need to partner with the University to develop a *faculty growth model* to be enacted over the next ARPAC period. Our mission - to identify and address key questions in cognitive science - is central to major, contemporary societal challenges, including navigating the human/machine cognitive nexus, helping humans to effectively learn and retrain, and developing non-addictive approaches for managing stress and mental health. Our faculty have demonstrated both the saliency of cognitive science and its enduring relevance through their ability to consistently secure peer-reviewed sponsored research funding at high levels for the past 30 years. A faculty growth model will enable us to proactively maintain and strengthen this cohort, rather than reactively responding to individual departures, which

can have strong financial consequences in a small unit. Over the next period, we will undoubtedly lose some faculty through failed retention challenges, and over half our current faculty will be eligible for retirement.

**Opportunities.** The Institute has a strong history of supporting intellectual diversity, welcoming faculty, fellows and students that study cognition and intelligence by drawing from a wide variety of disciplines, methodologies, and theoretical approaches. While traditional cognitive science from previous decades focused on human mental representations, our Institute has grown to include brain structure and function; statistical and connectionist machine learning; knowledge representation; emotional processing; as well as situated, embodied, and socio-cultural views of human cognition and learning. As described under *Inclusiveness*, we can build on this history of supporting intellectual diversity and partner with new *campus initiatives* to make our Institute more inclusive, diverse, and equitable.

As an Institute, we have always partnered with other units to provide our educational programs. Our current courses, programs, and student support structures are described under *Interdisciplinary Education*. We will build on our *partnering skills* as we reimagine our educational programs, with the aim of developing approaches that are financially sustainable and can scale to meet student demand. For instance, the Institute has already partnered with the post-baccalaureate program in Computer Science to offer our first online course in Fall 2018: *Machines and Minds*. We have begun discussions with Continuing Education to expand access to this course and to consider how it can contribute to emerging online degree options.

## PLAN

The key actions we will undertake to achieve our vision, and their mutually reinforcing nature, are outlined in the ICS Flywheel diagram below (Figure 2). We will adapt this plan over time based on data described under Demonstrate Results. This approach to strategic planning is adapted from the monograph by Collins, entitled “*Good to Great for the Social Sector*”<sup>2</sup>. Collins advocates an approach whereby an institution connects the key components of their resource engine (time, money, and energy in social institutions) with processes necessary to support achieving the mission (center of flywheel). This approach is appropriate for ICS to use at this time as one element of our vision is strengthening our resource engine. Rather than focusing on individual programs or initiatives, the flywheel model is

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<sup>2</sup> Collins, J. (2001), *Good to Great and the Social Sectors: A Monograph to Accompany Good to Great*, Harper, New York, 38 pages.

intended to outline a set of cyclical and reinforcing activities and outcomes that gradually gather more momentum over time.

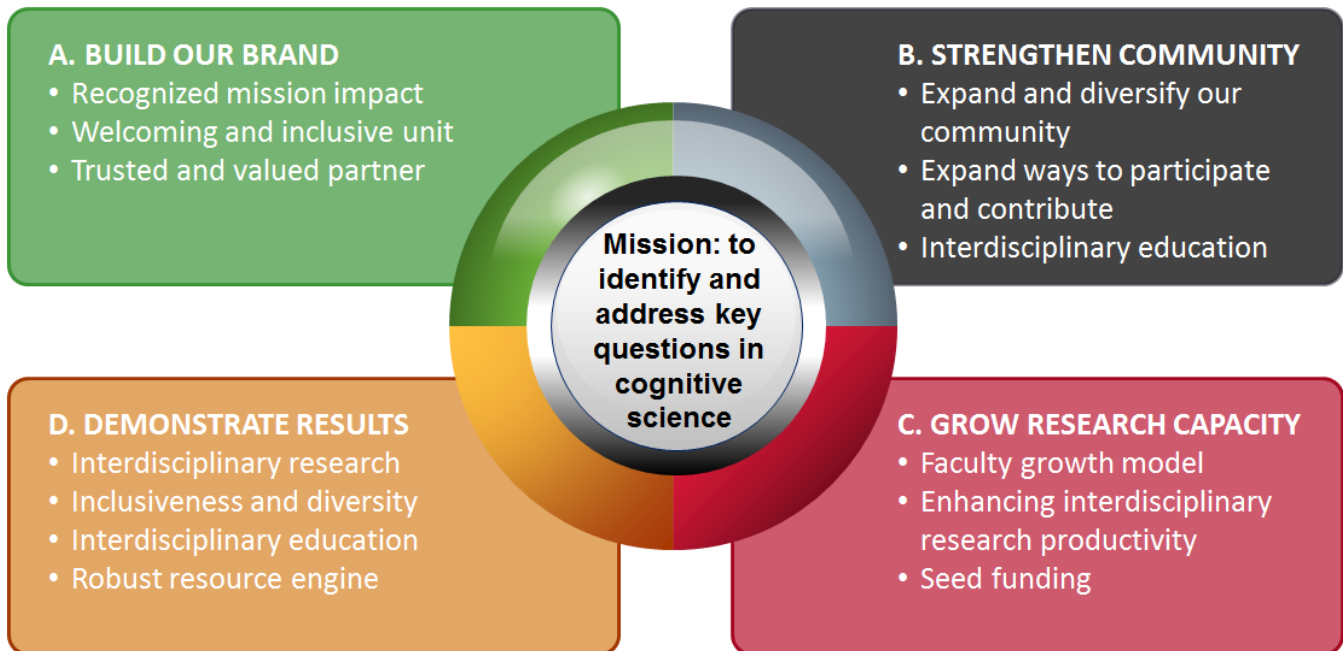


Figure 2. ICS Flywheel, adapted from "Good to Great for the Social Sector" [Collins, 2001]

**A. Build Our Brand.** This component of our flywheel focuses on understanding and improving our relationships, business practices, and communication with partners and the public. These activities will contribute to all components of our vision.

- Recognized mission impact. We will enhance our communication and marketing practices to ensure that we are consistently communicating our mission, vision, and research and education outcomes and impacts to a wide range of audiences, including our community, our affiliated units and partners, the larger CU community, and the general public.
- Welcoming and inclusive unit. As discussed under *Inclusiveness*, we will engage in regular internal assessment, planning, education, and professional development opportunities to continuously enhance diversity, inclusiveness, and equity practices and to ensure that our community is accessible and welcoming to all.
- Trusted and valued partner. As a small unit, it is essential that we work productively with other units on campus and a wide range of partner institutions to achieve our mission and vision. We will refine our communication processes to ensure that our affiliated units and other partners understand the research and education opportunities available to their faculty and students through participating in or partnering with the Institute. We will continue to develop and share

innovative, transparent, and objective business process tools, such as the ICR calculator we jointly developed with Psychology & Neuroscience, to streamline cross-unit transactions and ensure consistent outcomes.

**Resources Needed.** These additional activities are beyond the capacity of our current staffing and budget to pursue. Yet, we believe that they are essential for meeting our vision, particularly the *inclusiveness and diversity* component. Therefore, we are asking the University to partner with us to bootstrap this process by providing three years of support for an additional 0.5 FTE staff. We anticipate half of this being applied towards a marketing and outreach specialist and half being applied towards a ‘diversity officer’ charged with leading our inclusivity, diversity, and equity assessments, education, and other activities.

**B. Strengthen Community.** This component of our flywheel emphasizes building our community and providing a range of ways for members to participate in the Institute and to develop their interdisciplinary research and education capacity. New participants will strengthen and diversify our community; new forms of participation will strengthen and diversify our research and educational programs, and ultimately, our resource engine.

- Expand and diversify our community. Building on our better understandings and practices for creating and maintaining an inclusive and welcoming unit, the Institute will seek out new faculty, fellows, students and partners that contribute to the intellectual vitality and diversity of our community.
- Expand ways to participate and contribute. We will continue to expand options for non-traditional faculty to contribute to the Institute’s research, education and service activities. The Institute is home to many non-traditional faculty - including research professors, research associates, and affiliated faculty fellows - who outnumber traditional tenure track faculty. Participation in our research programs and weekly colloquium are the primary avenues for participating. Recently, we developed a stipend program to support research faculty to contribute to ongoing and occasional service activities. Several of our research faculty made outstanding contributions to this self-study report. As we reimagine our educational offerings, we will develop new ways for our non-traditional faculty, community members and partners to contribute to these offerings.
- Interdisciplinary education. The Institute has begun the process of reimagining our educational programs, after first introducing them 20 years ago. As a first step, we identified several core values that will guide our re-imagining effort: build interdisciplinary capacity, support pedagogical innovation, provide new kinds of teaching opportunities, generate revenue, further our reach, and support translational research. We anticipate two main thrusts for our

‘reimaging’ activities: online learning and advanced interdisciplinary research training. In terms of online learning, we are studying the range of online options and partners emerging as a result of new campus initiatives, and we are conducting pilot implementations with select partners. Each campus initiative has a very different business model and they reach different audiences. As discussed under Interdisciplinary Education, graduate students at the Fall 2018 Townhall generated a range of interesting ideas for enhancing their interdisciplinary research training. We will build on these ideas to enhance our current practices and we will develop an interdisciplinary training grant application to investigate new models and approaches.

**Resources Needed.** In order to grow our educational offerings, both on campus and online, we will need staff support and a viable financial model that allows us to sustain the effort and not be dependent on ICR. Seed funding is needed to support online course development and enhancements. We will need RIO support and advice to navigate the institutional processes and limits for submitting federal training grant applications through CU.

**C. Grow Research Capacity.** This component of our flywheel outlines how we will make progress toward our vision of being a campus leader in innovative, interdisciplinary research.

- Faculty growth model. Earlier in this plan, we discussed the rationale for investing in cognitive science, outlining the intellectual merits and broader impacts that can be realized through our innovative, interdisciplinary research. We also discussed the pitfalls of the current ‘reactive’ approach to faculty growth, which typically results in a zero sum game and can leave a faculty position unfilled for a prolonged period. Establishing a proactive faculty growth model is essential to the long-term vitality of our Institute.

Our tenure track faculty is small in number (8.5, including Director Sumner); yet these individuals function as keystone species within our broader research ecosystem, supporting critical interactions across units, mentoring research associates and graduate students, and leading new research programs and grant initiatives. We anticipate each new tenure track position will increase our research expenditures by \$800,000 annually, allowing for a period during which they build up their lab and their local research network. As detailed in Q3 (Interdisciplinary Research and Scholarship), our track record and evidence suggests that each faculty line would yield robust research expenditures: our per capita FTE productivity by active grant dollars over the last seven years was \$807,942. In addition to being a great investment, we need to start investing in our future to ensure continuity: our current tenure track faculty is top heavy (5 Full Professors, 2 Associates, and 1 Assistant) and maturing, with a potential “retirement cliff” approaching over this next period.

- Enhancing interdisciplinary research productivity. The Institute will continue to refine and implement recommended research-based strategies for creating and sustaining research-productive departments. We are drawing on the excellent work of Bland et al (2005)<sup>3</sup> which integrates an extensive literature review with their own in-depth and longitudinal research on a wide range of departments. As noted in this work, there is no single strategy for guaranteed effectiveness, rather a broad set of strategies needs to be consistently implemented to support cultural change and build research capacity:
  - Research is a clearly-communicated priority
  - Systematically foster rich scientific conversations
  - Identify strategic areas
  - Align rewards and recognition
  - Mentoring and professional development (grant development, technical skills, research methods)
  - Identify leaders and coalesce around them
  - The Institute has focused on making changes to align with these strategies that do not require additional resources.

Towards this end, we have: (1) adopted clear communication of our research priority, (2) worked with our Executive Committee to revamp our merit review criteria and processes, (3) engaged in strategic planning, and (4) held a number of meetups and workshops to foster scientific conversations. Over the coming period, depending upon available financing, the Institute will develop ways to incentivize interdisciplinary research collaborations that lead to successful grant submissions. We also need to update our CINC research facility to accommodate growth and to make the existing space more useful and usable to our faculty, staff, and students (see Space section for rationale).

- Seed funding for pilot studies. Our faculty have identified the lack of seed funding for pilot studies as a serious impediment to interdisciplinary research. An internal source of funding is particularly critical for high risk/high reward interdisciplinary research, which may not cleanly fall into current programs and funding sources. While the CU Seed Grant program is well-regarded, it provides only a small number of annual awards and may be focused on a topic that is not aligned with cognitive science.

**Resources Needed.** We will need university financial commitment to develop and implement a faculty growth model. The Institute will investigate models for financing and implementing seed

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<sup>3</sup> Bland, Weber-Main, Lund and Finstad (2005), *The Research-Productive Department: Strategies from Departments that Excel*, Wiley.



funding. The small program recently implemented by CU REACH provides a promising model. It was started through a philanthropic donation; grantees are expected to repay twice the original grant in order to grow the seed funding pool.

**D. Demonstrate Results.** This component of our flywheel outlines the *measures* we will use to assess and communicate our progress towards realizing our mission. Collins believes that clearly and consistently communicating progress is essential for providing momentum to the social sector flywheel. We will focus on results aligned to the four components of our vision:

- Be a campus leader in innovative, interdisciplinary research. Our measures here will target our ability to grow our research programs, the degree to which we are promoting interdisciplinary collaborations, and the impact of our research. To understand growth, we will track annual research expenditures (total, average), research publications (total, average), as well as change over time. To understand how we are promoting interdisciplinary collaboration, we will disaggregate grant and publication data to characterize the breadth and depth of non-traditional faculty and graduate students participation as well as interdisciplinary collaborations. To understand the impact of our research, we will track: (1) K12 teachers and students impacted; (2) general public impacted through events such as Brain Awareness Week; (3) products produced (e.g., new curriculum, learning environments, tools); (4) research-practice partnerships (schools, districts, industry); and (5) technology/research transfer arrangements. We will also track media coverage of ICS-related research and educational programs, as well as coverage of our faculty, fellows, students and other community members.
- Be a campus leader in inclusiveness and diversity. We will work with our Executive Committee to establish processes for administering a ‘climate and inclusiveness’ survey at regular intervals. These data will be used to monitor changes in our climate and inclusiveness and they will inform periodic updates to our Inclusiveness Policy.
- Reimagine our interdisciplinary educational programs. We will use quantitative and qualitative measures of student success and learning outcomes, similar to those described elsewhere in this self-study. These measures include: (1) students matriculating from our certificate and degree programs; (2) students participating in online courses; (3) graduate research assistants (number supported annually, change over time, post-graduation placements); (4) research assistants and post-docs (number supported annually, change over time, promotions and placements). We will need to refine our measures as we reimagine our educational programs.
- Develop a robust resource engine to support future growth. ICS will continue to improve the robustness of our resource engine through growth and revenue diversification. Revenue diversification aligns with the Chancellor’s goals for the entire campus. We will measure

research expenditures, ICR percent returned to the Institute, and revenue diversification on an annual basis. The flywheel outlines our theory of how to grow our research capacity and portfolio, which should directly impact our research expenditures and ICR return percentage. We are working to diversify our revenue sources by including direct cost returns in low overhead grants, tuition return from online courses, and contributions from faculty, alumni, and the community. We are also expanding our research funding portfolio to include non-federal sources.

- *Prepared by Prof. Tamara Sumner on behalf of the Institute of Cognitive Science.*



### Q.3 - RESEARCH AND SCHOLARSHIP

*Task: Describe the unit's current and proposed contributions in research and scholarship.*

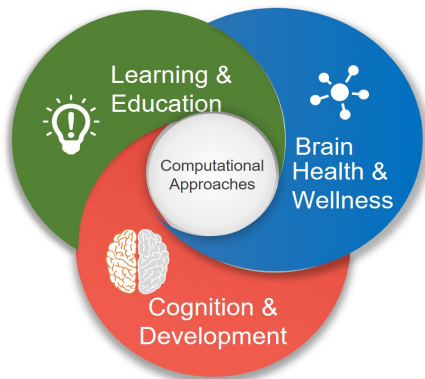
#### RESEARCH MISSION

The Institute of Cognitive Science conducts interdisciplinary research into the science of the mind building on our expertise in cognitive neuroscience and artificial intelligence. Over the last seven years, institute research has contributed both basic and applied knowledge in cognitive development, brain health and wellness, cognitive modeling, emotion detection and processing, education and training, educational technology, and speech and language processing.

ICS is home to over 200 individuals who contribute to its research mission, including 18 full and part-time tenure-track and research professors, affiliated Fellows from other academic departments, research associates, graduate students, visiting faculty, and staff.

In FY 2018, the Institute is managing a rolling grant budget of 55 awards totaling \$24.7 million. Between 2012 and the present, ICS faculty received 102 new grants and subawards, totaling \$60,759,889, and led work on 137 unique grants totaling \$80,794,209. The difference of \$20,044,320 between these two amounts stems from activity on grants that were awarded prior to 2012 but remained active beyond 2012. An analysis of our current grant award portfolio demonstrates that the bulk of our work is focused around three interrelated themes:

- **Learning and Education.** Theories, interventions and applications supporting human learning, sometimes augmented by artificial intelligence and machine learning, across a variety of learning and working environments, as well as environments supporting human and human-machine interactive decision-making.



- **Brain Health and Wellness.** Basic and applied research on the neural basis of emotions, pain, and addiction, combined with development of innovative frameworks and applications supporting new wellness therapies and interventions.
- **Cognition and Development.** Neural basis for executive, emotional, and social processes, as well as applied research into adolescent brain development, and language processing.

Data-intensive computational approaches provide an integrating framework for all of these efforts. These computational efforts involve the storage, analysis and modeling of large and diverse sources of data including brain, physiology, speech/text, and human performance sources, providing rich opportunities for us to build on and expand our capacity in machine learning, natural language processing, and other computational methods.

The following sections are organized around the three research themes described above and led by core ICS Faculty and Research Associates and administered by the Institute. Of necessity, this focus fails to capture the full range of research activities in which the Institute fellows and their colleagues participate across the campus. A complete listing of the grants managed by the Institute during this reporting period can be found on the ICS website. This question examines our research and scholarship retrospectively; our future plans are described in Question 2: Strategic Plan.

## LEARNING AND EDUCATION

A significant portion of ICS research activities are centered around the themes of Learning and Education. In particular, we focus on the interaction of theory, modeling and translational interventions that can support human learning across a wide variety of learning and working environments.

Led by an Profs. Tammy Sumner, Jennifer Jacobs, William Penuel, and Katie Van Horne from CU, and Susan Olozene and Douglas Watkins from Denver Public Schools, the **Inquiry Hub Research + Practice Partnership** began in 2008 as a joint research venture between Denver Public Schools and the University of Colorado Boulder. The mission of this partnership is to design, test, and implement tools and strategies for supporting all teachers in developing rigorous and responsive instruction that can help all students achieve at high levels in mathematics and science.

