Spring 5-25-2021

Faculty Perspectives on Neuroscience Interdisciplinary Integration: A Descriptive Study from the American University in Cairo

Sondos Mohamed Moshtohry
sondos.moshtohry@aucegypt.edu

Faculty Perspectives on Neuroscience Interdisciplinary Integration: A Descriptive Study from the American University in Cairo

A Thesis Submitted by

Sondos Mohamed Moshtohry

to the

International and Comparative Education

Graduate Program

May, 2021

In partial fulfillment of the requirements for the degree of

Master of Arts in International and Comparative Education (M.A. ICED) -
International Education Development & Policy

To my mother,

To every member of my family,

You fill my heart with love,

I dedicate every success to you…

Acknowledgement

To my mentor and supervisor, Professor Malak Zaalouk, thank you for your invaluable guidance and support. Throughout my journey, you have taught me how to be reflective and how to dig for deeper meanings and values.

I am grateful to all faculty members who participated in this study and to Dr. Hassan Zaky, the coordinator of the SRC Research Clinic, for his kind help with confirming the accuracy of some SPSS statistical procedures.

Abstract

The interdisciplinary approach and the science of the brain are successfully wedded. Globally, neuroscience is expanding and offering substantial advances and versatile applications within various domains affirming the worthiness of its investments; however, nationally, a similar engagement with the field is not evident. This study proposes the integrative research cloud model as a framework for interdisciplinary engagement. The American University in Cairo (AUC) is known for its forward-looking strategy and belief in interdisciplinarity that is why it was chosen as the setting for this study. Accordingly, the opinions and perspectives of its faculty from the different schools and departments on the new emerging science were explored using survey research. Also, their familiarity with the field, their attitudes towards collaboration, their beliefs of the field's relevance to their domains, and their willingness to be part of interdisciplinary brain research were all examined. Biphasic data analysis was carried out where quantitative data was analyzed descriptively and inferentially, and then qualitative data was thematically coded and studied yielding six major themes. The survey response rate was almost 30%, and nearly half of the respondents were familiar with the field. Despite the challenges, faculty were interested and willing to engage with interdisciplinary brain research, and they believed it is a timely endeavor that is worth the investment. They also trusted that AUC could be the national and regional champion in this field, and hoped to realize such engagement in the near future.

Keywords: neuroscience, interdisciplinary, brain, faculty, collaboration, HEI, AUC, integration, familiarity, survey

Disclosure

As I came to ask myself why I believe much in interdisciplinarity, I realized that my relatively multi-disciplinary background may come into play. I am a pharmacist who had the experience of university teaching in one of the private universities, and I am doing a Master's degree in education which is the field I am most zealous about. I have realized that my "scientific" background has positively influenced my educational research and career, and the opposite is also true. Being exposed to the philosophies, paradigms, and methodologies of both hard and soft sciences enriched my perspectives, and my reflections on both domains opened new doors and channels of thought for me broadening my scope of inquiry. This personal experience increased my interest and belief in the merits of interdisciplinarity.

Table of Contents

1. Introduction and Context 8
1.0. Why Neuroscience? 8
1.1. Why Interdisciplinarity? 11
1.2. Terminology 12
1.3. The International Context 13
1.4. The Regional Context 15
1.5. The National Context 16
1.6. Problem Statement 18
1.7. Significance of the Study 18
1.8. Investing in Interdisciplinary Brain Research 18
1.9. Purpose Statement 19
1.10. Research Questions 20
2. Literature Review 21
2.1. History and Emergence of Neuroscience 21
2.2. Philosophical Underpinnings of Neuroscience 26
2.3. Neuroscience, Psychology, and Education 33
2.4. Neuroinformatics, Neurotechnologies, and Artificial Intelligence 37
2.5. Neurochemistry 38
2.6. Educational Neuroscience 39
2.7. Models of Neuroscience Interdisciplinary Integration 49
3. Methodology 55
3.1. Research Framework 55
3.2. Participants and Setting 58
3.3. Study Design and Data Collection 59
3.4. Data Analysis 59
3.5. Rigor and Ethical Considerations 64
4. Results and Discussion 66
4.1. Quantitative Data Analysis 66
4.2. Qualitative Data Analysis 95
5. Implications, Recommendations, and Limitations 108

5.1. Implications 108
5.2. Recommendations 111
5.3. Limitations 111
References 113
Appendix A 126
Appendix B 134
Appendix C 147
Appendix D 149

Chapter One

1. Introduction and Context

In this chapter, the two cornerstones of the study, which are neuroscience and interdisciplinarity, are introduced. Next, the international, regional, and national contexts are examined, and the significance of the study is established. The problem and purpose statements are also highlighted. The chapter ends with the study's research questions.