By rigorous, we mean teaching that (1) engages students with tasks and problems for which there is no ready-made answer and in which students must figure out how to approach them; and (2) engages

students in the disciplinary practices of mathematics, science, and engineering as defined in the Common Core State Standards and Framework for K-12 Science Education (NRC, 2012).

By responsive, we mean teaching that (1) involves elicitation of student ideas, interests, and experiences that are productive starting points for engaging with key disciplinary concepts, and (2) entails use of formative assessments to customize and advance student learning.

This partnership has produced research-based software tools for teachers and students, curriculum and other learning materials, assessments, and professional development models and programs that are being used within Denver Public Schools. Some products created by this partnership, such as the Curriculum Customization Service, subsequently scaled to 6 districts in 3 states (Colorado, Nevada, and Utah). This long-standing partnership has received ongoing financial support from the National Science Foundation (through awards 0734875, 0822314, 1043638, 1118392, 1147590, and 1742053), the Moore Foundation, the Hewlett Foundation, the Spencer Foundation, Denver Public Schools and organizational support from CU, UCAR, and Denver Public Schools.

A continuing thread of research in ICS has been the combination of work in **speech and language processing with educational applications**. Through its participation in the Center for Computational Language and Education Research (CLEAR) and the earlier Center for Speech and Language Research (CSLR), the Institute conducted translation research on interactive intelligent tutoring systems, systems that integrate automatic analyses of student's written work with educational digital libraries, and automated quality analysis of open educational resources. Of note, translational research from these efforts formed the basis for a number of commercial efforts.

Under the direction of Profs. Tammy Sumner, Jennifer Jacobs, James Martin, Wayne Ward and Chenhao Tan, this research thread continues with the NSF-funded Talkback project. This new project is aimed at developing an innovative application for addressing a significant challenge in education: providing teachers with immediate and actionable feedback on their use of effective classroom discourse strategies. The TalkBack application builds on advances in deep learning for natural language processing and speech recognition to automatically analyze classroom recordings and reliably generate information about specific discourse strategies called "talk moves." Talk moves can be used by both teachers and learners to construct conversations in which students share and build on others' ideas, and engage in sustained reasoning. For instance, when teachers revoice an idea posed by a student, press students to provide their reasoning, or ask students how one idea relates to another, they are using talk moves to promote and scaffold student participation in mathematical discussions. Using talk moves to orchestrate classroom discussions is recognized as a critical dimension of teaching, and prior research has established strong linkages between productive classroom discourse and student achievement.

This effort was initiated with an NSF EAGER award (#1600325; Early Stage Research on Automatically Identifying Instructional Moves in Mathematics) and has recently received a 3-year NSF BIGDATA award with additional support provided by Amazon Web Services.

Led by Prof. Michael Mozer, **the human-centric AI group** is committed to studying AI methods that mimic and enhance human capabilities, understand and anticipate an individual's needs, and act in synergistic coordination with individuals. Their work explores the following topics:

- **Cognitively informed AI.** Incorporating insights from human perception and cognition into the design of AI architectures and machine learning methods;
- **Human optimization.** Developing software tools to improve how people learn, remember, and make decisions. For example, one current project is studying how to instrument smart digital textbooks to boost student learning.
- **Cognitive modeling.** Building psychologically grounded models of human cognition that allow us to interpret behavioral and neurophysiological data; and
- **Intelligent environments.** Designing computer interfaces that are smarter, adaptive, and easier to use.

Cognitively-informed AI exploits our understanding of human cognition to improve AI methods. Our complementary research on human optimization draws on AI methods to boost human cognition. An example of this approach is our work on memory optimization. Human memory is imperfect; thus, periodic review is required for the long-term preservation of knowledge and skills. Prof. Mozer and colleagues developed a method for efficient, systematic, personalized review that combines a psychological theory of memory with latent-factor models. Psychological theory characterizes basic mechanisms of learning and forgetting shared among members of a population, whereas latent-factor models use observations from a population to draw inferences about individuals. The method was integrated into a semester-long middle school foreign language course via retrieval-practice software. In a cumulative exam administered after the semester's end that compared time-matched review strategies, personalized review yielded a 16.5% boost in course retention over current educational practice and a 10.0% improvement over a one-size-fits-all strategy for spaced study. Prof. Mozer's team is presently incorporating personalized review into augmented-reality environments, e.g., to teach foreign language terms in situ via labels. With rich data such as gaze and pupilometry, they can better predict the human's state of knowledge. The work in this lab has been funded by NSF awards as well as gifts and awards from industry partners.

Directed by Profs. Michael Eisenberg and Ann Eisenberg, members of the **Craft Tech Lab** conduct research at the intersection of computation and craft materials. This blending can take many forms, including the application of specialized software to aid in the design and construction of crafts (such as mechanical toys and paper sculpture) and in the creation of craft objects with embedded intelligence. A particular focus is on the educational realm – that is, the Craft Tech Lab is especially interested in extending the landscape of children's craft activities.



A current focus of this lab is on a new design medium that integrates traditional papercrafting with mechanical, electrical, and computational components. This multidisciplinary medium places additional layers to the creative possibilities of traditional papercrafting.

This work establishes a foundation for Paper Mechatronics as a medium to enable creative learning and open a further discourse on developing tools and techniques to widen access to exploratory construction, thus promoting creativity. In collaboration with the Concord Consortium, this work is currently funded by the NSF through the following award: *Paper Mechatronics: Advancing Engineering Education Through Computationally Enhanced Children's Papercrafts*.

Directed by Profs. Donna Caccamise and Peter Foltz, members of the **Salsa Lab** conduct research on the development of cognitive theory and its translation to classroom practices as it pertains to reading and writing competencies in K-12 classrooms, with the goal of preparing youth for challenging careers in STEM. The lab's focus is on the cognitive processes associated with deep comprehension and learning derived from texts, and translating these processes into pedagogies that teach students advanced comprehension skills. The projects, including *Summary Street* and *BRAVO*, combine theory with computational approaches to provide classroom learning tools adapted to individual students and AI-based automated scoring tools for assessing and giving feedback on written student artifacts. The latter resulted in a patented capability, licensed by the university and used by millions of students in schools.

In addition, members of this lab created and maintain a website that provides Latent Semantic Analysis (LSA) services that are used by educators and researchers throughout the world to educate students in AI projects that use LSA computational strategies. In addition, researchers use the site to incorporate LSA computation in their ongoing work. The work in this lab has been funded by numerous NSF and IES awards.

Prof. Sidney D'Mello directs the **Emotive Computing Lab**, which conducts basic research on the incidence and influence of socio-cognitive-affective states (e.g., confusion, boredom, mind wandering, joint attention, turn taking) during complex learning and problem solving by individuals and small groups. Through the use of data-intensive techniques such as eye tracking, physiological sensing, computer vision, nonlinear time series analyses, probabilistic graphical models, and machine learning they develop computational models of these states.

These models are then integrated into systems that enhance human performance by intelligently responding to the senses states in real-time. Example applications include conversational intelligent tutoring systems that sense when students are confused or frustrated and respond accordingly and computerized reading interfaces that track mind wandering and intervene to reorient attention. This research is situated in the lab, online, in schools, and in homes, and involves intelligent tutoring systems, educational games, and intelligent interfaces for reading, writing, problem solving, computer programming, and collaboration. Work in the D'Mello lab is supported by awards from the NSF, the

Dept. of Education, the Intelligence Advanced Research Projects Agency (IARPA) and the Walton Family Foundation among others.

D'Mello and his team organized the *20th ACM International Conference on Multimodal Interaction (ICMI 2018)*, which was held in Boulder CO, October 16 to 20, 2018.

ICMI 2018 continued and enhanced the legacy of the ICMI conference series, which serves as the premier international forum for multidisciplinary research on multisensor, multimodal human-human and human-computer interaction and interfaces. The Institute of Cognitive Science was a major sponsor for this conference, and ICS Prof. Sidney D'Mello served as Chair of the conference. This single-track conference featuring three keynotes, 63 technical full and short papers (including 28 oral and 35 poster presentations), two panel sessions, two tutorials, 18 papers presented in two grand challenges, 5 demonstrations/exhibits, a Doctoral Consortium with 12 papers, late-breaking results papers, and 5 workshops with approximately 50 papers. This year, the conference series' rigorous peer review system was modified to promote more interdisciplinary work incorporating behavioral, cognitive, and social sciences, in addition to the traditional technical/algorithmic novelty.

## BRAIN HEALTH AND WELLNESS

Research in the Institute on Brain Health and Wellness is focused on basic research on the neural basis of emotions, pain, and addiction, combined with the development of innovative frameworks and applications supporting new wellness therapies and interventions.

The **Center for Research and Education Addressing Cannabis and Health (CU REACH)** led by Prof. Cinnamon Bidwell, is a rigorous, multidisciplinary center that is devoted to the development of evidence based knowledge regarding the effects of Cannabis. The ultimate objective of CU REACH research is to provide empirical data that will improve lives, in particular the lives of those who suffer from disease states that may be alleviated by Cannabis. Center faculty are diverse, examining the effects of Cannabis at the genetic, molecular, neural, behavioral, and dynamic social systems levels of analysis.

The CU REACH community currently conducts research in four mutually-supporting areas: *Cannabis* plant genomics and chemical analyses, biomedical pre-clinical and clinical research, risk reduction, and information science. In the past year, the CU Boulder research community has received almost \$15 million in federal (NIH) and Colorado state funding for groundbreaking research in these areas, and there are an additional \$12 million in grants currently under review.

This year CU REACH and ICS sponsored the peer-reviewed poster session at the CORE Network conference on *Cannabis Research Perspectives* at CU Boulder in November, 2018, which was a forum of national and international presentations on cutting edge cannabis research. In addition, one of the

Center's founding members, Dr. Kent Hutchison was invited to speak at the Congressional Biomedical Research Caucus. Members have been interviewed throughout the year in the popular press, including in the Daily Camera, WIRED magazine, and Canadian Public Radio.

Under the direction of Prof. Christine Yoshinaga-Itano, the **Marion Downs Center Research Lab** focuses on research and training for the development of diagnosis and intervention strategies for infants and children who are deaf or hard of hearing. Their research includes children with normal hearing and children with other communication disorders. The Rehabilitation Engineering Research Center (RERC) grant activities sponsored by NIDILRR (National Institute of Disabilities and Independent Living Rehabilitation Research) are developing new methods for investigating the neural bases of auditory spoken language, including cortical auditory evoked responses for detection of sound, but with a primary emphasis on infant speech discrimination measurements, attention, memory, and language development.

The goal of the center is to do basic research activity that is translatable to clinically applicable techniques that can be used with children who are deaf or hard of hearing, children with normal hearing and children with other communication disorders. RERC research also participates in the development of new algorithms for LENA SP technology that is currently used with children who have communication disorders including deafness and hearing loss, for child initiated conversational turns with parental responses, signal to noise ratios, and duration of speech utterances measured in syllables per utterance.

Research activities funded by Disability Research Development Center (DRDC) through the Centers for Disease Control focus on epidemiological data monitoring the cognitive, language and social-emotional development of infants with newly identified hearing loss through universal newborn hearing screening, identification of predictors, development of interventions and measurement of effectiveness and efficacy of these interventions. Both cross-sectional and longitudinal datasets have been collected.

Prof. Tor Wager directs the **Cognitive and Affective Neuroscience Laboratory** which examines the neural systems that process and interpret pain, both physical and emotional. He then examines how such systems are altered in individuals who have chronic back pain, fibromyalgia, or who are susceptible to placebo effects. Prof. Wager's group has applied advanced machine learning methods to imaging data to identify a pattern of brain activity that scales up with the degree of pain an individual feels and which has been validated across individuals. As such, the greater the degree to which someone's brain activity matches the pattern, the greater is their pain. Prof. Wager speaks extensively around the world and has served on the board of one of the main neuroimaging organizations in the field, the Organization for Human Brain Mapping. This research is generously funded by the National Institutes of Health as well as private donors.

## COGNITION AND DEVELOPMENT

The portion of the ICS portfolio related to **cognition and development** investigates the neural basis for executive, emotional, and social processes, as well as applied and clinical research into adolescent brain development, and language processing.

**Prof. Marie Banich's directs the Intermountain Neuroimaging Consortium**, the campus' neuroimaging center, which was created under the auspices of ICS just after the last program review. Prof. Banich leads a large research group focused on understanding the neural systems that allow an individual to guide their behavior in a purposeful manner and in the face of distraction. She then examines how such systems may be disrupted or altered in individuals with tendencies toward anxiety and depression, and in youth with learning disability. Prof. Carter's research uses computational models of fMRI data to understand how the brain represents social information and how those representations affect decision making. To measure the effectiveness of this multidisciplinary approach, his lab targets two specific applications: 1. How can the neural mechanisms underlying social cognition can be leveraged to tailor treatment of social communication disorders? and 2. How can we shape social influences to encourage the safe exploration of risk?

Of note, a significant portion of this research involves creating tools and methods derived from machine learning to apply to brain imaging data to provide important insights into neural mechanisms. Prof. Banich, while not creating such methods, uses them in her work. This aspect of the research performed at ICS is notable because these methods allow patterns of brain data to be used in a *predictive* manner, rather than in the typical correlational manner. For example, Prof. Banich has used such techniques to determine the degree to which individuals can indeed clear their mind of thoughts, a question that is not at all trackable by behavioral methods (i.e., You can't be sure that someone has actually stopped thinking of something simply by asking them). In this research, machine learning techniques are used to identify patterns of brain activity associated with certain visual categories (e.g., fruits). If someone has indeed successfully cleared the thought of a category, the pattern of brain activity for that category should not be observed.

Notable among the research efforts in this area is the inclusion of CU Boulder, which was selected through a highly competitive process, as one of the sites for the unprecedented Adolescent Brain Cognitive Development (ABCD) Study funded by the National Institutes of Health and the Centers for Disease Control and Prevention. This 10-year longitudinal brain-imaging and behavioral study will enroll over 11,000 9-10 year olds to understand normative brain development and a multitude of factors that may influence it (social milieu, exercise, experimentation with substances, parenting styles, etc). Of note, this study (PIs Marie Banich and John Hewitt) and numerous other brain imaging studies at ICS involve a collaboration with the Institute of Behavioral Genetics, as they involve a focus on imaging twins so as to disentangle genetic and environmental effects on the neural systems involved in various psychological phenomena.

Visibility of the cognitive neuroscience program at the Institute is also reflected in numerous other ways. Prof. Banich serves as Editor-in-Chief of *Cognitive, Affective, and Behavioral Neuroscience*, a broad-ranging journal published by the Psychonomic Society, one of the leading organizations in the area of Psychological Science.

Under the direction of Profs. Al Kim and Phillip Gilley, work in the **Language and Cognition Lab** examines the basic neural processes underlying skilled reading. Reading is a pervasive part of modern human life, and impaired reading is highly detrimental to scholastic and professional success. In spite of its importance, the neural processes that enable skilled readers to comprehend multi-word combinations remain poorly understood. In our research, we use cutting edge neurophysiological methods to understand how the brain generates and uses predictions about upcoming words, guided by prior linguistic context. These predictions support the fast pace of normal reading by allowing the brain to prepare in advance for anticipated text before it arrives in the retinal input. Predictions are also crucial to the ability to perceive words accurately in the face of impoverished inputs, such as conditions of poor lighting, print quality, or visual acuity. The research in this project is expected to produce knowledge that guides the identification of reading disorders and distinctions between different sorts of disorders, which can in turn guide clinical and pedagogical approaches to reading disorders.

Under the direction of Prof. McKell Carter, the **Social Neuroscience and Games (SNaG) lab** focuses on basic and translational research of social influences in decision making. Nearly every aspect of human behavior, from eating to working to reproduction, depends on being able to fluidly communicate with others and predict their behavior (for examples of how a social context can change decision making. The SNaG lab is working to understand the neural mechanisms by which social contexts change our decision making by having people play games with one and other. The lab uses a combination of behavioral and functional magnetic resonance imaging experiments to tease apart the contributions that different brain regions make to decisions that involve someone else. Experimental participants are asked to play games to test cognitive models of healthy and disordered social function. Their work often requires the development or adaptation of computational tools for work on neuroimaging datasets.

## CENTERS AND FACILITIES

The Institute houses four research centers, which we define as long-term research partnerships involving multiple, interdisciplinary faculty with shared research agendas and/or facilities: The Intermountain Neuroimaging Consortium (INC); the CU Center for Research and Education Addressing Cannabis and Health (CU REACH); the Inquiry Hub Research + Practice Partnership (iHUB), and the Center for Research on Training (CRT). Consonant with changing CU practices

regarding Center authorization, only the CRT is formally authorized as a Center at CU. CU REACH and Inquiry Hub have been described earlier; here we focus on INC and CRT.

The **Intermountain Neuroimaging Consortium** provides a key capability that spans many of our research efforts. The INC brain-imaging facility enables novel research collaborations and funding awards between faculty in other departments and institutes at CU Boulder and the Institute of Cognitive Science, including the Institute of Behavioral Genetics, the Department of Integrative Physiology, and the School of Engineering. By developing and maintaining strong partnerships with Research Computing, INC enables researchers using its facility to develop and implement novel computational approaches in their study of brain function. INC also provides an important training opportunity for CU undergraduate and graduate students and post-doctoral fellows to learn brain imaging methods.

In its seven years of operation, imaging-related grants at INC brought in nearly \$30,000,000 in funding to the University. INC is also a regional facility used by scientists at institutions across the Front Range, including: Colorado State University, the University of Denver, the University of Colorado Denver, the University of Colorado Anschutz Medical Campus, and the National Institute of Standards and Technology. These collaborations enhance the ability of ICS faculty to conduct brain imaging research, by bringing in additional expertise and opportunities for collaboration such as new MRI sequences that enable ICS faculty to measure additional components of brain structure or function.

The goal of the **Center for Research on Training** is to optimize through training the efficiency, durability, and generalizability of knowledge and skills. Prof. Emeritus Alice Healy led this Center until her retirement in Spring 2018. Prof. Matt Jones, ICS Fellow and Professor of Psychology and Neuroscience, is the new Director. He has provided a comprehensive description of CRT, including his plans for this next phase of the Center, in our response to ‘Question 18. Center Reauthorization’ in this report.

## RESEARCH TO REAL LIFE

A differentiating aspect of research conducted in the Institute of Cognitive Science is the focus on research investigations that directly impact people’s lives in both the short and long term.

For example, CU REACH is collecting data in a field where basically little to no data exists, but simultaneously where the public is increasingly using cannabis-related products for medical or recreational purposes at an incredible rate. This research seeks to begin giving the public, medical community, and policy makers real data about the way these products may have both positive and negative effects in different contexts.



The ABCD study is using cutting-edge technology and scientists to determine how childhood experiences (such as sports, video games, social media, unhealthy sleep patterns, screen usage, and smoking) interact with each other and with a child's changing biology to affect brain development and social, behavioral, academic, health, and other outcomes. The results of the ABCD Study will provide families; school superintendents, principals, and teachers; health professionals; and policymakers with practical information to promote the health, well-being, and success of children. Recently preliminary findings were shared with the Colorado legislature on how screen time may be affecting children, and these finding may assist policymakers in creating evidence-based policies to improve the health of children.

The Wager Lab is involved in multiple pain studies, including testing the efficacy of back pain treatments. Prof. Wager has developed an algorithm for measuring pain objectively with a brain activity-based biomarker enables much more robust testing or pain treatments than anything currently existing. His work on the role of placebo and alternative treatment for pain such as mindfulness training may have far reaching impact on an individual's choices in managing pain.

The Inquiry Hub partnership has recently produced a year-long high school curriculum - Inquiry Hub Biology - designed to support the Next Generation Science Standards from the ground up. This curriculum is released under a Creative Commons 4.0 license, and a native Google Drive format, to support teachers, schools, and districts to adopt and adapt it to meet local needs. This curriculum is currently be used by thousands of students in Denver Public Schools and is being considered for district-wide adoption in 2019. The curriculum is also being considered by the State of Louisiana, a leader in the use of Open Educational Resources in K12, for adoption in the same time frame.

## OVERALL RESEARCH STATUS

### **Our People**

ICS is home to over 200 individuals who contribute to its research mission. Of these, 9 are ICS rostered tenured and tenure-track faculty with tenure homes in the Departments of Psychology and Neuroscience and Computer Science, 9 are Research Professors, and 55 are Faculty Fellows drawn from all of the participating units. In addition, the Institute serves as the home to 42 Research Associates (RA) and visiting faculty, 38 Graduate Research Assistants and 7 research staff members.

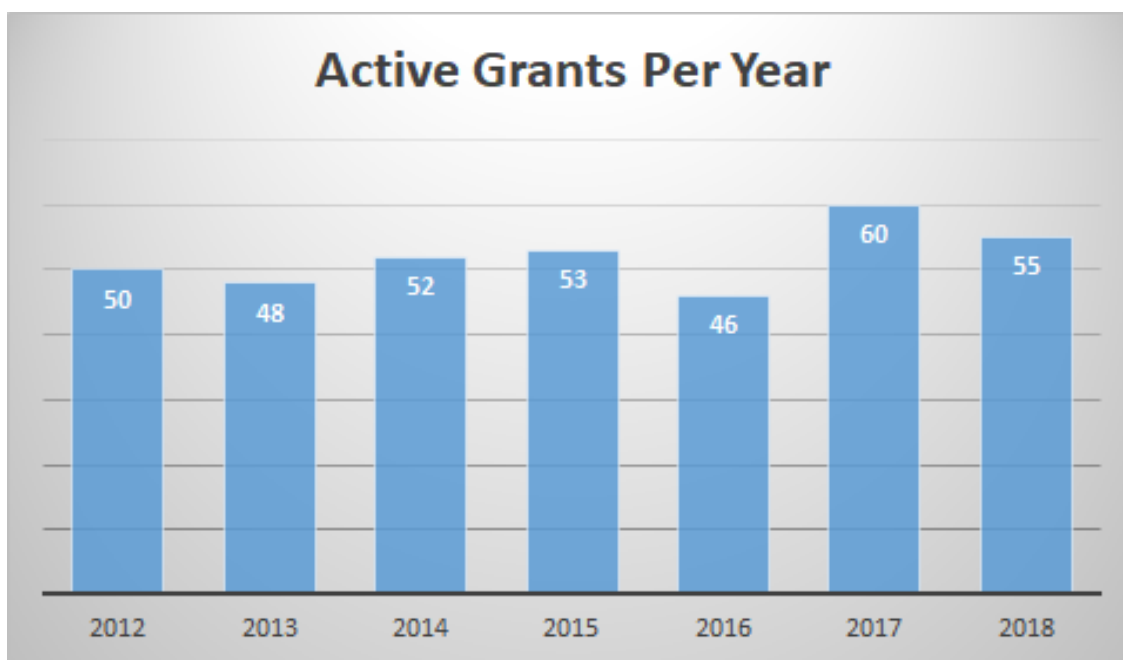
Calculating core research staff time as Full Time Equivalents (FTE), an annual average of 14.3 FTE of ICS tenure-track faculty, research faculty, and RAs led grant acquisitions and research. Over this seven year period 100 FTE of researchers participated in grant-supported work.

	2012	2013	2014	2015	2016	2017	2018	TOTAL
FACULTY (FTE)	11	11	13	12.2	12.9	13.2	12.6	85.9
RA (FTE)	3	2.45	2.45	1.5	2.1	2	0.6	14.1
TOTAL (FTE)	14	13.45	15.45	13.7	15	15.2	13.2	100

### Active Grants & Acquisition of Grants

Between 2012 and now, an average 14.3 Full Time Equivalent (FTE) ICS faculty and Research Associates received 102 new grants, subawards, and co-PI awards of \$60,759,889 and led work on 137 unique grants totaling \$80,794,209. The difference of \$20,044,320 between amounts for new grants and total unique grant work comes from activity on grants that were awarded prior to 2012 but remained active beyond 2012. A complete list of unique grants is accessible from the [ICS website's Research page](#)<sup>1</sup>.

The following chart shows the changes in active grants over the seven year period. The number of grants that ICS researchers conducted remained relatively stable over the review period.



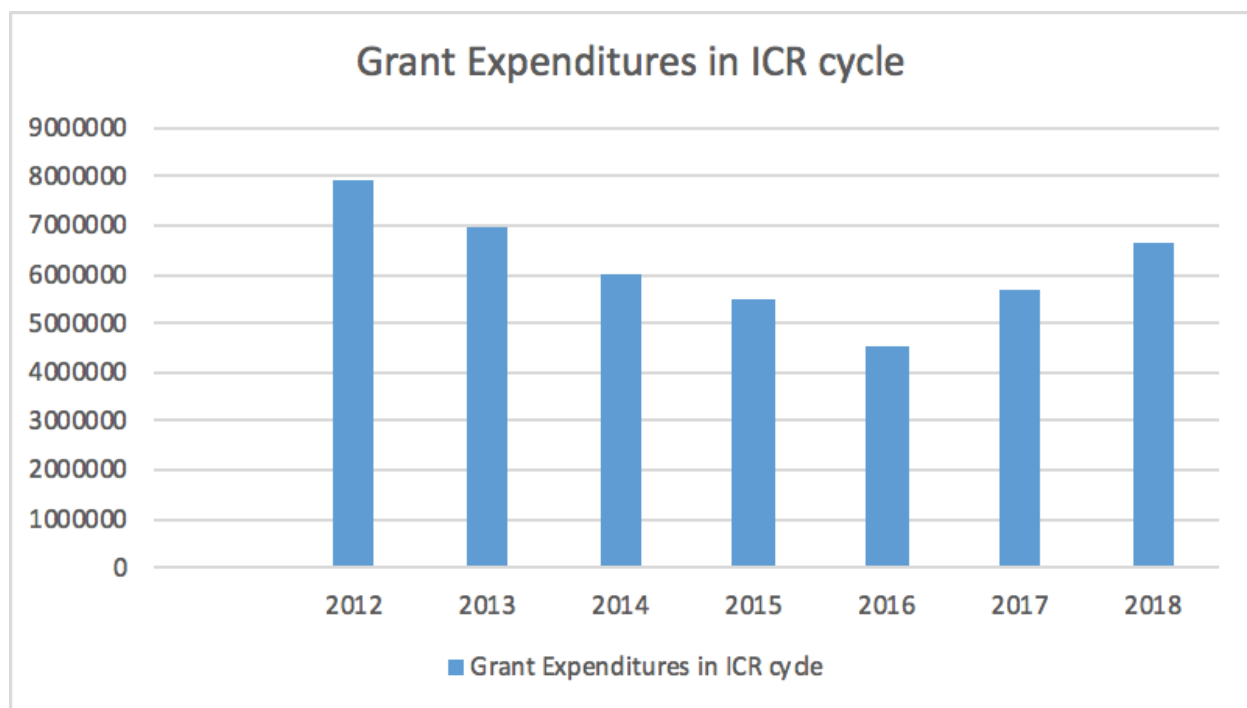
<sup>1</sup> [https://docs.google.com/spreadsheets/d/1bb3poyoTdUJZZi3DjjP1acq243-6FGkriKDvdK\\_sXPQ/edit#gid=2102085407](https://docs.google.com/spreadsheets/d/1bb3poyoTdUJZZi3DjjP1acq243-6FGkriKDvdK_sXPQ/edit#gid=2102085407)

### Productivity

The per capita FTE procurement of new grant funding over seven years by 100 FTE lead researchers was \$607,498.89 and the per capita FTE productivity by active grant dollars over seven years was \$807,942.09. Given the small number of tenure-track and research faculty and research associates that led grant acquisition efforts (average of 14.3 FTEs over 7 years), the per capita procurement and productivity numbers are quite robust.

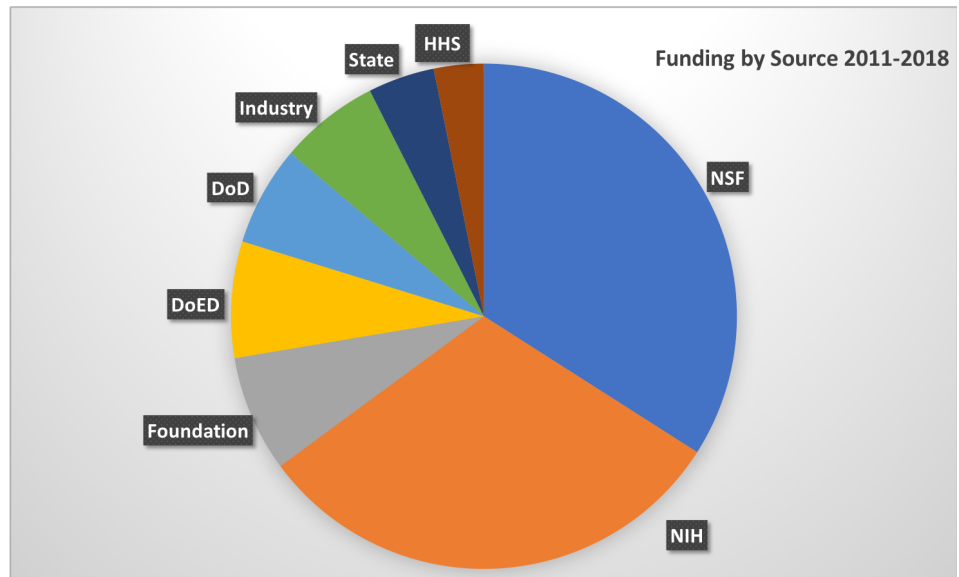
### Research Expenditures

The Institute is currently managing a portfolio of 55 active awards with a rolling grant budget of \$24.7 million during fiscal year 2018. As shown in the following figure, research expenditures began to recover in 2016 after significant declines beginning in 2013. The decline in expenditures can be traced to a number factors including: externally, a steady decline in federal research funding associated with federal budget woes and a winding down of the ARRA stimulus era; internally, the departure of Prof. Martha Palmer from the Institute, and the protracted search which left her position unfilled until the arrival of Prof. Sidney D'Mello in 2017.



### Funding Sources

As shown in the following figure, the Institute relies on a broad range of funding sources: federal; not-for-profit companies and foundations; industry; school districts; state agencies; and universities, with nearly 80% coming from federal sponsors. As shown in the figure, nearly  $\frac{2}{3}$  of our funding comes from NIH and NSF.



It is noteworthy that ICS work is funded by a diverse group of organizations both within and outside the federal sector. From NASA to the Navy, State agencies to school districts and Samsung, 75 unique organizations have sponsored ICS research since 2012. Of the nearly 80% of ICS work sponsored by federal sources, [22 different agencies and programs](#)<sup>2</sup> sponsor our work under the Centers for Disease Control, Department of Health and Human Services, NSF, NIH, Department of Defense, Department of Education, NASA, and the Small Business Innovation Research organization. Around 9% of ICS funding is provided by not-for-profit companies and foundations, around 10% by state agencies, school districts and universities, and 5% by industry. This variety of sponsors speaks to the broad relevance of ICS research and stability of funding. A complete list of sponsors is accessible on the [ICS website's Research page](#)<sup>3</sup>.

### Research Collaborations

As part of its funded research, the Institute has engaged with a wide array of collaborations with 84 unique partners (the list is accessible from [the website's Research page](#)<sup>4</sup>) here at CU and across the

<sup>2</sup> [https://docs.google.com/spreadsheets/d/1bb3poyoTdUJZZi3DjjP1acq243-6FGkriKDvdK\\_sXPQ/edit#gid=842164782](https://docs.google.com/spreadsheets/d/1bb3poyoTdUJZZi3DjjP1acq243-6FGkriKDvdK_sXPQ/edit#gid=842164782)

<sup>3</sup> [https://docs.google.com/spreadsheets/d/1bb3poyoTdUJZZi3DjjP1acq243-6FGkriKDvdK\\_sXPQ/edit#gid=517099511](https://docs.google.com/spreadsheets/d/1bb3poyoTdUJZZi3DjjP1acq243-6FGkriKDvdK_sXPQ/edit#gid=517099511)

<sup>4</sup> [https://docs.google.com/spreadsheets/d/1bb3poyoTdUJZZi3DjjP1acq243-6FGkriKDvdK\\_sXPQ/edit#gid=0](https://docs.google.com/spreadsheets/d/1bb3poyoTdUJZZi3DjjP1acq243-6FGkriKDvdK_sXPQ/edit#gid=0)

country. As a result of engaging in a large number of multidisciplinary collaborative work, the Institute pushes forward new theoretical and innovative work that spans a wide field of interrelated disciplines.

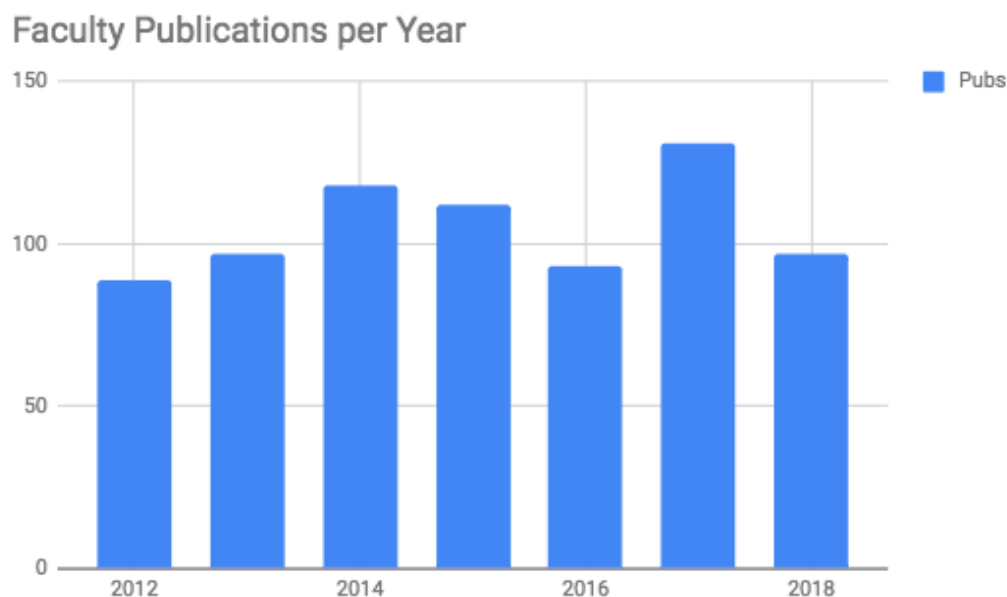
- Within CU: ATLAS Institute, Computer Science, School of Education, Institute of Behavioral Genetics, Integrative Physiology, Linguistics, Psychology and Neuroscience, Institute for Arctic and Alpine Research, National Snow and Ice Data Center.
- Universities: Collaborations with 36 universities here and abroad. The listing is accessible from the ICS website's Research page.
- Federal and State organizations such as: University Corporation for Atmospheric Research; Colorado Department of Human Services; Colorado Department of Public Health and Environment
- School districts and Educational Agencies such as: Denver Public Schools and Oklahoma State Department of Education (OSDE)
- Industry: BBN/Raytheon, Google, IPSoft, SparkFun Electronics, Oculus, Samsung, PainQx, and Intel
- Not-for-Profit Companies and Foundations: Gordon and Betty Moore Foundation, Hewlett Foundation, John Templeton Foundation, NARSAD, Raikes Foundation, Walton Family Foundation.

### Research Publications

Research output, in terms of peer-reviewed publications is robust. From 2012 to the present, Institute faculty published 320 unique peer reviewed journal articles (articles with multiple ICS authors were only counted once), 83 book chapters, 1 peer-reviewed book, 4 peer-reviewed textbooks, and 263 refereed conference publications. Members also presented 53 invited presentations and 201 keynote presentations. A [complete listing of ICS faculty publications](https://docs.google.com/spreadsheets/d/1bb3poyoTdUJZZi3DjjP1acq243-6FGkriKDvdK_sXPQ/edit#gid=1380337440) <sup>5</sup> is accessible from the ICS website's Research page.

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<sup>5</sup> [https://docs.google.com/spreadsheets/d/1bb3poyoTdUJZZi3DjjP1acq243-6FGkriKDvdK\\_sXPQ/edit#gid=1380337440](https://docs.google.com/spreadsheets/d/1bb3poyoTdUJZZi3DjjP1acq243-6FGkriKDvdK_sXPQ/edit#gid=1380337440)



The Institute saw a significant increase in peer-reviewed publications during the review period. 2012's peer-review publication for faculty and students was 88 and number of publications for 2017, the last complete calendar year in the review cycle, was 131.

Institute faculty and students also disseminated research findings through 417 academic presentations, colloquia, keynote talks, and invited presentations for a per year average of 64 presentations per year. Research was also disseminated to the larger community through 12 articles through popular press and television news outlets.

The Institute's Professional Research Assistants (PRA), Research Associates (RA) and Graduate Research Assistants (GRA) contribute significantly to publication productivity.

22 PRA, RA, and GRAs published an additional 216 peer-reviewed journal articles, conference proceedings, book chapters, invited presentations from 2012 to 2018, many as primary authors and presenters.