1.0. Why Neuroscience?

As I continued to step into my classroom, I wished there was a way I could visualize what invisibly – at least that is how it seemed to me at the time - happens to my students while engaging in learning activities. How do they feel those aha moments? What makes their eyes shine with inspiration? The notion that the seen can tell much about the unseen and vice versa captivated me. What heartened the idea in my mind is the observation that despite the diversity of the academic content I deliver, it was mainly the art of delivery that made students' eyes shine. I kept researching, and while chasing that dream of visualizing the unseen, I got acquainted with neuroscience. Later on, I understood and studied how neuroscience is a versatile field of inquiry that is capable of connecting the seen and unseen not just in learning but in almost all phenomena related to the brain.

Neuroscience is the field concerned with investigating neural structures (the brain in particular) and how they function (Dhawan, 2014). Primarily, the field was focused on scientifically studying the nervous system which is one reason why it started as a branch of biology and why the medical field took its lead (Dhawan, 2014; Ivey, D'Andrea, & Ivey, 2012). Neuroscience later grew as an interdisciplinary field that combines knowledge from several sciences like philosophy, psychology, physics, mathematics, computer science, and medicine

(Ivey et. al., 2012). In other words, the field evolved from its traditional classification as a subfield of biology (neurobiology) to encompass almost everything that is related to the nervous system (neuroscience) (Nordqvist, n.d.).

This development of the field enriched its applications to go beyond the medical sense of diagnosis and therapy of brain disorders and diseases. Examples of non-medical brain-related research topics include artificial consciousness, artificial emotional intelligence, brain-computer interface (BCI), aesthetic experience and brain activity, stress and memory, brain rewiring and psychological distress, decision-making, emotional regulation, and brain and criminology. As West (2011) highlights, “Although they remain important in the health field, studies of the brain have also contributed to a host of enhancement techniques used outside of the medical realm” (para. 1).

Infinite questions related to the brain emerge, to which neuroscience is thought to offer “evidence-based” answers. And, even since its earlier development as a field of study, its significance for providing better understandings that are closer to truth was appreciated. That is because it can help realize “progressive elimination of error from the imaginative hypotheses, and so a progressive approximation to truth, although it must be realized that truth in itself can never be known or attained except at a trivial level” (Eccles, 1968, p.68). Such balanced expectation from brain research justifies its need despite the presence of pre-existing theories or hypotheses describing mental phenomena. Nevertheless, the interdisciplinary approach serves such process of error elimination better by integration of insights from different fields that use diverse tools while studying the same phenomenon. This will be further elaborated in the literature review and the research framework of the study.

With more technological advances, techniques used in neuroscience research developed from mere molecular and biophysical examination of single nerve cells to encompass imaging psychological, motor, perceptual, and cognitive reactions (Ivey et. al., 2012). Neuroscientific methods of inquiry include lesion studies, pharmacological manipulations, neuroimaging, single-cell and multicellular recording techniques, tract tracing, molecular biological techniques such as gene silencing and editing (Bassett et al., 2020; Gold & Roskies, 2008). Moreover, it is now even possible to control genetically modified neurons using light through optogenetics (Bassett et al., 2020).

Despite its advances and capabilities, the relevance, significance, and legitimacy of neuroscience were often questioned by some researchers in fields like psychology and education (e.g. Bowers, 2016; Bruer, 1997; Dougherty & Robey, 2018). Whether they explicitly mentioned it or not, they wished to resist the shift of the funding climate away from their own disciplines towards neuroscience projects (e.g. Dougherty & Robey, 2018). However, both advocates and critics of the field would probably agree on the importance of governing and preventing the commercial exploitation of neuroscience in marketing for tools, techniques, programs, or initiatives that falsely claim they are based on findings from brain research (Thomas, 2019).