It is important to note that the above publications include only those produced by faculty and research assistants directly rostered at ICS. As mentioned earlier in the report, currently 55 Fellows from other units are affiliated with ICS, many of them working closely with ICS faculty and facilities. For example, Profs. Angela Bryan from Psychology and Neuroscience and Erik Willcutt from Institute of Behavioral Genetics have collaborated closely with ICS's Intermountain Neuroimaging Consortium (INC) both with researchers and the MRI facility. Prof. William Penuel from the School of Education is a co-founded of Inquiry Hub and has written extensively on Research + Practice partnerships based on our



work with DPS. Vast numbers of publications arose out of the interdisciplinary collaborative work, but they are not counted for the purposes of this report. As university publication management resources such as CU Elements add planned new features, we anticipate being able to expand our reporting to include these collaborative publications with Fellows in the future.

### **Textbooks**

Prof. Marie Banich's *Cognitive Neuroscience*, (co-authored with Prof. Rebecca Compton, a previous mentee and now full professor at Haverford) provides a broad overview of the field. It has just come out in its fourth edition (published by Cambridge University Press). It is used at universities across global, and is currently being translated into Korean.

Prof. James Martin's *Speech and Language Processing*, (co-authored with former ICS faculty Prof Dan Jurafsky, now at Stanford), is a comprehensive text covering all aspects of speech and language processing technology. It is the premier graduate textbook in the field and has been translated into Chinese and Korean. Currently in its 2nd Edition, the draft 3rd edition is in widespread use and will be published in 2019.

Emerita Prof. Lise Menn's *Psycholinguistics: Introduction and Applications* was updated with its second edition in 2015. It is the first textbook in psycholinguistics created for working language professionals and students in speech-language pathology and language education, as well as for students in psychology and linguistics. The revised brain chapter contains new findings on brain structure and function, including the roles of newly delineated fiber tracts and language areas outside Broca's and Wernicke's areas.

Prof. Jennifer Jacobs *The Problem-Solving Cycle Model of Mathematics Professional Development* (co-authored with form ICS fellow Prof. Hilda Borko (Stanford University) and Karen Koellner (Hunter College)), describes a model of professional development that engages mathematics teachers in continuous cycles of professional learning.

### **Patents**

Institute Faculty have historically secured patents for a variety of applied technologies and intellectual assets. Notable in the past two years is a patent by Prof. Sarel van Vuuren for a "Method and System for Implementing Three-Dimensional Facial Modeling and Visual Speech Synthesis" in 2018, and two patents by Prof. Tor Wager for "fMRI-based Neurologic Signature of Physical Pain" in 2016 and "Neurophysiological signatures for fibromyalgia" in 2018. Prof. Peter Foltz is a co-inventor on three pending patents as of the publication of this report.

## Honors and Awards

Many Institute Faculty and Research Associates have been recognized for their outstanding contributions to their fields of research through honors and awards. Below are highlights of the 79 honors received by Institute members between 2012 and 2018. A complete listing of Honors and Awards is accessible from the [website's Research page](#).

- **2018** - Associate Professor and Psychology and Neuroscience professor Sidney D'Mello received the Tom Trabasso Young Investigator Award from the Society for Text & Discourse, given to "outstanding young scholars who received his or her PhD within the last 10 years and has made a significant contribution to the understanding of discourse processing and text analysis."
- **2017** - Research Professor and Speech Language Hearing Sciences Professor Emerita Dr. Christine Yoshinaga-Itano was awarded the 2017 Woman of the Year Lifetime Achievement Award by the Boulder chapter of the Business and Professional Women of Colorado organization for her contribution to childhood auditory assessment, health, and early intervention  
Associate Research Professor Jennifer Jacobs received the "Distinguished Research in Teacher Education" award from the Association of Teacher Educator.
- **2016** - Professor Tamara Sumner received honors for SemEval 2015 Shared Task: Top Performing Algorithm in: Proceedings of the 9th International Workshop on Semantic Evaluation
- **2015** - Professor Mike Mozer was awarded the Educational Data Mining Society's Best Paper Award.  
Professor Tor Wager received the Herbert Spiegel Award from Columbia University
- **2014** - Professor Martha Palmer received the Outstanding Graduate Advisor Award, University of Colorado
- **2013** - Assistant Professor McKell Carter received the Brain and Behavior Research Foundation NARSAD Young Investigator Award

## Early Career Scholar Contributions

In addition to the high level of research dissemination through publications mentioned above, the Institute's GRAs, RAs, and PRAs formidable research abilities have been recognized through a variety of honors and awards.

Between 2012 and 2018, 10 GRA/PRA/RAs have been given 28 awards ranging from National Science Foundation Graduate Fellowship Competition Honorable Mentions to Howard Hughes Medical

Institute Research Grants, Finalist for the Gates Cambridge Scholarship UK, to the University of Colorado Chancellor's Achievement Scholarship awards.

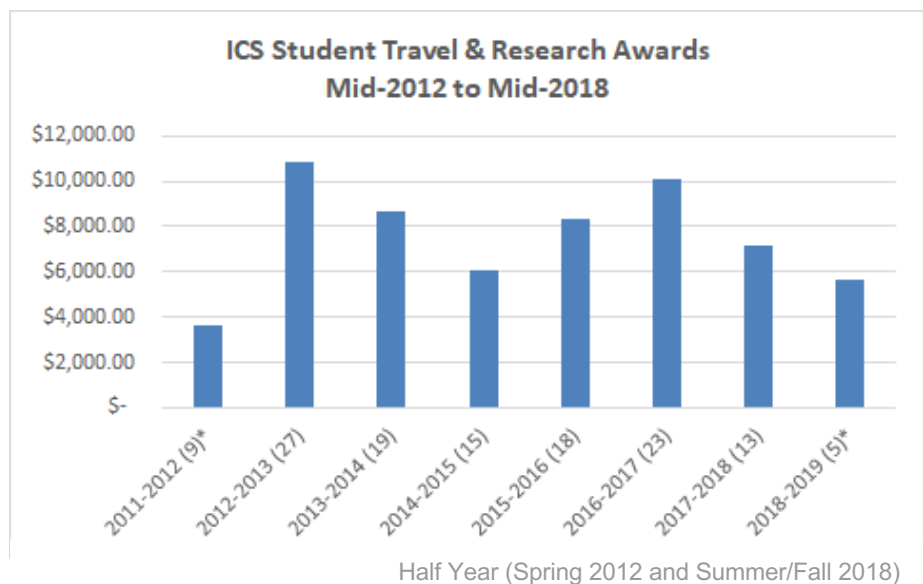
ICS graduate students have also been recognized for their outstanding scholarship. Recent examples include:

- The 2017 Ralph J. Slutz Student Excellence Award given to Dana Hughes and Rick Parker, ICS/Computer Science PhD students in recognition of students in Computer Science who have established a record of academic excellence and/or technical research and innovation.
- ICS and Linguistics PhD candidate, Steve Duman, received an Award of Excellence as an Outstanding Teacher for Technology in Teaching from ASSETT (Arts & Sciences Support of Education through Technology) in 2015.
- Jena Hwang, a December, 2014 LING/CogSci joint PhD, is one of four recipients of the 2015 Robert J. Glushko Dissertation Prize awarded by the Cognitive Science Society and the Glushko-Samuelson Foundation.

### Early Career Scholar Development

ICS encourages graduate student participation in interdisciplinary study and research through travel and research awards, participation in variety of aspects of research and teaching, inclusion in the writing of publications, and leadership roles.

Funding is provided three to four times a year for students to attend and present at conferences or to conduct original research. The funds are administered by a Travel and Research Award committee consisting of student representatives from ICS member departments. The student committee is responsible for the solicitation, allocation of funds, selection, announcement and disbursement of funds, providing an opportunity for leadership. Individual awards typically range from \$300 to \$700.



Since 2012, ICS has awarded over \$60,540 to 129 graduate students. Students from ATLAS, Computer Science, Integrative Physiology, Linguistics, Music Education, Philosophy, Psychology & Neuroscience, School of Education, and Speech Language Hearing Sciences have received awards. Award amounts are reported per academic year. Note that the amount shown for the first academic year (2011-2012) and the latest year (2018-2019) reflects only awards made in the half of the year included in this ARPAC reporting period.

ICS also includes one student who is nominated and voted on to the Executive Committee, providing representation of students in the decision making, policy, strategy, and direction of the Institute.

Students are encouraged and invited to contribute to writing of annual grant reports, final reports, and articles for publication of research findings, learning through participation, the roles that faculty take within research organizations.

### **ICS-Sponsored Research Conferences and Workshops (2012-Present)**

ICS supports a variety of events, workshops, and conferences in part or in entirety, through direct funding, or in-kind donations. Recent activities include:

- Society of Philosophy and Psychology (SPP) (2012)
- International Conference of the Learning Sciences (ICLS) (2014)
- Beyond Time: An Interdisciplinary Workshop on Aspectual Meaning (2017)
- ACM International Conference on Multimodal Interaction (ICMI) (2018)
- Perspectives in Cannabis Research and Education CORE Conference (2018)
- CUNY Conference on Human Sentence Processing (2019)
- International Brain Awareness Week public outreach activities (annually)
- University of Colorado Neuroscience Student Club events (annually)
- In addition, we spend \$6-10K per year to invite distinguished scholars from around the country/world to visit with institute members for 2 days and give a talk (annually)
- *Prepared by Prof. James Martin, Prof. Marie Banich, and Yasko Endo on behalf of the Institute of Cognitive Science.*



## Q.4 - INTERDISCIPLINARY RESEARCH AND TEACHING

*Task: Describe the unit's current interdisciplinary interests and where opportunities exist for expanding collaborations or initiating new ones.*

### OVERVIEW

Cognitive Science is inherently an interdisciplinary field of study, research, and development that is arguably one of the “sciences of the 21<sup>st</sup> century.” It is being nurtured at CU by the Institute of Cognitive Science and does not exist as an academic department. ICS’s mission is to build synergy for research involving cognitive processes and related training enterprises that are best accomplished through cooperative efforts between multiple academic units on campus. Indeed, the cognitive science community here at CU is comprised of members from several departments on campus that span the College of Arts and Science, the College of Engineering and Applied Sciences, and the Schools of Education and Information Science. To enhance and sustain this mission, ICS provides a robust interdisciplinary academic program in Cognitive Science, administered by the Institute of Cognitive Science.

Training in cognitive science prepares students admirably well for many of the fields that are targeted as the major growth fields of the 21<sup>st</sup> century: Data science, Artificial Intelligence/Machine Learning, Computational Neuroscience, Human Computer Interaction, and Learning Analytics. As the world is enveloped by ubiquitous data, intelligent computational systems, and a renaissance of creative embedded computational approaches directly tied to enhanced human performance spanning cognition and affect, cognitive scientists are uniquely positioned to integrate understanding of how human abilities can process information and perform within complex environments, maximizing normal human capabilities as well as at an enhanced level that exceeds normal, unassisted human capabilities. Complementing this enterprise are the striking breakthroughs in cognitive neuroscience, pursued at a high level by renowned researchers at the Intermountain Neurological Consortium, a center at ICS.

## APPROACH

The Institute of Cognitive Science has put in place a suite of interdisciplinary academic programs that include an undergraduate and two graduate certificate programs as well as a joint Ph.D. program, the first of its kind in Colorado. The collaborative approach with ICS's academic programs reflects the thinking that originally drove the way ICS is organized from its inception. Given that cognitive science is an interdisciplinary field, made up of several core disciplines, establishing a cognitive science presence at CU Boulder could go one of two directions, each with pros and cons. We could organize as an institute with participating departments. This ensured that faculty stayed affiliated with core departments and their discipline affording them the connections that would keep them up to date in their core field, while still allowing an interdisciplinary hub (ICS) to build interdisciplinary research collaborations across campus. The downside of this approach is that the traditional infrastructure of universities is not designed to reward or even fund educational programs outside of departments. The second approach, followed by several other universities, is to set up a department of cognitive science. The advantage of this approach is the department fits seamlessly into the infrastructure in its ability to offer educational programs. The downside is the potential for department faculty to become disconnected from emerging research and theory in their core discipline. And so it was decided among faculty from founding departments at CU Boulder to form an institute to pursue their interdisciplinary interests in cognitive science. Thus, this institute structure is our framework for both our research goals and our academic programs. While it affords a rich intellectual community across relevant disciplines for interdisciplinary research projects, there is basically no mechanism for supporting academic programs in cognitive science, discussed in more detail below.

## COMMUNITY

The Cognitive Science academic programs take place within the larger community of ICS rostered tenure-track faculty, and Affiliated Faculty Fellows from other departments, including 9 academic departments; Psychology & Neuroscience, Computer Science, Education, Linguistics, Speech/Language/Hearing Sciences, Integrative Physiology, Information Science, Business, Architecture Planning and Design. Interdisciplinary interactions among these scholars and their students has led to vibrant careers, not only in academic settings, but our cognitive scientists bring a lot of unique expertise to today's society, with its high-tech enterprises involving complex systems that can exceed the resources of the normal, unassisted human. The research and development required to create products that are designed for this complex, information age; with its normal, aging and disabled populations, necessitates an interdisciplinary team of experts in which cognitive scientists figure prominently.



## ICS ACADEMIC PROGRAMS

From surveys and anecdotal evidence, we know that our programs attract students to CU academic departments, particularly at the graduate level. These programs include an Undergraduate Certificate, two Graduate Certificate Programs, and 2 Combined PhD Programs that provide exceptional breadth and depth of interdisciplinary training in the cognitive sciences. Our institute is not an admitting unit because of its research unit status in the current university infrastructure. Our students are current CU Boulder students in good standing majoring in some academic unit as an undergraduate or a current graduate student in one of our participating academic departments. The program is managed by ICS staff, including advising, program progress review, approvals, and notification to the Registrar. Successful completion of an ICS program is acknowledged by a Certificate of Completion on the student's transcript. The PhD programs are noted on the student's diploma. After taking required core courses developed by ICS for these programs and offered as cross-listed classes in participating departments, students in all these programs individualize their plan of study based on their research and or career interests through their choice of approved electives, offered in participating departments. Thus, students pick elective courses from up to 7 different departments to create a plan of study unique to them. The approved courses for the programs in cognitive science reflect a subset from these participating academic departments that have been carefully curated to reflect study in cognition—artificial as well as biological, along with essential research methodologies, reflecting the interdisciplinary demands of good practices in cognitive science. The ICS Academic Programs Director consults with ICS Fellows in participating departments to keep the approved courses for cognitive science programs up-to-date.

Specifically, these programs are:

- One undergraduate certificate that involves core cognitive science courses and advanced skills courses selected from 6 different academic departments. For further details see: <https://www.colorado.edu/ics/undergraduate-certificate-cognitive-science-overview>
- Four graduate programs (details at <https://www.colorado.edu/ics/graduate-programs>):
  - Cognitive Science Graduate Certificate (Grad Cert)
  - Human Language Technology Certificate (HLT Cert)
  - Cognitive Science Combined PhD (CogPhD)
  - Cognitive Neuroscience Combined Triple PhD (CogNPh)

A “combined” PhD means that the student will have earned a PhD in their home department, and a Ph.D. in either Cognitive Science or Cognitive Science/Neuroscience for the “triple” PhD. The Triple PhD is a program worked out with the Neuroscience program under the Dept. of Psychology and

Neuroscience to include coursework that addresses the needs of students pursuing a career in Cognitive Neuroscience (in contrasted to Behavioral Neuroscience, which is the mainstream path of that combined PhD program).

Student numbers by programs by year:

	Undergrad Cert	Grad Cert	CogPhD	CogNPh	HLT Cert
APPLICATION BY YEAR					
2012	12	8	2	0	6
2013	16	2	9	4	7
2014	17	4	7	5	2
2015	14	10	6	2	4
2016	14	16	4	1	6
2017	15	4	0	0	3
2018	2	7	3	3	1
2010 – 2018	90	51	31	16	29
COMPLETIONS BY YEAR					
2012	3	8	4	1	3
2013	12	2	6	0	8
2014	10	4	6	1	3
2015	15	10	3	2	6
2016	19	15	6	3	3
2017	7	4	2	2	3
2018	4	7	1	1	0
2010 – 2018	55	50	28	10	26
TOTAL INCOMPLETES					
	24	5	9	0	3

### Where are they now?

Looking only at our PhD graduates over the last 7 years, they have pursued careers in the following areas of endeavor:

Academic – Professor - 17	Academic – Other - 14	K-12 Education - 1
Industry - 14	Government - 4	Medical - 3
Research Consulting - 4	Other - 1	Unknown - 2

## STUDENT RESEARCH AND TRAVEL AWARDS

For students enrolled in the ICS graduate programs, ICS offers an awards program to assist students with research and conference travel resources. A student run committee reviews proposals 3 times a year and awards grants up to \$700 a year for travel funds to conferences to present their work and up to \$500 per year to purchase research supplies. Students prepare a proposal describing their funding needs. These are reviewed and awarded by a student committee. Assistance for students to use the funds (i.e. purchasing) is done through ICS staff. The \$10,000-15,000 spent per year for this awards program comes from research grants' ICR to ICS. Details about this program can be found at: <https://www.colorado.edu/ics/graduate-programs/student-travel-research-awards>

## SUSTAINABILITY

ICS has managed to put in place leading edge academic programs in cognitive science but is seriously struggling to sustain them. From 2012-2018 we have approximately 100 active students in any given year in the various programs. ICS manages these programs and students without any of the support that academic units enjoy—no secretarial support to prepare class materials, advise students, or monitor program data; no Teaching Assistantships to assist faculty who offer cognitive science courses; no graduate fellowships to attract better students. This occurs because cognitive science courses are cross-listed across several departments, and therefore do not have a home in any traditional academic unit. Elective courses are offered via the various departments and come from their normal list of courses in that discipline and are a subset selected in collaboration with the ICS Academic Director to be those subjects within core disciplines that align with the sphere of topics relevant to the cognitive sciences. Administration and support of cognitive science training at CU falls to the Institute of Cognitive Science, which has no infrastructure support for this enterprise. What little support ICS provides comes from indirect cost recovery (ICR) from institute grants, which has other important uses in the support of research initiatives. For these reasons, ICS has not embarked on any significant marketing because we don't currently have the infrastructure to support expansion. Even without marketing, our undergraduate course, introduction to cognitive science is consistently popular, and although we have increased and maxed out the student enrollment limits we routinely have to turn away students; in Fall 2018 30% of students who hoped to enroll were turned away. Sadly, because of lack of support, including no allocated TA support for this large undergraduate class, ICS faculty discussed replacing this class with an online version if some economy of effort could be obtained through automation and/or some revenue could be generated to cover the cost of offering the course.

This state of affairs around lack of funding and infrastructure support was noted in the last two ARPACS, beginning with the ARPAC 2000, and was earmarked by reviewers for increased system support. While we are looking into online approaches to offering our academic programs, the campus processes and underlying budget strategies have not yet matured to a level where this is feasible (i.e. pays for itself).