As Sabbatini and Cardoso (2002) highlighted, “Creativity in science depends on the establishment of links between previously unrelated ideas” (p.310). In spite of the critiques, the field of neuroscience and its applications effortlessly found their way to diverse fields including economy, education, psychology, linguistics, machine learning, health, marketing, politics, information science, and more (e.g. Alvino et al., 2020; Burns, 2020; Miller & Beeson, 2021). Moreover, several international organizations embarked on neuroscience research, and a large number of international, regional, and national societies, groups, and institutes were formed.

Numerous research centers, journals, conferences, and degrees in neuroscience and its sub-specialties were also developed (Bowers, 2016). The 1990s were designated as the “Decade of the Brain” by the United States to foster advancements in brain research (Goldstein, 1994). Thus, the field elicited significant global development over the years; however, on the national Egyptian and regional African and Middle Eastern levels, we may fail to observe an equivalent growth of the field. This justifies the need for having a regional champion in the field and supports the significance of this study which will be further discussed under the significance of the study section.

1.1. Why Interdisciplinarity?

In this era, interdisciplinarity is usually found on the publicized research agenda of universities (Klaassen, 2018). The interdisciplinary approach is already one of the defining characteristics of third generation universities. Over-and-above, with more socio-economic engagement of universities and introduction of a fourth generation, universities’ roles as national, local, and global actors cannot be overlooked. Governmental and societal interactions as well as entrepreneurial functions within higher education institutions (HEIs) are no longer a luxury. Proactivity and research utilization are also compulsory. Accordingly, the economic and societal impacts of having a significant neuroscience interdisciplinary initiative at the AUC would extend to bringing local and global advantages.

That is why, this study aims at discovering whether faculty members from one of the most notable and reputable universities in Egypt, the American University in Cairo (AUC), are ready and willing to bring to the local, regional, and international community a collaborative cross-disciplinary approach to neuroscience. Known for its interest in interdisciplinary research, its forward-looking strategy, as well as its relatively advanced capacities and facilities, the AUC was selected as the setting for this study. And, to address the challenges facing this widely multi-disciplinary field, an integrative pluralistic model is suggested (Ansari & Coch, 2006; Jilk et al., 2008; Morris & Sah, 2016; Thomas, 2019), which will be explained under the conceptual framework section in chapter three.

The study is descriptive and exploratory since it does not only aim at describing a phenomenon but also attempts understanding it using both close-ended and open-ended survey questions in a mixed-method design. It is organized in five chapters. The first chapter provides an overview of the international, regional, and national contexts relevant to neuroscience, which sets the scene for stating the problem, purpose, and research questions of the study. In chapter two, the literature is reviewed for the history, emergence, and philosophical underpinnings of the field. Subsequently, the intersections of different disciplines with neuroscience are viewed, which further leads the study to the next piece that tackles neuroscience interdisciplinary integration. In the third chapter, the conceptual framework, study design, data collection, data analysis, and ethical considerations are presented. Chapter four presents and discusses the results of both quantitative and qualitative analyses, while chapter five draws on the recommendations and limitations of the study.

1.2. Terminology

Before continuing on, it is worth understanding why the study prefers to use those two terms: “integration” and “interdisciplinarity. Firstly, “integration”, in this context, offers more than just “collaboration”. That is because usually, in order to achieve integration, collaboration would have to occur; however, the opposite might not be true (Boon et al., 2009). That is to say, researchers could be collaborating without achieving integration. Most importantly, integration describes collaborative practices even better when it comes to avoiding fragmentation/cut–andpaste of knowledge that disregards contexts. Integration also implies consistency and wholeness of practices and outcomes of collaboration. And, it suits more the model of interdisciplinarity proposed by this study where insights from different disciplines dissolve into one homogenous cloud of knowledge.

As for interdisciplinarity, it is not the process of resorting to two or more fields with the aim of better understanding a certain phenomenon. This process is usually referred to as multidisciplinarity. Some scholars stress that multidisciplinarity may infer less integration while transdisciplinarity may draw attention to the overarching theories (Borrego & Newswander, 2010; Stock & Burton, 2011). However, interdisciplinarity involves integrating disciplines in such a way that novel views appear and surpass the limitations of individual disciplines (Penof et al., 2020).

1.3. The International Context

Several multilateral organizations developed interest in neuroscience throughout the years. The interest of the UNESCO in this field dates back to 1952 when Professor Alfred Fessard of the Collège de France announced a plan for the establishment of an international brain institute (Fessard, 1952). He highlighted that this institute “would meet a need for centralization and co-ordination rather than serve to awaken interest in such work” (Fessard, 1952, p.1). He further clarified that due to the inter-disciplinarity of such a science, it is important to offer effective solutions in realizing collaboration (Fessard, 1952).