- *Prepared by Prof. Donna Caccamise and Prof. Peter Foltz on behalf of the Institute of Cognitive Science.*



## Q.9 - SPACE AND STAFFING

*Task: Describe the unit's needs for space and infrastructure. Also, detail the unit's anticipated staffing needs.*

### OVERVIEW of FACILITIES AND INFRASTRUCTURE

ICS headquarters is located in the campus Muenzinger building and is comprised of our main office, Director and Associate Director offices, and three meeting spaces holding from 12 to 50 people (approx. 4000 sq. ft.). This space facilitates meetings fostering interdisciplinary research and education with affiliated faculty and students from units across campus. The main research laboratories for ICS are located at the Center for Innovation and Creativity (CINC) northeast of campus and has 18,399 square feet of laboratory space, including single occupancy rooms, double occupancy rooms, equipment rooms, several meeting room spaces for lab meetings and for computer laboratory activities, and student cubicles. The space provides rooms outfitted with high-speed Internet connections and power supply for all data analysis and image processing and a specifically designed machine room for high-end computer equipment. Mac and PC workstations are located in CINC offices, designated lab spaces, and in the behavioral testing rooms. CINC is tasked with providing space and facilities for successful completion for a large range of research projects. Currently, 195 people, 22 laboratories and 54 funded research studies all share the space at CINC. CINC also is the site of our 3T neuroimaging facility, which includes a working MRI scanner, a mock scanner, and a control room with highly specialized computer equipment. CINC is rented at a rate of \$7666.25/month (ICS pays \$6193.75 and INC pays \$1472.50). CINC is accessible via free parking and limited public transportation. In particular, with the recent cancellation of the Stampede bus service to Marine Street, transportation options from CINC to main campus are quite limited, impeding the ability for ICS faculty, staff, and students to interact with teams and resources on campus.

## CURRENT USE OF ICS SPACE IN CINC

ICS space at the CINC building was designed for ICS faculty, fellows, and students to work in their own, private office spaces Monday through Friday during regular business hours. This model never came to fruition given the lack of easily accessible transportation options between the main campus and the CINC building. This lack of transportation makes it very difficult to move between CINC and campus while teaching and/or attending classes. We also noted that some research projects make significant use of subject running facilities predominantly on weekends. The nature of research studies at ICS, combined with the modern ability to work anywhere paradoxically leaves ICS space at the CINC building both scarce and underutilized at the same time.

ICS completed a survey of faculty, fellows, staff, and students in September 2018 to better understand space needs at CINC. Three tenure track faculty members, one staff member, seven research professors, 15 research associates or assistants, eight students, and one shared research facility completed the survey. A majority of the labs that use space at the CINC building were represented in the survey results. On average survey respondents worked at CINC 25.8 hours each week. However, there was a large bimodal distribution with graduate students, faculty, and research professors working at CINC approximately 19-23 hours each week and research assistants, associates, and staff working at CINC approximately 40 hours each week.

In an open-ended description of the type of work people do at the CINC building, the majority of the 35 respondents reported engaging in a combination of desk work and meetings: 23 (66%) reported doing some sort of desk work at CINC (e.g., computer programming, writing, data management or analysis), 15 (43%) reported doing research (details unspecified), 19 (54%) reported attending either 1:1 meetings or team meetings, and 6 (17%) reported interacting with research subjects (e.g., running participants in experimental protocols).

The following table summarizes the results for all respondents, to questions asking how frequently they require certain types of space (e.g., space for 1:1 meetings or running subjects).

	1:1 meetings	3-10 people meetings	>10 people meetings	Communal Space	Quiet Space	Subject Running
Daily	12	2		7	21	6
4-5 hours per week	9	8	3	8	7	4
1-2 hours per week	7	12	5	8	3	1
Once per month		6	12	2	1	
Never	3	5	12	7	2	20



The most frequently reported daily and frequent need was for quiet space. Space for 1:1 meetings was the second most frequently reported daily need. Space is also needed for larger meetings (3+ people and communal work spaces), albeit less frequently. Space for running subjects was a daily or almost daily need for a smaller but critical subset of respondents. These patterns were relatively consistent across different roles (e.g., graduate students vs. tenure track faculty).

When asked for more details about running participants in research studies, we learned there was a range of subject testing uses and needs. Five respondents reported running single participants at one time, and 7 reported running more than one participant at the same time (either as a group, or running multiple individual testing sessions at the same time). Nine respondents (26%), eight of whom run participants through research studies, had equipment or experimental setups that could not be moved. Nineteen respondents indicated a need for locked storage for equipment or study materials (e.g., confidential participant documents such as signed consent forms or study records), regardless of whether or not they were involved in running participants through research protocols.

The one need mentioned by more than one respondent in a free response area of the survey was for meeting spaces to be equipped with more technology: a/v systems, projectors, and teleconferencing equipment. With follow up questions, we learned that there is a high frequency of meetings and group work at CINC and these needs for improved technology in meeting spaces are quite prevalent.

A few general themes arise from the survey data:

- ICS spaces are used by a range of individuals, including staff, professional research assistants, graduate students, research associates, research professors, and tenure track faculty.
- The primary use of CINC space is for research purposes such as: working with participants one on one or in groups, managing and analyzing research data, writing grants or papers, group meetings, and working collaboratively with research teams.
- Although much of the individual, computer-based research work requires a quiet workspace (e.g., data management and analysis, writing), the workspace for this type of individual work does not necessarily need to be *private*. Participant testing and screening is the exception to this general pattern, as both activities must be done in spaces that are both quiet *and* private.
- For individuals involved in testing subjects, both the format of subject testing sessions (group vs. individual) and the size and mobility of testing equipment (large, small; mobile, immobile) vary widely.
- Meeting rooms are lacking in sufficient audio visual and other technology.

## LIMITATIONS OF ICS SPACE AT CINC

CINC space does not currently accommodate the needs of ICS researchers and staff. Given the collaborative nature of ICS research and the increase in subject testing in the CINC building, particularly with the movement of the CHANGE lab and the INC to the CINC building, ICS research teams need more spaces for group meetings and communal work, private subject testing, and quiet/independent work. Efficient functioning means we need additional walled and private work spaces for one-on-one meetings, private subject running, and larger group meetings. Another primary limitation of the current space allocated to ICS at CINC is its inflexibility. As noted above, the space was designed at a time when more individuals worked on their own, in private offices. There may be ways to enhance the physical space to more closely meet the needs of ICS with some creative planning and restructuring of current spaces. Some spaces could be shared among groups (e.g., private subject running space). The CU CHANGE lab and the Intermountain Neuroimaging Consortium provide good models of how multiple studies can share private spaces and equipment for diverse study needs with training, collaboration, and a central staff person to oversee space sharing. Communal spaces should meet the needs of people working in 2018 (docking stations to allow sharing, etc).

Thus, over the next five years, we will need both targeted additional space as well as an opportunity to remodel our current space in order to allow it to function more efficiently.

## OUTLINE OF CURRENT NEEDS

We took the opportunity to follow up on the survey results and hold a town hall with all of our members in order to discuss the evolving space needs of the ICS staff, students, and faculty and solidified the following needs.

### 1. Targeted space enhancement and redesign

To meet our growing faculty, staff, and research program we need additional walled, private and communal space. There may also be ways to enhance the current CINC physical space to more closely meet the needs of ICS with some creative planning and restructuring of current spaces. Thus, in addition to a need for targeted additional space, a design consultant or architect is needed to provide expert guidance on how to maximize ICS space at CINC to increase our ability to meet current space needs and prepare us to meet future space needs. We *request funds* to hire an outside design consultant to explore the option of increased walled space and updated communal space at CINC. The consultant process will determine our options to enhance our current space, enabling us to be flexible in meeting the future space needs of growing ICS personnel and research projects.

**2. Technology improvements in shared meeting spaces.**

In addition to redesigning walled space, our meeting rooms need a major technology overhaul to meet the needs of groups collaborating with local and national partners. The meeting room technology needs to include television screens for projecting work, web cameras, center table microphones, and power at each table. We will work with the designer to make the technology choices efficient, flexible, and long lasting.

**3. Reliable transportation to main campus.**

ICS staff, students, and faculty regularly commute between main campus and CINC (which is technically not part of east campus) located 1.7 miles from main campus. It is a 35-minute walk and a 20-minute bike ride or drive+park. Due to parking restrictions on main campus, most rely on public transportation for the commute between CINC and main campus. Efficient and reliable public transportation is therefore of critical importance as main campus serves as the central venue for behavioral data collection, symposia, faculty meetings (in home departments), teaching, attending classes, and other events.

Whereas we were previously served by the Stampede bus route, which provided acceptable transportation from CINC to main campus, the RTD (Regional Transport District) cancelled the Stampede bus route from east Marine street (a few blocks from CINC) to main campus. Although originally promised when we rented CINC, RTD service to CINC has never been provided. CU replaced the Stampede with a local, campus-run shuttle called the Marine Street Express. Compared to the Stampede, the Marine Street Express bus stops are both further from CINC as well as from Muenzinger on main campus where ICS classes, meetings, and symposia are held. Whereas the Stampede ran approximately every 10-15 minutes, the Marine Street Express runs every 30 minutes. Taking into account added walking, wait, and transportation time, it is not unusual for a one-way trip to take between 45-60 minutes.

It is clearly not viable for ICS faculty and students to spend up to an hour and a half for a 3.5 mile round trip, particularly when at times multiple trips are needed each day. Neither is it a valuable use of University resources because it takes researchers and students away from the lab and the classroom. Finally, there is an equity issue here because only students who can afford a car, parking, or a Lyft/Uber can benefit from the excellent facilities of CINC whereas students without their own transportation are denied these opportunities. In addition, individuals with physical disabilities are unable to travel between CINC and CU's main campus unless they have their own vehicle. The Marine Street Express stop that is located closest to CINC is in grass, and is not accessible via a paved sidewalk. An RTD bus that runs more frequently and stops closer to ICS facilities is needed to ensure that ICS members can interact with teams and resources on main campus, as well as for participants in research studies (who are often CU students or staff) to reach CINC. A designated shuttle running between the main entrance to the CINC building

and the main campus may be an alternate solution to a bus route, if times can be identified that would meet the majority of CINC occupants' transportation needs.

#### **4. Staffing needs**

As our research enterprise grows, so too do the ICS staffing needs as they work closely with researchers on administrative issues such as budgets, finances, purchasing, hiring, travel, communications, space, and equipment issues. Currently staff occupy 4 offices: 1 is the size of a closet with 1 occupant; 1 regular sized office holds two full-time staff and ICS grant files; another large office (in Muenzinger) holds 2 full time staff plus 3 student workers, ICS personnel and academic files, and the copier center; and one part-time staff shares a regular sized office that is designated for researchers. There is currently no room to grow if we need more staff.

#### **5. Need for consolidated space close to campus**

Although we see approaches to make the current CINC space more usable for ICS researchers, faculty, staff, and students, there are inherent limitations to this approach that make it prudent to identify long-term, comprehensive solutions to ICS space needs. The interdisciplinary nature of cognitive science research and education and the many core disciplines that make up this field are more in line with 21st century interdisciplinary science than the monodisciplinary approach to science characteristic of the 20th century. Currently our researchers are physically distributed across campus in their home department's spaces and are therefore physically removed from colleagues in other fields. This model of separating research teams into discipline-specific spaces distributed across a 1.5 mile radius stifles innovation, particularly in the absence of a viable transportation option to connect these spaces.

Currently our classroom in the Muenzinger building (on main campus) is the only viable physical location to foster interdisciplinary collaboration, and weekly colloquia and other events provide the only location for ICS faculty, students, and staff to come together. This infrequent interaction cannot replace the rich interactions that go on daily in shared work spaces, and the challenges this lack of work space poses for students, faculty, and staff are faced with in integrating into the ICS community are apparent (see Q13: Unit Climate). We have earnestly tried to develop habits to engage in presentations and interdisciplinary discussions around research initiatives at CINC, but the isolation and distance from other parts of campus has made it difficult to sustain these efforts. Even residents of CINC are pulled to campus daily to fulfill their teaching and service responsibilities.

There have been past efforts to envision a shared space for interdisciplinary research in neuroscience and related fields. Past units interested in collocation to invigorate their interdisciplinary research projects include Psychology & Neuroscience; the Institute of Behavioral Genetics (IBG); Integrative Physiology; Speech, Language & Hearing Sciences; and Computer Science, among others. The University's vision is to be a leader in addressing the

humanitarian, social and technological challenges of the 21st century by shaping tomorrow's leaders, being the top university for innovation, and positively impacting humanity.

Cognitive science and related fields have always worked on research questions where humanitarian, social, and technological challenges intersect. If the University is to identify solutions to humanity's greatest challenges, we need to recognize the barriers that traditional models of monodisciplinary research spaces play in preventing interdisciplinary innovation. In a world that is becoming increasingly connected, we do our students, faculty, and staff a disservice by keeping them physically separated. Tomorrow's leaders must be fluent in interdisciplinary work. To generate innovative solutions to humanitarian, social, and technological challenges, it is imperative to foster greater interdisciplinary collaboration among the outstanding faculty, staff, and students engaging in brain-related research across campus. Collocated space would facilitate this collaboration and help the University of Colorado Boulder become a leader in solving humanity's most complex humanitarian, social, and technological challenges.

- *Prepared by Drs. L. Cinnamon Bidwell, Donna Caccamise, Sidney D'Mello, Nicole Speer, and Katie Van Horne on behalf of the Institute of Cognitive Science.*



## Q.11 - OUTREACH INITIATIVES

*Task: Describe the unit's outreach efforts.*

### INTRODUCTION

ICS faculty are involved in a wide range of outreach initiatives, reflecting their expertise and interest in numerous scientific disciplines. For the purposes of this report we define outreach quite broadly in order to cast a wide net around the various endeavors in which the members of our institute are currently engaged. Our acting definition of outreach initiatives is “activities that connect community members, both internal and external to the university, to the research endeavors currently undertaken by faculty within ICS.”

Outreach activities help extend the reach of ICS by communicating the nature and importance of our members' work to a variety of audiences. Individually and collectively these activities serve the broader mission of CU Boulder by providing numerous learning opportunities related to the research achievements of ICS faculty. ICS outreach initiatives help to educate citizens of all ages on a range of topics, engendering positive impacts within Boulder County, across the state of Colorado, and throughout the country.

In this report we describe three categories of outreach initiatives in which ICS faculty are involved. On the whole, these activities are intended to inform, engage, and join together diverse members of the community, through formal and informal interactions with ICS faculty. We also discuss the need for a dedicated ICS Outreach Coordinator, who can better support communication and connections between ICS faculty and others outside the ICS community in order to showcase our research, form relationships, and build a coordinated and well known outreach presence.



## CURRENT ICS OUTREACH INITIATIVES

Outreach initiatives in which ICS faculty are currently engaged can be differentiated based on their target audience as: (1) the education community, including K-12 educators and students; (2) other faculty and researchers, both internal and external to CU Boulder; (3) the broader community, locally and throughout the state and country; and (4) the media. This type of classification is useful because particular outreach activities are designed to be relevant and intellectually stimulating to the intended audience. Also included is a fourth category: ICS media-based outreach initiatives.

In this report we provide multiple examples of recent ICS outreach initiatives within each of the four categories described above. These examples are meant to offer insights into what our outreach efforts look like; they are not intended as an exhaustive list.

### 1. ICS OUTREACH INITIATIVES TARGETING THE EDUCATION COMMUNITY

Much of the research conducted by ICS faculty has direct relevance to K-12 education, thus outreach efforts geared towards members of this community are common. These types of initiatives are intended to highlight how ideas germinated from research can move into and be taken up by the education field, including educational leaders, teachers, and students. Here we break down examples of ICS outreach initiatives by (a) outreach geared towards K-12 teachers and leaders and (b) outreach geared towards K-12 students.

#### Outreach targeting k-12 teachers and leaders

##### Inquiry Hub research + practice partnership

The Inquiry Hub research partnership team -- which includes ICS faculty Tamara Sumner, William Penuel, Katie Van Horne, and Jennifer Jacobs -- developed a digital, open-source high school biology curriculum, which is currently available to school districts in Colorado and throughout the country. In addition, Inquiry Hub offers professional development workshops (approximately 3 per year) open to all inservice science teachers in their partner school district. Members of the Inquiry Hub team have presented at educator-focused conferences (such as the National Science Education Leadership Association and the National Science Teacher Association) and they have facilitated workshops at the district and state level to help teachers and leaders gain familiarity with the Next Generation Science Standards and related assessment practices.

##### Boulder Reading Intervention (BRAVO)

The BRAVO research team, led by ICS faculty Donna Caccamise and Peter Foltz, works directly with local school districts, including supplying them with a web-based curriculum called eBRAVO that personalizes instruction for each student depending upon their needs. The BRAVO team developed this

curriculum to improve middle school students' ability to build knowledge from reading challenging text, such as that found in STEM education and other complex subjects.

### **Examples of outreach targeting k-12 students**

#### Engineering Experiences - Out of School STEM Program

The Engineering Experiences team led by graduate student, Srinjita Bhaduri, adapted the curriculum developed through a grant to create a three-week summer course for high school students. The summer course focused on the use of unmanned aerial vehicles (UAVs) in disaster relief efforts. Youth in the program used 3D modeling and augmented reality to create UAVs equipped with tools to maneuver through obstacle courses to deliver resources in a simulated disaster. This provided opportunities for youth outside our partner sites to experience the learning developed through this effort.

#### Vail Valley Foundation

The Engineering Experiences team created a two-day professional development experience for educators from Vail Valley Foundation to learn how to use the curricular resources and how to adapt them for their students. This effort expanded the reach of the materials to another regional outlet and hundreds of additional students.

#### Inquiry Hub World Cafe

As part of the Inquiry Hub high school science curriculum, students participate in a World Cafe in which they debate the ethics of genetic engineering. Members of the Inquiry Hub research team help to organize and support the annual World Cafe in the partner school district. This event typically includes several hundred high school students, teachers, parents, and local scientists. Taking part in the World Cafe offers students an opportunity to integrate their knowledge of science with the practice of civic dialogue.



**World Café held as part of the Inquiry Hub's high school biology curriculum at UC Denver in 2017.**

### Neuroscience Classroom Lessons

Led by INC's Director of Operations, Nicole Speer, a team of CU Boulder undergraduate and graduate students are trained to deliver outreach lessons to K-12 students, based on current research in neuroscience and psychology. As they engage in these lessons, students learn about the brain through a series of fun, hands-on activities that are intended to both educate and spark their interest in neuroscience and psychology research. In this way students and teachers have the opportunity to learn about the brain, become excited about the field of neuroscience, and apply emerging research findings to their lifestyle choices in ways that may improve their cognitive functioning and emotional wellbeing. These outreach lessons have been delivered across the Front Range in Colorado and to K-12 students in rural areas of the state (e.g. Trinidad and this winter, Sterling), and partnerships with the CU TEACH program have provided neuroscience-themed professional development opportunities for approximately 30 Denver-area K-12 teachers.