It is interesting to observe how the interdisciplinary nature of this field and the need for collaboration were declared over seventy years ago, and still some areas of research within the field might be considered contested terrains that struggle with resistance to transdisciplinarity. Following Fessard’s plan, the International Brain Research Organization (IBRO) was established in 1961 with the aim of promoting neuroscience across the globe (https://ibro.org/about/). In order to realize this, they embarked on research, teaching, training, and several engagements and research activities. Moreover, the organization publishes two sister journals: *Neuroscience* and *IBRO Reports*. IBRO's flagship peer-reviewed journal, *Neuroscience,* was inaugurated in 1976 and is published by Elsevier. The IBRO's mission, as stated on their website (https://ibro.org/about/), revolves around three main themes: scientific research, international collaboration, and dissemination of information. Quadrennially, the IBRO, together with other neuroscience societies, holds an international congress on neuroscience (IBRO World Congress on Neuroscience) since 1982 with the aim of enhancing collaboration across the field. Currently, around ten international organizations are members in the IBRO (https://ibro.org/member-organizations-by-region/).

In 2013, the U.S. launched the Brain Research through Advancing Innovative Neurotechnologies (BRAIN) public-private initiative with huge investments (https://braininitiative.nih.gov/). Simultaneously, in 2013, the European Union started the Human Brain Project (HBP) which it claimed to be one of the largest research projects in the world (https://www.humanbrainproject.eu/en/about/overview/). According to the UNESCO (http://www.unesco.org/new/en/natural-sciences/science-technology/single-view-sc-policy/news/brain_research_has_become_a_policy_focus_for_china/), brain research is one of the six major science and engineering projects to 2030 in China.

Numerous interdisciplinary neuroscience programs are present world-wide and are offered at the graduate and undergraduate levels (e.g. Bordeaux Neurocampus Graduate Program; Taiwan International Graduate Program-Interdisciplinary Neuroscience (TIGP-INS) graduate program; The University of Rhode Island's graduate Interdisciplinary Neuroscience

Program (INP); the interdisciplinary program in neuroscience for undergraduates at Vanderbilt). Also, governmental and non-governmental research institutions are engaging with such enterprise (e.g. the interdisciplinary neuroscience research center at Bournemouth University founded in 2014; the Interdisciplinary Institute for Neuroscience (IINS) at Université de Bordeaux created as a research center 2011 and revamped in 2016; Interdisciplinary Center for Neuroscience Frankfurt (ICNF) founded in 2006 at the Goethe University in Frankfurt).

1.4. The Regional Context

Since the year 1993, The Society of Neuroscientists of Africa (SONA) has served as an overarching umbrella for the national and regional societies and groups of neuroscience in Africa (https://sonafrica.org/) (Russell, 2017). It is now a member of the IBRO, and it holds a biennial international conference. Over ten African organizations are currently also members of the IBRO including the Association pour la Promotion des Neurosciences (APRONES), the Mediterranean Neuroscience Society, the Southern African Neuroscience Society (SANS), and the Moroccan Association for Neuroscience. The Society for Arab Neuroscientists (SfAN) was established in 2006 to facilitate collaboration, innovation, and education of Arabic neuroscientists (http://www.arabneuroscientists.org/mission-goal.html). They partner up with the Middle East Molecular Biology Society (MEMBS) and the International Brain Research Organization-Middle East North Africa region (IBRO-MENA).

In a study conducted in the period from January 2003 to January 2013, neuroscience publications in 52 African countries were examined in certain medical databases primarily Medline (Abd-Allah et al., 2016). Egypt came second after South Africa in the total number of **clinical** neuroscience publications accounting for 19.7% of the neuroscience publications in Africa over that period. The study also reported a significantly positive correlation between the number of neuroscience publications in a certain country and its gross domestic product (GDP) (Abd-Allah et al., 2016). This finding is probably predictable, for the stronger the economy, the more attention is usually drawn to research and development at large bearing in mind national agendas and priorities. However, this second place is probably restricted to neuroscience in the medical or clinical sense whereas the broader applications of neuroscience to various fields including humanities and social sciences may not be reflected in the mentioned study since only medical databases were searched. Thus, there might be a gap when it comes to taking the applications of neuroscience beyond the medical and healthcare boundaries, which highlights the need for this study.