## **2. ICS OUTREACH INITIATIVES TARGETING OTHER FACULTY AND RESEARCHERS**

A number of outreach activities conducted by ICS faculty are directed towards other faculty and researchers, both within the CU Boulder community and in other external organizations. These type of initiatives serve to connect ICS members with interested individuals and institutions by sharing information and supporting the building of relationships among potential colleagues. Below we provide examples of initiatives that support networking (a) within CU Boulder and (b) outside CU Boulder.



Elementary school students engaging in a neuroscience lesson

### **Outreach targeting faculty and researchers within CU Boulder**

#### ICS Colloquia

ICS holds weekly colloquia throughout the academic year on the CU Boulder campus. These colloquia are targeted to support the interests of faculty and graduate students in the institute, but they are open to anyone interested in attending and often draw members of the broader CU Boulder community. Many of the ICS colloquia highlight current research conducted by ICS faculty, fellows, and students in

order to inform the audience about their work and to encourage interested attendees to talk further with the presenter about possible collaborations. In addition, distinguished scholars (generally faculty at other universities) are invited to give colloquium talks several times per semester. Current information about the ICS colloquia is posted on the [“colloquia” tab of the ICS website](https://www.colorado.edu/ics/colloquia)<sup>1</sup>, which includes a brief description of each colloquium offered during the current academic semester.

### **Outreach targeting faculty and researchers outside CU Boulder**

#### Hosting and attending research-focused meetings

Several ICS faculty take part in formal and informal research-focused meetings with colleagues outside the university. For example, ICS research professor Leanne Hirshfield attends a monthly meeting with researchers along the Front Range to share information about current Human-Robot Interaction research. In addition, Dr. Hirshfield collaborates with researchers from the US Air Force, and invited several of them to attend her recent ICS colloquium talk in Fall 2018 and then tour ICS and the INC.

#### Sponsoring research conferences

ICS routinely sponsors research conferences that are organized and led by ICS faculty and community members. These include conferences targeting local and regional researchers, as well as internationally-renowned conferences. For instance, in 2018, ICS sponsored the regional CORE conference on cannabis and health, and the ICMI international conference on multimodal interaction. These conferences, all located in Boulder, CO, included invited speakers as well as relevant papers and posters accepted via a peer-review process. In 2019, ICS is sponsoring the CUNY conference on human sentence processing, which is being organized and led by a committee of ICS faculty and fellows.

## **3. ICS OUTREACH INITIATIVES TARGETING THE BROADER COMMUNITY**

Numerous ICS outreach initiatives are targeted toward the broader community, including the local Boulder community and throughout the state and country. These broadly focused initiatives are intended as opportunities to share information stemming from the work of ICS faculty that may be relevant and useful to diverse audiences. The initiatives take a variety of formats included from organizing workshops, leading group tours, and hosting talks. Several examples are listed below.

#### CU Boulder’s Brain Awareness Week

ICS faculty and students, in partnership with the Intermountain Neuroimaging Consortium, participate

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<sup>1</sup> <https://www.colorado.edu/ics/colloquia>



in Brain Awareness Week, which is an international week of activities focused on bringing attention to brain research. Brain Awareness Week provides a venue for ICS faculty and faculty engaging in cognitive science or related research across the Front Range to talk about their research, as well as an opportunity for students and postdocs to develop hands-on demonstrations about their research projects to educate the community about neuroscience and cognitive science research. The event takes place at ICS and in venues throughout Boulder over a week-long period each spring and is intended to be interactive and educational for audiences of all ages. In Spring 2018, 312 community members attended Brain Awareness Week events along with 71 researchers, students, and staff members.

#### Tours of the MRI imaging facility

The MRI imaging facility in the Intermountain Neuroimaging Consortium housed in ICS at the CINC building provides tours to K-12 students, college classes, and other groups as requested (e.g., Colorado politicians such as Governor-elect Jared Polis). These tours showcase the state-of-the-art magnetic resonance imaging research facility, explain how brain imaging is used to understand the brain's structure and function, and discuss research currently being conducted by researchers at the INC.



Community members engaged in a tour of the MRI imaging facility

#### Talks for community members

The research centers housed at ICS, including the Intermountain Neuroimaging Consortium (INC) and the CU Center for Research and Education Addressing Cannabinoids and Health (CU REACH), commonly host talks targeted for community members. For example, INC faculty and staff give talks about their research in both formal and informal settings such as: public libraries, community centers, churches, museums, and schools. INC has put on talks and workshops for college administrators, CU advisors, K-12 teachers, early childhood caregivers, and older adults to educate the community about various aspects of brain function, development, health, and wellbeing.

CU REACH is devoted to the development of evidence-based knowledge regarding the effects of cannabis that will improve the lives of those who suffer from disease states that may be alleviated by cannabis. CU REACH connects clinicians, community members, and researchers by disseminating empirically-based messages about cannabis and health. The center hosts outreach talks for clinics and community members, as well as discussion forums and luncheons between community members and research faculty to share research findings outside of academia.

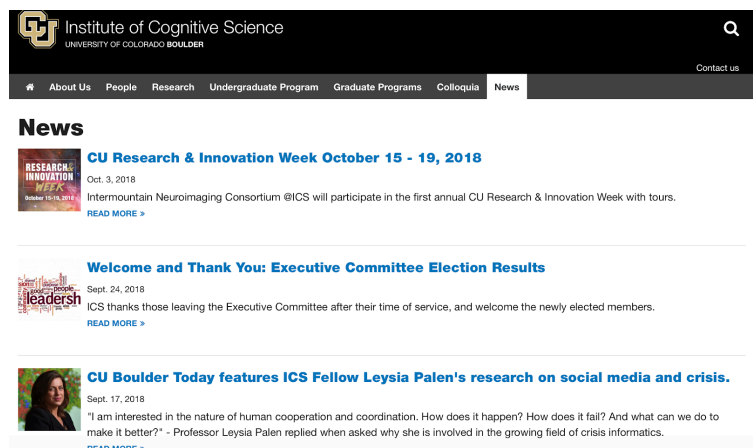
#### 4. ICS MEDIA-BASED OUTREACH INITIATIVES

ICS organizes several media-based outreach initiatives, which ensure that up-to-date information is readily accessible via the internet. This information is targeted for ICS faculty and staff, as well as for interested others around the world who want to know more about ICS events and current research.

ICS website updated with outreach news The ICS website was recently upgraded and now features a [“news” tab](#)<sup>2</sup> that provides a comprehensive, chronological list of ICS-related news. This news includes information about recent and upcoming activities such as outreach opportunities, faculty achievements, and ICS research and faculty spotlighted in the media. The website incorporates hyperlinks, pictures, and informational text, with news dating back to 2014. It is regularly maintained to include current information and upcoming activities.

##### ICS newsletter

ICS produces a newsletter two times per year (winter and spring) that is distributed to faculty, staff, students, and alumni via email and shared with the larger university and community members by posting on the ICS website. Copies of the newsletters dating back to 2016 are linked on the “news” tab of the ICS website. ICS newsletters showcase recent ICS-related events, publications, presentations, awards and grants. In addition, the newsletter



Screen shot of the ICS website showcasing outreach news

<sup>2</sup> <https://www.colorado.edu/ics/news>



spotlights a few research efforts led by ICS faculty that are currently underway.

#### ICS Outreach Coordinator

ICS has a strong history of providing outreach programs, across a variety of scientific domains, to different audiences in numerous locations. The culture of ICS is encouraging of outreach programs, and a large number of faculty and students participate in outreach scholarship. Furthermore, ICS has capacity to host some outreach activities at our existing facilities, and there are numerous other accessible spaces on the CU campus as well as within the local community for outreach events.

Moving forward, ICS intends to continue to support such outreach efforts in order to educate, connect with, and serve the broader community. To grow the institute's outreach capacity, we intend to (1) increase the visibility of current and planned outreach initiatives and (2) encourage more participation in outreach initiatives. We propose to hire a part-time outreach coordinator to help meet these goals. This individual would be tasked with developing an outreach identity for ICS, collaborating with the university's outreach and communication systems, helping to convey the message within and outside of ICS that our faculty and students welcome and encourage opportunities for outreach.

An ICS Outreach Coordinator would engage in activities such as:

- Developing an ICS outreach identity that supports the notion of bringing our research into the community
- Providing guidance regarding processes and procedures to identify outreach needs and priorities among ICS faculty, and follow through on identified targets.
- Participating in the design, planning, and promotion of outreach programs, as needed
- Collaborate with established university strategic relations, communications, outreach efforts to decrease duplication and leverage existing resources
- Ensuring that the impacts of outreach efforts are documented in detail around a variety of components such as: the scope of the activities that took place, the attendees, resources required to conduct the activities, still pictures and/or video, and reflections on the activities by attendees and/or the organizing ICS faculty.
- Building an outreach user guide to share ideas, design, planning from previous efforts so that replicating and growing outreach activities are simplified

- Maintaining a database of potential audience members, relevant outside organizations, and community leaders who would potentially be interested in attending or further promoting outreach efforts.
- *Prepared by Associate Research Professor Jennifer Jacobs and Assistant Research Professor Katie Van Horne on behalf of the Institute of Cognitive Science*



## Q.13 - UNIT CLIMATE

*Task: Describe the unit's climate.*

### INTRODUCTION

The purpose of this Unit Climate section is to provide summary remarks related to the method and results of the Institute of Cognitive Science's review of the overall culture of our program. This self-study collected information from community members through a variety of processes and forums: a university-administered climate survey, an institute-administered space survey, strategic planning sessions, a student town hall, and faculty meetings. This section of the report shares findings from the Faculty Affairs Survey and the Student Town Hall.

Specific questions addressed and highlighted here include:

- *Are all unit members treated with respect?*
- *Is there a positive social climate for all groups?*
- *How is the civility?*
- *Is there a supportive and cordial environment?*

In addition to the contribution these reflective studies can provide for this ARPAC document, preliminary findings from the university administered climate survey (March 2018) and an ICS all faculty meeting (April 2018) informed the creation of an ICS Inclusivity Statement which was added to the ICS Bylaws in May of 2018. Below is an account of the methods, summary remarks, and specific responses from the Faculty Survey and Student Town Hall.

## UNIVERSITY ADMINISTERED CLIMATE SURVEY

In the spring of 2018 the Institute of Cognitive Science (ICS) director, Tammy Sumner with support of the ICS executive committee worked with the University of Colorado Office of Faculty Affairs to develop a single survey that could be used by all units to assess the degree to which ICS provides a welcoming and inclusive work environment. We were amongst the first of CU institutes to conduct such a study. This survey was made available to anyone employed by ICS including faculty, fellows from affiliated units, support staff, and students with an appointment within the institute (GRAs). As per CU policy, the survey *was not* sent to graduate students enrolled in the ICS certificate or dual PhD program though a student run town hall meeting was later held to gain student perspective on similar issues covered.

After consulting with the ICS director, staff in the Office of Faculty Affairs organized the survey and finalized the specific language. The questions varied based on the category of participant, though all responses were in the form of a five point Likert-like scale with options including: strongly agree, agree, disagree, strongly disagree or don't know / not applicable. This version of the self-study was made public for a 10 day period March 13-23, 2018. Participants were invited via email and several reminders were sent out. A total of 66 usable responses were gathered.

The overall summary of the Faculty Affairs survey indicates that in general faculty, staff, and students agree or strongly agree that ICS is a positive and supportive environment for all parties involved.

Specifically, respondents indicate that they feel respected and valued in the community. Two broad patterns do emerge in the data. First, many respondents indicate 'Don't Know / Not Applicable' to questions related to the experience of women, people of color, LBTQIA community members, and persons with varied political and religious beliefs. This may be indicative of a lack of diversity or visibility for these groups in the ICS community. Also, though ICS employed graduate students feel that their peers and most faculty respect and are friendly with them, there appears to be a wide range of student perception of how they are supported or valued in the community.

## DETAILED SUMMARY OF FINDINGS FOR FACULTY, STAFF, AND STUDENTS

### ICS Faculty and Fellows from Affiliated Units

99 individuals were invited to participate in this study. 56 responses were gathered though only 51 qualified as 'complete responses' and were included in the compiled data review for a total of 52% participation. Not including basic logistical matters the survey included 18 questions sorted into three broad categories.

Category 1 "I am treated with respect by..." followed by particular members of the ICS community. It is notable here that not a single respondent indicated disagreement or strong disagreement to these

questions. For the ‘Institute Director’ 84% indicated strong agreement with 14% indicating agreement. For ‘ICS Faculty Colleagues’ 80% had strong agreement and 18% agreement. For ‘ICS Staff’ 82% strong agreement and 14% agreement. And For ‘Students’ 78% strong agreement and 14% agreement. The notably higher 8% not applicable response related to students may be telling of faculty or fellows not directly working with students. Overall these responses indicate that faculty strongly agree they are treated with respect.

Category 2 “In ICS, the social climate is generally positive for...” Again, no respondent indicated ‘strong disagreement’ and only three responses indicated ‘disagreement’. What is most notable here is the number of ‘don’t know / not applicable’ as discussed below. For the categories of ‘Faculty of All Ranks’ and ‘Women Faculty Members’ 60-62% strongly agreed with 24-29% agreement. The question related to women had a 15% ‘don’t know response’. In the next three questions a pattern begins to emerge. For questions related to ‘Faculty of Color’, ‘Faculty of Different Sexual Orientation’, and ‘Faculty Regardless of Religious’ views each response has a 39-41% response of ‘Not Applicable / Don’t Know’. (and a 40-50% of strongly agree). One reading of the markedly increased number of ‘Not Applicable / Don’t Know’ may be indicative of a lack of diversity related to race, sexual orientation, or religious views in the ICS program, or at least a lack of awareness of how & where this exists.

Category 3 “Support and Civility” Faculty respondents strongly disagreed at a rate of 60-62% that other faculty, staff, or students behave in ways that intimidate or humiliate them. There are however, 5 respondents that strongly agree or agree with this statement. The rate of faculty members expressing that they strongly agree or agree that faculty members are supportive of each other, they are valued in the ICS network, and ICS is a positive community is in the 90-94% range.

### **ICS Staff Members**

5 individuals were invited to participate in this study and 4 responded (one staff member was on parental leave). Not including basic logistical matters the survey included 18 questions sorted into the same three categories as indicated above.

Category 1 “I am treated with respect by...” followed by particular members of the ICS community. No responses indicated disagreement or strong disagreement. 3 of the 4 staff members strongly agree that the ICS director, ICS faculty and ICS students treat them with respect (the other respondent ‘agrees’). As to being treated with respect by other staff members 2 respondents strongly agree and 2 agree.

Category 2 “In ICS, the social climate is generally positive for...” These responses vary from those provided by ICS faculty in that no respondent indicates ‘Don’t Know / Not Applicable’ as was an emergent trend in faculty responses. Instead 3 of 4 staff strongly agree that ICS is a positive environment for women, people of color, LBTQ staff, and persons with varied political and religious beliefs. The fourth respondent ‘agrees’ with these claims.

Category 3 “Support and Civility” For some questions in this category responses vary pretty widely with no clear pattern. However, for the majority of the questions staff strongly agree or agree that there is a positive, inclusive, and welcoming culture in ICS. The most distributed response concerns comments that staff may feel intimidated or humiliated with some agreement (1), disagreement (2), and strong disagreement (1).

### **ICS Graduate Research Assistants or Teaching Assistants**

19 individuals were invited to participate in this study. 12 responses were gathered though only 11 qualified as ‘complete responses’ and were included in the compiled data review for a total of 58% participation. The same 18 questions were asked respondents with some slight variation to capture the student experience.

Category 1 “I am treated with respect by...” Overall, with a response of 84-99% agreement or strong agreement students do feel respected by ICS faculty, staff, and other students. There is some variation though in the relationship students have with their academic advisor. 8 respondents strongly agree they are respected by their advisor while there is one response each for agreement, disagreement, or strong disagreement.

Category 2 “In ICS, the social climate is generally positive for...” These student responses reflect the pattern in the faculty section to an even greater degree. For questions related to the positive experience of female graduate students, people of color, LGBTQ students, and persons with varied political and religious beliefs 45-55% of respondents claim, ‘Don’t Know / Not Applicable’. The rest of responses are split between strong agreement or agreement, with one respondent indicating that they did not feel that ICS is a positive environment for students of different sexual orientations.

Category 3 “Support and Civility” The responses here seem telling of a wide variety of student experiences. Only two clear patterns emerge. 81% of respondents indicate that both faculty and students are friendly and supportive of other faculty or graduate students. Similarly, 81% of respondents do not feel that their peers act in an intimidating or humiliating manner. However, 2-4 of the respondents do feel that faculty incivility is negatively affecting the ICS program, that faculty humiliate or intimidate students, and that as students they do not feel valued in the ICS community. In short, it appears that there is a positive and friendly support network amongst students and faculty, though the overall level of perceived civility from faculty to students varies from student to student.

## STUDENT RUN TOWN HALL MEETING

As noted earlier, the only ICS graduate students included in the March 2018 Climate Survey were students currently employed directly by ICS as Graduate Research Assistants. This did not include graduate students involved in the ICS certificate or Dual PhD program that held GRA or TA post paid



for through their home department. As such, the initial survey did not include the perspective of the majority of actively involved graduate students. To address this lack of student voice the ICS Executive Board student representative worked with the ICS director to develop a ‘town hall’ meeting for graduate students to come together and share thoughts related to the ICS climate, the sense of inclusivity and engagement, and future directions of the ICS program.

The Student Town Hall meeting was held in September of 2018 during a regularly scheduled colloquium block. The meeting was facilitated by the ICS Executive Committee student representative, and by design ICS staff, faculty, or fellows were not present. The absence of anyone who may be perceived as being in a supervisory role was designed such that graduate students could speak candidly and honestly about their experiences. Fourteen students participated, three of whom had been involved in the ICS program for three or more years. The rest of participants were in their first or second year of the program. The overwhelming majority of participants were from the CS or PSYC program. The student representative gave a brief overview of the ICS program and a review of the minutes from the faculty strategic planning meeting. For the next hour, students broke into small groups to discuss student opportunities, sense of belonging, and overall climate of the ICS community. A large group discussion followed related to the graduate student experience of ICS. Results of this town hall were shared with the ICS director and executive committee and are summarized below.