In the Middle East, there are few programs/centers engaging with interdisciplinary neuroscience. At the New York University Abu Dhabi (NYUAD), a couple of brain research labs were established: Neuroscience of Language Lab (NeLLab) and Perception and Active Cognition Lab. In 1997, The Middle East Technical University (METU) in Turkey established a cognitive science graduate program with an interdisciplinary perspective (https://ii.metu.edu.tr/cognitive-science).

1.5. The National Context

With the aspiration of enhancing neuroscience integrated research and supporting excellence in teaching disciplines relevant to neuroscience, a group of researchers from basic and clinical sciences established the Neuroscience Group of Egypt (NGE). The group aims at boosting collaboration and providing training opportunities for its members inside and outside Egypt as declared on their website (http://www.fayoum.edu.eg/nge/index.html). NGE is also a member of the SONA and IBRO. However, their activity in the field beyond clinical neuroscience is not evident (http://www.fayoum.edu.eg/nge/index.html).

The Alexandria Neuroscience Committee (ANC) is a non-profit organization that works in close collaboration with the Faculty of Medicine, Alexandria University and aims at reflecting the global importance of this rapidly developing field on the local level (https://alexneurocom.wixsite.com/brainbee/about). ANC targets students, public, professionals, and neuroscientists. It aspires to improve educational curriculum, enhance students' knowledge and skills, raise public awareness about the field, ensure the support of related governmental policies, and finally create a network of national and international neuroscientists from different disciplines. Moreover, ANC organizes the Egyptian Brain Bee (EBB) which is an annual competition for high school students all over the country with the purpose of learning about neuroscience. The winner may have the opportunity to participate in the International Brain Bee World Championship (IBB) whose governing partners are the International Brain Research Organization (IBRO), the American Psychological Association (APA), the Society for Neuroscience (SfN), the Federation of European Neuroscience Societies (FENS), and the DANA foundation. With the exception of the Euro-Mediterranean Master's degree in Neuroscience and Biotechnology (https://alexu.edu.eg/index.php/en/2015-11-24-10-39-04/58-academics/56-euro-mediterranean-master-in-neuroscience-and-biotechnology), very few post-graduate programs are offered in Egypt in the field of neuroscience especially cognitive neuroscience.

The growth of the field in Egypt, especially when it comes to its intersections with social sciences, might begin to thrive if a well-established well-funded organization took the lead of a neuroscience interdisciplinary program. Founded in 1919, the American University in Cairo aims at serving the region and the world through establishing a rich culture of research and providing advanced facilities. As per the university's website, it currently has 13 cross-discipline research centers, which highlights its belief in and vision towards integrative multidisciplinary research.

The American University in Cairo is probably the best fit for establishing an active and advanced research center for interdisciplinary neuroscience studies in the Middle East.

1.6. Problem Statement

Although the field of neuroscience is expanding on an international level, a similar trend in Egypt is not observed. The AUC with its vision, capacities, and facilities is thought to be a good candidate for locally mobilizing integrative research in the field of neuroscience with regard to its intersections with other sciences beyond the clinical sense. However, before planning for interdisciplinary integration, it is essential to understand the viewpoints and perceptions of faculty members.

1.7. Significance of the Study

Understanding the viewpoints of faculty and assessing their familiarity with neuroscience and their willingness to participate in brain interdisciplinary initiatives are significant components of any future planning of such initiatives. However, the significance of this study is not limited to that. With the scarcity of similar studies on the national level that describe and explain faculty's viewpoints on neuroscience and interdisciplinarity, there is a research gap that would be fulfilled. The study can also serve as a nucleus for other studies that are interested in neuroscience integration. Findings can help understand perceptions of the field, potential challenges towards it, capacities and facilities needed to embark on this kind of research in a higher education setting.

1.8. Investing in Interdisciplinary Brain Research

This final section of the chapter summarizes some of the reasons why AUC should invest in collaborative brain research based on what has been discussed. As a HEI, the research and development functions of the university would be served since there is much room for discovery and innovation in brain research. Moreover, the entrepreneurial functions would benefit from the nature of the field where it intersects with many other disciplines allowing for vast applications and research utilization in fields like medicine, education, human resources, and marketing. Such applications can impact everyday life and solve everyday problems (West, 2011). Scaffolding startups that utilize and optimize carried out research would add to the university's economic and societal roles.

On the global level, as discussed in the international context, there is a universal interest in the field, and many universities are engaging with it which indicates the worthiness of investing in such a field. On the regional level, as demonstrated, there are some engagements with brain research; however, there is still much to be achieved in this arena. AUC could make use of the competitive advantage and serve as an African and Middle Eastern champion in interdisciplinary brain research. It could also be part of global brain research initiatives. On the national level, engagement with the applications of brain research is aligned with the current national policy and priority towards digitalization and artificial intelligence. Its medical and non-medical applications, products, and services could serve the Egyptian people.

1.9. Purpose Statement

The aim of this study is to describe and understand the viewpoints of faculty members from the different disciplines at the American University in Cairo (AUC) about neuroscience interdisciplinary integration. Moreover, their readiness to be part of integrative initiatives on neuroscience would be portrayed in terms of their familiarity with the field, their beliefs of its relevance, their willingness to participate, and their attitude towards collaboration. Meanwhile, the capacities and facilities that faculty think they need to realize collaboration will be explored as well as the challenges faced.

1.10. Research Questions

1- How **familiar** are faculty members with neuroscience as an emerging field of research and with its applications and to what extent are they **willing** to be part of neuroscience interdisciplinary initiatives?

2- To what extent do faculty members believe neuroscience and its applications are **relevant** to their respective disciplines and can affect their **teaching** and **research** practices?

3- To what extent do faculty trust that **AUC** is capable of leading the region in neuroscience interdisciplinary integration?

4- What **challenges** do faculty think might face neuroscience interdisciplinary initiatives?

5- What **capacities** and **facilities** do faculty think they need to help them achieve neuroscience interdisciplinary integration?

Chapter Two

2. Literature Review

The review is organized in seven main sections. The emergence of neuroscience as a field of study will be primarily studied; next, the philosophical assumptions that shaped the field and heated its metaphysical debates will be reviewed. Then, some of Neuroscience intersections with other disciplines including Psychology, Education, Information Technology, and Chemistry will be highlighted. However, this review of intersections is not meant to be exhaustive. This is because Neuroscience intersects with many other disciplines; for example, Neuro-linguistics, which investigates the language-brain interface. Other nascent fields include neuro-art, neuro-politics, neuro-economics, neuro-marketing, neuro-esthetics, neuro-law, and neuro-culture. The choice of the disciplines reviewed is purposeful, however. Despite the logical, direct, well-established, prevalent links of psychology and education as learning sciences to the brain (see 2.3. Figure 1), their intersections with neuroscience was debatable according to some researchers, and this study supports the relevance of the emerging field to the reviewed disciplines. The link with the chemistry domain will also be highlighted since it appeared in the historical review with the development of behavioral explanations through brain chemicals. And from the past to the future, the review of Neuro-informatics was important to shed light on the significance of the field in technological advances and Artificial Intelligence (AI). Finally, different models of neuroscience interdisciplinary integration will be studied.

2.1. History and Emergence of Neuroscience

"A historical perspective provides an education in how scientists are able to push past the limits of current concepts in order to fashion a new and more comprehensive understanding of the laws of nature" – (Shepherd, 2010, p.4).

In this section, the growth of the field will be reviewed from antiquity up to the development of contemporary neuroscience via visiting some of the landmarks on the trajectory of this integrative discipline. The story dates back to the Egyptian civilization 3000 B.C. and ancient Greece around the 5th century B.C. Over these two and a half millennia, people were probably not attributing actions, desires, or thoughts to be originating from the brain. Instead, they thought it was the heart that was responsible for behaviors. For instance, the Pharaohs carefully preserved the heart in their mummification process whereas, as far as we know, they extracted the brain from the nose and discarded it. Still, the first documented reference to what we now know as the brain was in an ancient papyrus named after Edwin Smith, the American who purchased it (Gross, 1987; Russell, 2017).