The overall summary of the student town hall conversation was that students do feel supported and included in the ICS community once they manage to ‘break into’ that social space. More tenured students indicated support from faculty and ICS members, though noted that it was at first difficult to navigate how to participate or be included outside of their home department. Suggestions for increased inclusivity focused on more opportunity for collaborative research or graduate appointments outside of their home unit, more informal social events, increased promotion of events across disciplines, and more clear student guidelines of academic expectations and opportunities for involvement.

### **What Opportunities are there for ICS students to be involved in the program?**

This discussion focused on opportunities and pathways for students to actively engage in the ICS community. Students identified that the primary ‘point of entry’ to the ICS community is through attending the weekly colloquium series. People appreciated the breadth of topics covered as this introduced less tenured students to the wide variety of research that ICS members engage in. Students also were eager to attend future poster sessions, social events, and research talks that would provide more opportunity for interaction and discussion, as this is not often afforded at colloquia. The required practicum course was also a highlight as students are able to share their advanced work in a small group setting with their peers.

Overall, the constructive comments concerned how to further promote interdisciplinary collaboration between departments. Graduate students noted that it is often difficult to get to know faculty or students from ICS outside of their home unit. There was interest in different research labs hosting ‘open

house' events or other opportunities to share out their work and discuss opportunities for collaboration. Specifically, participants were interested in GRA appointments and faculty mentorship from outside their own department and did not currently know if there is an avenue to pursue this. Participants also had a desire for more interactive, informal social events to promote community building and increase their sense of being valued and heard. A more detailed community calendar showcasing events in all departments was suggested.

### **Support for ICS Graduate Students**

More tenured graduate students noted that once they actively developed a support network on campus faculty were very helpful and encouraging. However, all students noted that ICS can be a hard community to 'break into' unless the student's primary academic advisor is already somehow involved. Students noted that the website, course requirements, and ICS program can be difficult to navigate unless they have clear primary point of contact & support. While Computer Science and Psychology students felt there was an obvious pathway to become involved, students from 'more peripheral' departments felt less connection and support. Suggestions for future development included having a peer cohort model of students, opportunities to work in other departments, a secondary advisor, a shared physical space, and an up-to-date ICS 'student handbook'

### **Interdisciplinary Work & Inclusivity in ICS**

This discussion primarily focused on how ICS could be more inclusive and inviting to students. More advanced students indicated that often the 'interdisciplinary' scope of their work primarily came by way of advising and conversation with faculty that the students worked to cultivate relationships with. Less tenured students were unclear how to do this. Suggestions for future work to promote interdisciplinary work and inclusion included a more regularly published newsletter showcasing ICS community members work, an ICS student representative for each department, GRA work in other departments, and 'less intimidating' (read more informal / casual) community events.

### **Student Progress & Long Term Connection**

Students indicated that they would like to see connections and social bridges to ICS alumni.

Participants expressed that they are curious to know what career trajectories alumni follow, so as to understand what sort of opportunities may be available to them in the future. These graduate students said that they themselves would be open to an ongoing relationship with ICS once they themselves graduated, and imagined past alumni would as well. Students also felt that ICS could work to increase its social & academic profile through outreach on campus, advertising the program, and working to diversify participants and opportunities.

## CONCLUSION

The Institute of Cognitive Science has made deliberate efforts through a variety of activities and venues to provide our community members a platform to vocalize their experience in ICS and suggestions moving forward. The data compiled from the Faculty Affairs Survey and Student Town Hall indicate that despite the widely varied experiences of faculty and students, our community members feel supported, included, and that they operate in a positive social environment.

- *Prepared by Stephen Sommer, Doctoral Candidate and ICS Executive Committee Student Representative (2017-2018), on behalf of the Institute of Cognitive Science*



## Q.14 - INCLUSIVENESS

*Task: Address inclusive excellence as a unit goal.*

### INCLUSIVE EXCELLENCE AT THE INSTITUTE OF COGNITIVE SCIENCE

***“Navigating, embracing, and understanding a diverse environment can take considerable time, energy, and work, but it must be done if our institutions are to be successful.”***

- ***Stapleton, L. (2015) The Disabled Academy: The Experiences of Deaf Faculty at Predominantly Hearing Institutions. Thought & Action, 3(2), 55-69***

The Institute of Cognitive Science understands the importance of inclusion, diversity, and equity to its research and teaching excellence. Inclusion, diversity, and equity:

- enable faculty, students, staff, and affiliates to reach their full potential
- foster scientific innovation by bringing different perspectives to solving research problems, and
- make cognitive science more relevant to humanity’s needs by ensuring the problems to be solved represent a broad range of people.

The Institute is also aware that overcoming centuries of societal and institutional biases is not easy. ICS has always been an environment where people are welcome regardless of their field of study or position at the University, but as with many departments at CU Boulder, ICS has not made inclusion, diversity, and equity an explicit focus of attention. We are aware that there is a lot of work to be done to achieve inclusion, diversity, and equity. However, ICS is full of innovators who have never shied away from hard

problems. We are confident that concerted attention to inclusion, diversity, and equity efforts will enable the Institute to better fulfill its research and teaching missions, and to more closely align with the University's vision and strategic imperatives.

Because the Institute recognizes that research, teaching, and mentoring become stronger and more relevant by bringing different perspectives to the table, ICS has identified excellence in inclusion, diversity, and equity as an explicit goal for the next decade. Below we outline the current state of inclusion, diversity, and equity work at the Institute, provide an overview of our current efforts to become more diverse and inclusive, and lay out an initial plan to enable us to become a model of inclusive excellence at the University within 10 years.

## CURRENT STATE OF DIVERSITY AND INCLUSION

The Institute does not have any official data on the diversity of its current faculty, staff, students, and affiliates as it does not formally track this information. Unofficially, when focusing on race, ethnic, and gender diversity, ICS faculty has:

- fairly equal gender balance
- a large percentage of white, non-Hispanic faculty
- No Black or Hispanic faculty

The Unit Climate document demonstrates that the Institute has the basic ingredients for being a place where inclusion, diversity, and equity can thrive:

- Members of the ICS community have a basic level of respect, empathy, and openness to different perspectives
- ICS leadership is open to hard discussions and challenges from anyone in the ICS community
- Faculty, staff, students, and affiliates generally feel respected

The Unit Climate document also suggests there may be a lack of understanding of what it means to be an inclusive, diverse, and equitable organization, and why it is important to infuse all ICS activities with a focus on inclusion, diversity, and equity:

- It is not clear whether this climate perception is the same for people of different races, ethnicities, genders, sexual orientations, ages, physical capabilities, family status, and other forms of diversity because demographic data were not collected.

- A large proportion (up to 40%) of ICS faculty and student respondents reported not knowing what the experiences are within ICS of people of different races, ethnicities, genders, sexual orientations, ages, physical capabilities, family status, and other forms of diversity.

This latter result raises several issues that the Institute will need to grapple with going forward:

- There may be a lack of awareness of diversity and inclusion issues in our community, indicating that more education and assessment needs to be done to understand barriers that may inadvertently create discriminatory practices.
- Historically, the Institute has focused on developing practices and policies for incorporating and welcoming faculty, students and other participants from a wide range of disciplines, departments, Schools and Colleges. This emphasis on intellectual diversity is visible in the [ICS Inclusion Policy](#). We will need to extend our policy to recognize and support diversity in other characteristics of the individual.
- When combined with lack of diversity in our faculty and membership, these results suggest that some members could be blind to differences rather than openly recognizing systematic “otherism” and its negative impacts on faculty, staff, and student success.

Discrimination can often exist in the form of unnoticed barriers through organizational policies and practices that discriminate against individuals by excluding them from participation (systemic barriers); or when some individuals hold negative perceptions and beliefs about an individual’s ability based on the person’s differences from the majority culture (consciously or unconsciously; social/attitudinal barriers). A greater awareness of inclusion, diversity, and equity issues will enable ICS to identify and find innovative ways to remove these barriers to inclusive excellence, as well as to ensure all faculty, staff, and students understand the importance of explicitly focusing on increasing equity and diversity in the Institute, and working toward inclusive excellence.

## INITIAL EFFORTS TO FOSTER DIVERSITY AND INCLUSION

There have been efforts within ICS to intentionally foster inclusion, diversity and equity, particularly among outreach programs which are often targeting underrepresented-in-STEM groups. For example, for four years Dr. Marie Banich was a co-PI on an award from the Office of Outreach and Engagement for a K-12 neuroscience outreach program in which CU students taught neuroscience lessons to K-12 schools across Colorado. Dr. Nicole Speer managed the outreach team, and intentionally recruited a diverse team of undergraduate and graduate students such that a majority of the male and female students in the program identified as one or more of: Black, Hispanic, LGBTQ, first generation college students, immigrants, military, and/or low income. The students themselves developed and



implemented K-12 neuroscience lessons and events, and the program focused on reaching classrooms in which a majority of the students were low income, non-white, Hispanic populations. The program was highly successful in providing a diverse team of undergraduates with a community and support network, mentorship, and valuable professional development opportunities that are not found in a traditional college classroom.

Building on its outreach work, the Intermountain Neuroimaging Consortium is in the early stages of developing a paid research internship program, with guidance from the [Student Academic Success Center](https://www.colorado.edu/sasc/) (SASC)<sup>1</sup>, which is expected to be implemented for the 2019-2020 academic year. SASC is an organization on campus that has as its mission providing equal opportunity for academic development and excellence for all students—especially those who are: underrepresented, low income, first generation in college, educationally disadvantaged, physically or learning disabled, non-traditional students, affected by bias. Given SASC's expertise in supporting a diverse student population, they are ideal partners to initiate a research internship for traditionally underrepresented students.

The internship will focus on providing interns with specific research and professional development experiences that will increase students' readiness for careers and graduate study in cognitive neuroscience. Currently research opportunities in research teams working at the Intermountain Neuroimaging Consortium are not always equitable. They rely on volunteer research assistants which is by nature a restricted population (typically wealthier, white, non-Hispanic students who can afford to volunteer their time), and research teams are often looking for students who have had prior research experience (who are again typically wealthier, white, non-Hispanic students). This internship program is a first step to ensuring underrepresented students are represented in brain imaging research at the INC, and receive the additional supports needed to excel in this field. Although the specifics of this program are still in development for the next 3-4 months, the program will be fleshed out and documented by spring 2019, at which time it would be available for review.

These student-focused efforts have been important steps in creating a more diverse and inclusive environment. The efforts are limited in that there is minimal or no faculty representation in some groups to provide role models for students and junior faculty. In addition, although ICS faculty and administrators are committed to supporting diverse groups of students, there is currently no standard within ICS, or within the University as a whole, to ensure potential research mentors are adequately prepared to support the unique needs of a diverse student population. In setting the goal of becoming a model of inclusive excellence in teaching and research at CU Boulder, ICS recognizes that inclusion, diversity and equity work will need to be done in collaboration with partners across the University to

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<sup>1</sup> <https://www.colorado.edu/sasc/>

take advantage of existing and planned resources and supports. Having always recognized the value of interdisciplinary work and partnerships, the Institute is excited to undertake this effort and grow its connections within the University community.

## PLANNED EFFORTS TO BECOME A MODEL OF INCLUSIVE EXCELLENCE

As of November 2018, the University is currently in the process of finalizing its Inclusion, Diversity, and Excellence in Academics (IDEA) plan, and ICS's near-term goal is to have a strong foundation to support inclusion, diversity, and equity efforts by the end of the 2019-2020 academic year. Achieving this goal will enable ICS to take advantage of the resources and opportunities that will begin to arise from the IDEA plan. By focusing on departmental buy-in and building foundations now that can take advantage of these broader University resources as they arise, ICS will ensure a strong start to its efforts to become a model of inclusive excellence. The plan below includes a timeline and goals for building this foundation over the next 18 months and developing a strategic plan to guide the Institute's inclusion, diversity and equity work over the next decade.

### INITIAL INCLUSION, DIVERSITY AND EQUITY GOALS

This self-study has generated the following recommendations, with the aim of making improvements to our culture, policies and practices by June 2020. Institute leadership is committed to working with our Executive Committee, faculty, staff, students, and other members to refine and implement these recommendations:

- Develop internal processes and leadership to coordinate the Institute's inclusion, diversity, and equity efforts, identify and lead the work that needs to be done, communicate transparently with all of ICS, and stay abreast of University-wide diversity and inclusion efforts
- Extend and regularly refine the ICS Inclusion Policy to reflect ICS's emerging vision for excellence in inclusion, diversity, and equity
- Use the CU IDEA plan as a foundation to develop a vision and strategic plan for ICS to become a model of diversity, inclusivity, equity, and anti-discrimination at the University in 10 years, including identifying hidden biases and barriers (if they exist), and generating specific outcomes and benchmarks to monitor progress toward goals
- Work with groups on campus with the appropriate expertise to assist ICS in initially assessing and then regularly measuring and monitoring inclusion, diversity, and equity in the ICS community across all levels

- Identify groups that do not have a voice at our table and actively seek out individuals from those groups to join the ICS community across all levels (e.g., finding diverse candidates to support for the [Chancellor's Post-doctoral Fellowship Program](#) <sup>2</sup>)
- Partner with groups on campus to create sustainable, innovative ways to increase inclusion, diversity, and equity by creating more equitable work environments for students (e.g., hiring undergraduate research assistants from the work study program rather than using volunteer research assistants, identifying a mechanism for transportation to and from the CINC building, and providing specific training in research and professional skills to enable more students to excel in ICS research teams).
- Improve our culture and capacity through training (e.g., by requiring training on best practices for diverse and inclusive hiring for everyone who participates in the hiring process such as the 1-hour training led by Dr. Theresa Hernández, Professor of Psychology and Neuroscience and Associate Dean for Research at CU Boulder) and promoting existing campus-based training opportunities to ICS faculty, research associates, staff, students (e.g., implementing trainings by Amy Moreno, Diversity and Inclusive Education Program Manager at CU Boulder)
- Encourage participation in the annual CU Inclusion & Diversity summit for continual learning
- Identify a mechanism and/or funding sources to support a graduate student or post-doctoral fellowship related to inclusion, diversity, and equity

## RESOURCES REQUESTED TO FACILITATE INCLUSION, DIVERSITY, AND EQUITY WORK

While there is significant work to be done in turning ICS into a model of excellence, the coordination of inclusion, diversity and equity efforts could be accomplished with a 25% FTE administrative position for someone with a graduate degree, leadership and management experience, and experience working with a broad range of individuals and building collaborations across campus. There are sufficient resources being developed at CU Boulder that if someone is dedicated to the coordination of this work, they can maximize the efficiency of the Institute's inclusion, diversity, and equity efforts (e.g., assessing and regularly monitoring diversity and barriers to/progress in inclusion and equity; setting up a training program for students; recruiting more diverse students; coordinating trainings for faculty, research assistants, and staff; leading a committee focused on inclusion, diversity, and equity; building

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<sup>2</sup> <https://www.colorado.edu/postdoctoralaffairs/current-postdocs/chancellors-postdoctoral-fellowship-program>

connections with partners across the University; and learning about and sharing best practices for inclusion, diversity, and equity).

## SUMMARY

Overall, the Institute has the basic ingredients required to achieve excellence in inclusion, diversity, and equity, and has openly recognized that excellence in these areas will make ICS research, teaching, and mentoring stronger and more relevant to the vision of the University and the needs of the 21st century. The Institute has an initial plan to take advantage of growing momentum at the University, and is motivated to take advantage of growing momentum at CU Boulder to become a model of excellence in inclusion, diversity, and equity within the next 10 years.

- *Prepared by Drs. Nicole Speer, Prof. Tamara Sumner and Ms. Yasko Endo for the Institute of Cognitive Science*

## REFERENCE DOCUMENTS

Academic Futures - [https://www.colorado.edu/academicfutures/sites/default/files/attached-files/academic\\_futures\\_report\\_100118\\_final.pdf](https://www.colorado.edu/academicfutures/sites/default/files/attached-files/academic_futures_report_100118_final.pdf)

IDEA Plan - [https://www.colorado.edu/odece/sites/default/files/attached-files/idea\\_plan\\_draft\\_11.2018.pdf](https://www.colorado.edu/odece/sites/default/files/attached-files/idea_plan_draft_11.2018.pdf)

CU Boulder Strategic Plan - <https://www.colorado.edu/chancellor/strategic-plan>

Sample Inclusive Excellence Statement/Policy - <https://www.colorado.edu/chancellor/strategic-plan>

[ICS Inclusiveness Policy](#) - <https://www.colorado.edu/ics/about-us/inclusiveness-policy>



### Q.15 - MENTORING

*Task: Describe the unit's mentoring process.*

The Institute of Cognitive Science provides mentoring to its own tenure-track faculty, research faculty, as well as relevant faculty in the academic departments.

#### INSTITUTE ROSTERED TENURE-TRACK FACULTY

Tenure-track Institute faculty are mentored in accordance with the normal procedures of their tenure home department. Typically, tenured Institute faculty take the lead on mentoring pre-tenured faculty through the tenure home department's processes. The relevant department chair or their designate provide feedback to the Institute director on the status and progress of the faculty. The Institute cooperates with the departments in addressing any issues that arise.

At the current time, the Institute's sole pre-tenure faculty, Prof. McKell Carter, is mentored by former director Prof. Marie Banich in accord with the policies of the Department of Psychology and Neuroscience. Prof. Al Kim, also of Psychology and Neuroscience, was also mentored by Prof. Banich and was successfully tenured and promoted to associate professor in 2012 at the beginning of the current review cycle.

#### INSTITUTE RESEARCH FACULTY

University policies specify that research faculty have a promotion path that parallels tenure-track faculty. The Institute assumes the role of directly mentoring its associate and assistant research professors. Each research professor is assigned an Institute faculty as a mentor. The mentor meets with the faculty on a regular basis and provides input on university and ICS policies and procedures with

respect to promotion, annual merit review and any teaching or advising issues. Special attention is given to publishing strategies, grant preparation, budget management, and graduate student advising.

Mentors report annually to the director and the ICS executive committee.

## MENTORING DEPARTMENT FACULTY

Institute faculty also serve as mentors for non-ICS tenure track faculty, many of whom are ICS Fellows, in their home departments where appropriate, again in accordance with the policies of the home department. Over the years, Institute faculty have provided formal and informal mentoring to faculty in Computer Science, Information Science, Linguistics, and Psychology and Neuroscience.

- *Prepared by Prof. James Martin on behalf of the Institute of Cognitive Science*





## Q.16 - BYLAWS

*Task: Attach a copy of the unit's bylaws.*

### INTRODUCTION

The Institute's bylaws were significantly updated over the course of Spring semester 2018. This effort was led by members of the Executive Committee. The bylaws went through multiple revisions based upon feedback from both the broad membership of the Executive Committee as well as the ICS community, during a two week community discussion and review period. Faculty and Fellows were also asked to provide comments during our spring Strategic Planning session. Version 1.1 was approved unanimously following an anonymous vote by the Executive Committee.