Ibn Sina, one of the most influential medical scholars whose works were translated to Latin, had advanced contributions to the field of neurology, neuroscience, and neuropsychiatry (Zargaran et al., 2012). In the 3rd book of the **Canon of Medicine**, he explained the nervous system with its structure and function including parts of the brain, ventricles, the spinal cord, meninges, and more (Zargaran et. al., 2012). He also described many neurological and neuropsychiatric disorders in detail including signs and symptoms as well as treatment procedures. Examples of these disorders are stroke, epilepsy, amnesia, dementia, paranoia, psychosis, 15 types of headaches, and more. In his **Canon of Medicine**, over 300 medicines were prescribed for neurological conditions, and he also suggested application of electrical shocks using crampfish to treat epilepsy (Zargaran et. al., 2012). Among the Arab and Islamic scholars whose contributions to the field cannot be overlooked is Al-Zahrawi (Abulcasis). He is considered the father of modern surgery, and, owing to him, neurosurgery was prominently developed (Martin-Araguz et al., 2002; Mohamed, 2008).

In times of the antiquity, the Dark Ages, and the Renaissance, vitalism predominated, and a soul-like force was thought to run through neural pathways to produce movements or sensations until **Descartes** proposed his mechanistic model (Stinson & Sullivan, 2018; Wickens, 2015). With the seeds of the industrial revolution in the West, the 17th and 18th centuries witnessed a polarized debate regarding the philosophical approaches to physiology between the mechanists/ iatrochemists on one hand and the vitalists on the other hand (Wickens, 2015). The former argued that our body, like the machine, acts by physical/chemical forces, and its actions can be comprehended through the laws of physics/chemistry; however, the latter believed it is a soul-like force that is responsible for endowing our body with vitality (Wickens, 2015). **René Descartes**, a French mathematician, is believed to be the father of modern philosophy and is widely known for his mechanical school of thought.

Although **Cartesian dualism** (named after **Descartes**) acknowledged that only humans have a thing that thinks which is the mind and that the mind is a substance without any material basis or fixed location, it still rejected the notion of the soul as the force of life (Wickens, 2015). Descartes' unprecedented account on the **reflex concept**, however, is one of the enduring legacies in neurology. He described a series of events that would occur as an involuntary response from the body to an external stimulus, and he depicted this withdrawal response in a drawing where a person is unexpectedly moving his foot away from fire (Stinson & Sullivan, 2018; Wickens, 2015). Such automated response, which has no determination or will from the own self, might have been one reason why the mechanistic explanation prevailed with Descartes' thinking. The way his philosophy affected the field of neuroscience will be further analyzed under the philosophical underpinnings.

In 1791, the Italian Luigi Galvani proposed that a certain kind of electricity, not corpuscles (i.e., animal spirits), is inherent in all living organisms and is responsible for transmitting nerve signals (Stinson & Sullivan, 2018). However, his theory was disputed until the invention of the **galvanometer by Johann Schweigger** in 1820, which confirmed the presence of electric currents in nerves and muscles (Wickens, 2015). Twenty years later, the German Emil Du Bois-Reymond discovered that the electric wave leads to contraction of the innervated muscle, and consequently he termed it the action current (now known as the action potential) (Raghavan et al., 2019).

By the end of the 19th century, Santiago Ramón y Cajal, renowned as the father of modern neuroscience, was able to reveal the various constituents of the nerve cell, and he was able to infer the direction through which the information flowed in neural networks as well (Llinás, 2003; Wickens, 2015). Over and above, he discovered that there are tiny junctions between neurons which Charles Sherrington later called synapses (Bennett & Hacker, 2008; Wickens, 2015). Sherrington also managed over his career span to describe thoroughly how complex reflexive behaviors are manifested by the nervous system (Bennett & Hacker, 2008; Wickens, 2015). In addition, acquired reflexive behaviors, such as salivation following a buzzer sound, were considered by Ivan Pavlov as a form of learning; accordingly, he came up with his famous theory of classical conditioning (Stinson & Sullivan, 2018; Wickens, 2015).

Meanwhile, Donald Hebb suggested a novel view of reflexes. In his opinion, learning and memory are manifested as a result of reflexive neural activity in the brain where impulses are stimulated or inhibited due to changes at the synapse (Palchaudhuri, 2020; Wickens, 2015). Hebb’s work is seminal, for it paved the ground for the rise of cognitive psychology and the retreat of behaviorism (Wickens, 2015). This is because, unlike how behaviorists at that time might have viewed learning as an involuntary response to frequent similar external stimuli, Hebb proposed a new dimension that rendered the linear stimulus-response arc more like a loop. This new dimension was due to some sort of reveberatory activity occurring at the synapse even after the stimulus ended, and if such an activity sustained for long enough, it was likely to bring about a facet of permanent memory (Wickens, 2015). Hebb's theoretical synaptic rule was crowned later on by the discovery of a phenomenon called Long-Term Potentiation (LTP) in 1973 where initial electric impulses brought about long-lasting potential in the recipient cells through strengthened synapses (**Hebbian synapses**) (Palchaudhuri, 2020; Wickens, 2015). Hebb's work and the later discovery of LTP had powerful impacts on contemporary neuroscience and artificial intelligence.