#### [Bylaws for the Institute of Cognitive Science](#)

The unit's bylaws address promotion and tenure, but not merit review. Over the past two years, ICS leadership and the Executive committee have worked to create consistent rubrics and processes supporting merit review for both tenure track and research professors.

#### [Merit Review for the Institute of Cognitive Science](#)

- Prepared by Prof. Tamara Sumner on Behalf of the Institute of Cognitive Science



## Q.17 - ASSESSMENT

*Task: Describe the unit's undergraduate and graduate learning outcomes assessment procedures.*

### INTRODUCTION

The Institute of Cognitive Science has multiple interdisciplinary academic programs: an undergraduate certificate program, two graduate certificate programs as well as two combined Ph.D. programs. These programs derive from collaborations with nine academic departments that affiliate with the Institute. The details of the academic programs are covered in *Q4: Interdisciplinary Education*. Because the Institute is not an admitting program, our academic programs rely primarily on cross-listed department courses. Indeed, only three graduate courses, “Issues and Methods in Cognitive Science”, “Topics in Cognitive Science”, and “Cognitive Science Practicum”, as well as one undergraduate course “Introduction to Cognitive Science” are provided by the Institute. The remaining approximately 100 courses that are part of our programs are cross-listed from other departments. As such, there is high dependence on coordination with the departments in order to recruit and track students and to assess performance.

The current state of outcomes assessment has involved evaluating student performance through grades in the Issues and Methods, Topics and Practicum courses. It has also involved performing regular tracking of students in the certificate and Ph.D. programs to ensure that students have taken the correct courses and are progressing in a timely fashion. However, no formal measures of outcomes have been used. In this section, we propose to create a more formal outcomes measurement process and describe a plan, as well as the additional resources needed, to develop the process.

### DEVELOPING THE LEARNING OUTCOMES ASSESSMENT PLAN

We propose four steps to build an effective learning outcomes assessment plan. The steps are 1) Identify what information we want to know, 2) Refine the goals of the teaching mission, 3) Identify the student

learning objectives tied to the goals, and 4) Develop and refine the assessment methods that are aligned to the student learning objectives. Components of some of these steps have been done previously. But we propose to create a process that will combine them to develop the full outcomes assessment plan.

**1. There are a range of potential goals that the Institute would like to achieve from an Outcomes Assessment.**

These include:

Curriculum Evaluation: To confirm that the actual knowledge/skills students acquire by completing the requirements is consistent with the intended goals of the curriculum.

Student Success: To better monitor student success across the programs, identify gaps, and suggest initiatives to enhance the educational experience.

Evaluate Alumni Success: To ensure that graduates/certificates demonstrate competencies that employers in relevant fields identify as prerequisites for success. We recognize that most students go into industry and so we must evaluate preparation of students for both academic and industry tracks.

Measure Program Effectiveness: To gather and aggregate evidence across the programs – not just in individual courses -- to measure effectiveness and guide efforts to continuously improve the quality of the programs

Accountability: Provide evidence that demonstrates the value students receive from participating in our program.

Not all of these goals can be easily achieved equally and so we will determine which of these goals should have greatest priority and how to balance how we will address these goals in the plan.

**2. We will refine the mission statement for student learning.**

The current mission statement is: To teach students the skills, dispositions and mindsets of 1) computational and methodological approaches; 2) cross cutting ideas in order to develop an appreciation of theories, methods and techniques outside of your core discipline; 3) domain content skills and disciplinary knowledge.

The current program provides an introductory level course designed to develop students' understandings of the requisite skills, dispositions and mindsets. The practicum then gives them practice in applying these understandings in a rich variety of research contexts. The courses provided by the departments provide the broad cross cutting theories, methods and techniques as well as the domain and disciplinary knowledge.

### **3. Once we have reified the goals for student learning, we will identify the student learning objectives tied to those skills.**

These objectives will be identified within the ICS courses, but will also be identified in consultation with ICS faculty and instructors from courses across the collaborating departments.

### **4. Determine the assessment methods that can measure how students meet each learning objective.**

This can be accomplished within the ICS courses, but we recognize that we can not measure as much in courses within the associated departments. However, we can measure beyond the course level. For example, as part of the process to develop the learning outcomes assessment, we will examine more carefully what courses students take and how well they do. We anticipate that we will do a mixture of measures of course performance, practical experience (lab work, interdisciplinary work), measures of where students go, and how successful alumni are at using the skills gained in ICS.

## IMPLEMENTING OUTCOMES ASSESSMENT

Unlike many departments, across ICS students there are a wide range of plans of study, thus there is no single *correct* outcome for any student. Indeed, because of the interdisciplinary nature of the field, each student may take a unique path.

We also recognize that we are highly dependent on other departments to provide critical data as well as human resources to list and manage our courses. As an Institute, we are not allowed to directly access the University's course management systems; we rely on staff in other departments such as computer science to list courses, manage room and instructor assignments, and to add and drop students - *even for our own ICS courses*. In order to be successful in measurement we need to acknowledge that unlike a department, we can't talk about learning outcomes without these additional data and course listing/management resources being provided by partnering units. As such, we will need to identify ways to work with associated departments on tracking students and measuring outcomes.

## WHAT WE NEED TO ACCOMPLISH IT

It should be noted that accomplishing such an assessment program can not be done without additional resources. The proposed work would require significant administrative help and the commitment of ICS faculty to join the team for a project that could span an academic year as well as be done periodically, for example, every 5 years. Currently, financial support for our educational programs is provided by ICR

from grant expenditures which is used to pay for administrative staff support, graders, and other teaching expenses. Developing and implementing a robust learning outcomes assessment plan will require the University to provide administrative support for our educational programs.

- *Prepared by Prof. Peter Foltz on behalf of the Institute of Cognitive Science*





## Q.18 - CENTERS

*Task: Reauthorize affiliated centers.*

### PURPOSE GOALS AND EVALUATION OF THE CENTER

The goal of the Center for Research on Training is to optimize through training the efficiency, durability, and generalizability of knowledge and skills. This research has been supported continuously by federal agencies, including the Army Research Office (ARO), the Army Research Institute, the National Science Foundation (NSF), the National Aeronautics and Space Administration (NASA), and the Air Force Office of Scientific Research (AFOSR). The CRT Faculty Advisory Board will convene annually to evaluate the Center's progress toward that goal, based on assessment summaries generated and maintained by the Center Codirector.

One important goal of training research to be done in the Center is to construct a theoretical and empirical framework that can account for and make accurate predictions about the effectiveness of different training methods over a large range of tasks, including military, industrial, vocational, and academic tasks. The ability to predict the outcomes of different training methods on particular tasks will, as a natural by-product, point to ways to optimize training outcomes. Many of the basic mechanisms of knowledge and skill acquisition are similar across a variety of perceptual, cognitive, and motor tasks. However, some specific skills have unique features that might demand special training techniques. One focus of the Center is an analysis of which findings, mechanisms, and principles broadly generalize across learning types and task requirements. This evaluation allows us to make specific predictions about the effectiveness of training and general recommendations to improve training that would apply to virtually any training program. The Center also aims to identify the unique features of specific knowledge and skills, where they exist, and how best to train them. The Center works to develop taxonomies for both types of training and types of tasks that will span the range of training types, from classroom to simulator, and task types, from simple individual laboratory tasks to



complex tasks involving team cognition. The Center develops and contrasts several working predictive models of training effects and assess their ability to account for and predict training outcomes.

In addition, the Center provides a mechanism to interact with industry, government agencies, and educational institutions to produce guidelines relevant to their training needs. An example of potential interaction with private enterprise is collaborative work with personnel from Alion Science & Technology, a Boulder software corporation, on predictive modeling of the effects of training on performance, and from Pearson Knowledge Technologies (PKT), a Boulder educational software company, on laboratory studies of language acquisition. The Center also provides an opportunity for undergraduate and graduate students and for visitors from other universities and non-academic institutions (e.g., the military, federal civilian agencies, or corporations) to gain hands-on experience in experimental methodology, predictive modeling, and state-of-the-art principles of effective training. As an example of the educational activity provided by the Center, we hold weekly 1-2 hour meetings to discuss current issues in cognitive psychology that are relevant to efficiency, durability, and transferability of knowledge and skills. These meetings are open and announced so that faculty and students outside the Center are welcome and invited to participate. Supplementing these regular meetings are irregularly scheduled ad hoc meetings between small groups of Center faculty and others with whom they share research interests. These meetings facilitate ongoing research and promote future collaborations and joint grant proposals.

**The purpose of the Center is to:**

1. Bring together faculty members from various departments at the University of Colorado and other universities in and outside the United States in an interdisciplinary effort to improve training. This is possibly the most important function that the Center can fulfill because it fosters collaboration and joint grants among researchers who otherwise might not get together because their formal training and current affiliations are quite disparate.
2. Conduct empirical research to identify valid and reliable principles of effective training over a broad range of domains. The outcome of this research is relevant to a variety of training types and tasks.
3. Conduct theoretical research to create models that are predictive of training outcomes.
4. Conduct taxonomic analyses of training methods, task types, training principles, and performance measures.
5. Educate undergraduate, graduate, and postdoctoral students in basic and applied research on training.

6. Transfer the outcomes of this research to governmental, industrial, and educational settings.
7. Offer independent study opportunities to students and faculty and others interested in training techniques.

In cooperation with the relevant academic departments (e.g., Psychology, Applied Mathematics, Computer Science, Education, Integrative Physiology, Linguistics, Political Science), the Center recruits and educate outstanding students for research and professional careers in the field. It also facilitates the use of effective training techniques by experts in various disciplines. It encourages students and faculty to investigate and use these techniques in their laboratories and classrooms and provide new opportunities for working with government and industries.

The Center will operate within the Institute of Cognitive Science (ICS) of the Graduate School of the University of Colorado. Many participants in the Center are already members of the Institute, but some are not. In particular, some participants are members of other departments at the University not presently connected with ICS (e.g., Applied Mathematics, Integrative Physiology, and Political Science) and other participants are affiliated with other universities (e.g., Purdue University, Carnegie Mellon University (CMU), Colorado State University (CSU), New Mexico State University (NMSU), and the University of North Carolina at Charlotte (UNCC)). Participants outside the University of Colorado (CU) are considered visiting members of the Center because their appointments reside elsewhere. The existence of the Center encourages multidisciplinary collaboration among recognized experts in the field of training research. The presence of Center members who are not already affiliated with ICS broadens the resources available to students and faculty who are currently affiliated with the Institute.

Other points of collaboration involve the Departments of Psychology & Neuroscience, Linguistics, Computer Science, Integrative Physiology, and Political Science, and the School of Education, all of which include faculty with whom we have collaborated in the past. Two examples of the issues that have been a focus of interaction between faculty in the Center and faculty in other centers and departments are (a) the effect of training variables on the acquisition of a first language by young children (e.g., Eliana Colunga, Psychology) and on a second language or on the remediation of language disorders (e.g., Lise Menn, Linguistics), and (b) alternative ways to model training and transfer effects (e.g., Michael Mozer, Computer Science).

The Center cooperates with various University departments and units to provide the facilities and infrastructure for faculty, staff, and students to conduct their work in the Center. As a part of the University of Colorado, the Center shares that institution's commitment to the education of students. Given its unique focus on training, the Center, through its research accomplishments, enhances the overall academic effectiveness of the institution.

## CONGRUENCE WITH ROLE AND MISSION OF UNIVERSITY, CAMPUS, &amp; PARENT UNIT

**The role and mission of the Center for Research on Training was developed with the explicit intention of complementing the Role and Mission of the CU System, the Boulder campus, the Department of Psychology and Neuroscience, and the Institute of Cognitive Science.** The Center is founded in a commitment to excellence, demonstrated by numerous center successes over the time it has existed. The Center encourages and supports access for all students, promotes diversity, teaching and learning, innovation, and entrepreneurship activities, for everyone. It addresses these goals both concretely, through concrete bureaucratic mechanisms, but also through its broader research purpose, as the theoretical models and frameworks developed by collaborating faculty. The CRT also contributes to ICS's mission of understanding and enhancing human cognition through the development of interdisciplinary partnerships, acting as an extension of ICS with much greater specificity and focus, complementing work from other ICS Centers that relies on diverse methodologies with different topical foci. The CRT also contributes directly to goals of the department of Psychology and Neuroscience by facilitating excellence in research and graduate and undergraduate training. The work of the Center meaningfully addresses the betterment of the human condition and prepares students to be competitive in the modern academic and professional environment.

**The Center for Research on Training is also designed to very specifically target CU's strategic plan, particularly the 3 Strategic Imperatives.** Through collaborative research among faculty within and outside of CU, the Center positively impacts humanity, contributes to shaping tomorrow's leaders, and enhances the ability of CU to remain a leader in innovation, by weakening the walls of departmental "silos" that have for so long stifled innovation. The Center for Research on Training addresses these goals both concretely, through graduate, undergraduate, and postdoctoral cross-disciplinary training, but also through the products of research – theoretical frameworks and models for optimizing training.

## INSTITUTIONAL CAPABILITY FOR IMPLEMENTING THE UNIT

**Center Faculty**

- Matt Jones, Director, Psychology & Neuroscience
- Shaw Ketels, Co-director, Psychology & Neuroscience
- Alaa Ahmed, Integrative Physiology
- Francis Beer, Political Science
- Eliana Colunga, Psychology & Neuroscience
- Susan Chipman, Psychology & Neuroscience
- Tim Curran, Psychology & Neuroscience

- Sona Dimidjian, Psychology & Neuroscience
- Bengt Fornberg, Applied Mathematics
- Alice Healy, Department of Psychology & Neuroscience
- Lise Menn, Linguistics
- Michael Mozer, Computer Science
- David Sherwood, Integrative Physiology

### Visiting Faculty

- Immanuel Barshi, NASA Ames
- Benjamin Clegg, Colorado State University, Psychology
- Cleotilde Gonzales, Carnegie Mellon University, Social and Decision Sciences
- Peter Foltz, Pearson Knowledge Technologies
- Robert Proctor, Purdue University, Psychology
- Eric Heggstad, University of North Carolina, Psychology
- Erica Wohldmann, California State University at Northridge

### Advisory Faculty

- Lewis O. Harvey, Jr., Department of Psychology & Neuroscience
- Walter Kintsch, Department of Psychology & Neuroscience
- Alice F. Healy, Department of Psychology & Neuroscience
- Tamara Sumner, Director, Institute of Cognitive Science

## ALTERNATIVE STRUCTURE

The Center is organized in accordance with the procedures and rules of the Graduate School of the University of Colorado, Boulder, Colorado. It resides in the Institute of Cognitive Science. The Center Faculty is the main body that makes major decisions regarding the Center's academic and research programs. The Center Director, the Codirector, and the Center Faculty jointly make the major decisions regarding the Center's academic and research programs.

The Center is administered by its Director, who reports to the Director of the Institute of Cognitive Science (Tamara Sumner). A Codirector has responsibility for the day-to-day administrative activities of the Center. The Business Office of ICS has responsibility for accounting and oversight of the Center finances.

The Director is recommended by the Center Faculty to the Director of ICS for appointment, and the appointment is approved by the Deans of the College of Arts and Sciences and of the Graduate School. The Director serves a four-year term and may be reappointed.

The Codirector is appointed by the Center Director, serves a two-year term, and may be reappointed.

Center Faculty include only University of Colorado faculty. Faculty members from other institutions are called Visiting Faculty and do not vote on decisions that are binding on the University of Colorado.

New Center Faculty members are recommended by the Center Faculty and appointed by the Center Director.

**Advisory Board.** The Center for Research on Training has a board to give advice and to review progress. These advisors will work in conjunction with the Center Director, the Chair of the Department of Psychology and Neuroscience, and the Director of the ICS to help guide the research and teaching efforts of the Center.

### **Provision for Changing By-Laws**

Changes in the by-laws must be approved by the Center Faculty with a 2/3 vote, either at a physical meeting or by e-mail.

## RESOURCE IMPLICATIONS

### **Sources of Funds**

The primary sources of funds for operating the Center are (1) Grants from Governmental funding agencies and private foundations and (2) Indirect Cost Recovery (ICR).

### **Indirect Costs**

It is the policy of ICS to return some portion of realized ICR to its contributing investigators for their direct support. Center grants administered by the Institute are given the same percentage of ICR as other investigators. If the policies of ICS concerning indirect cost recovery change in the future, then we expect that the Center will be subject to these possible policy changes.

### **University Matching Resources**

The University contributes to the Center by providing meeting, office, and research space. Office and research space is limited to that provided to individual center faculty in their roles as University faculty members. Meeting space is provided through ICS and the Department of Psychology and Neuroscience, subject to availability. These space resources are currently sufficient for the operation of the Center.

**Other Resources**

ICS helps the Center with equipment, staff time, and other particular needs as they arise. These needs may include communication and computing resources, new furnishings, laboratory equipment, laboratory remodeling, and other requirements to be determined.

**Note:**

The Center for Research on Training does not use direct cost grant funds for administrative (or any other) expenses typically covered by indirect costs.

**CENTER FOR RESEARCH ON TRAINING BY-LAWS**

**By-laws available upon request.**



## ATTRIBUTIONS

Self-Study responses were prepared on behalf of the Institute of Cognitive Science by the following contributors:

**Q.1 - UNIT OVERVIEW** - Prof. Tamara Sumner

**Q.2 - STRATEGIC PLANNING** - Prof. Tamara Sumner

**Q.3 - RESEARCH AND SCHOLARSHIP** - Prof. James Martin, Prof. Marie Banich, and Yasko Endo

**Q.4 - INTERDISCIPLINARY RESEARCH AND TEACHING** - Prof. Donna Caccamise and Prof. Peter Foltz

**Q.9 - SPACE AND STAFFING** - Drs. L. Cinnamon Bidwell, Donna Caccamise, Sidney D'Mello, Nicole Speer, and Katie Van Horne

**Q.11 - OUTREACH INITIATIVES** - Associate Research Professor Jennifer Jacobs and Assistant Research Professor Katie Van Horne

**Q.13 - UNIT CLIMATE** - Stephen Sommer, Doctoral Candidate and ICS Executive Committee Student Representative (2017-2018)

**Q.14 - INCLUSIVENESS** - Drs. Nicole Speer, Prof. Tamara Sumner and Ms. Yasko Endo

**Q.15 - MENTORING** - Prof. James Martin

**Q.16 - BYLAWS** - Prof. Tamara Sumner

**Q.17 - ASSESSMENT** - Prof. Peter Foltz

**Q.18 - CENTERS** - Matt Jones