Over the second half of the 20th century, our knowledge about the brain grew exponentially with the myriad of scientific and technological advances (Wickens, 2015). Two of the peaks of such mountain range of advances that stood out were the discovery of the molecular structure of the DNA and the invention of the digital computer. The first achieved great strides whose benefits extended to all the biosciences including neuroscience, and the second led to the advancement of non-invasive scanning techniques, like computed tomography (CT)/computerized axial tomography (CAT), functional magnetic resonance imaging (fMRI) and positron emission tomography (PET), that are now at the heart of neuroscience (Wickens, 2015). Ever since, brain initiatives across the globe have been rising where governments, NGOs, and research institutes invest in discovering the mysteries the brain beholds.

A historical review is significant for understanding how the philosophy of neuroscience developed which will be discussed in the following section. Most importantly, the history of neuroscience reflects how the greatest contributors to the field were mostly polymaths with interdisciplinary knowledge. This highlights the significance of interdisciplinarity and integration for achieving more discoveries and devising better interventions.

2.2. Philosophical Underpinnings of Neuroscience

Delving into the philosophical assumptions that might shape the nature of a given science is paramount not only for understanding the principles, methods, and central questions of this science but also for scrutinizing how its experiments are formulated and how the results are interpreted (Calzavarini & Viola, 2020; Gold & Roskies, 2008). Also, philosophy plays a substantial role in making inferences from the available data and theorizing it. Thus, understanding the nature of neuroscience is indispensable before theorizing a model that aspires to realize integration. Attending to the focus of this study, the following section will look through the philosophy of neuroscience.

In this regard, two questions might arise: Has neuroscience matured enough to formulate its own (local) philosophy? Is it borrowing from other disciplines some philosophical assumptions that are not proprietary to neuroscience? Gold and Roskies (2008) suggested that although neuroscience is a data-rich endeavor, it might not encompass a similar abundance of broad theories. That is to say, as a field, neuroscience may not be like physics for instance which has several well-established theories like quantum mechanics, relativity, statistical mechanics, and electromagnetic field theory. In fact, this, if true, might energize the field's potential for breaking away from the character of traditional paradigms. In fact, such relatively-gradual conceptual development of the field adds to the openness of its inquiry. Such openness facilitated the construction of a multitude of models and concepts such as Long-Term Potentiation (LTP), brain plasticity, and functional localization. These may not have been well-rounded yet to form broader theories. Models are usually more specific than well-articulated overarching theories which might provide a bigger picture for a given system (Gold & Roskies, 2008). It might sound predictable to claim that the field of neuroscience has not yet developed (and may not necessarily develop) a multitude of overarching theories that are exclusive to it owing to its multi-disciplinary nature as well as its relative infancy. Nevertheless, adherence to models, principles, or theories whether borrowed or original would eventually impact the way neuroscientific studies are designed and interpreted.

Natural sciences aim at understanding the physical world, and, the relationship between structure and function has been pivotal in such sciences (Gold & Roskies, 2008). This extends to neuroscience. Epistemologically, the knowledge that neuroscience offers is usually descriptive. For instance, in brain-imaging studies using techniques like fMRI, participants do cognitive tasks while their brains are being monitored. Activated areas in the brain are spotted by increased blood flow which denotes a rise in metabolism at these anatomical sites (Calzavarini & Viola, 2020). Consequently, inferences are drawn connecting the activated anatomical structures to the exhibited cognitive functions.

However, some scholars argue against the contribution of functional neuroimaging to understanding cognitive functions. They build their premise on the impossibility of isolating the neural locus responsible for a single cognitive component (Gold & Roskies, 2008). That is to say, unlike other controlled experiments where the subtractive method might seem successful in inferring causality, other confounding variables in neurobiological processes might seem impossible to rule out. This is because such processes are largely intertwined and interacting. Moreover, feedbacks render the resultant apparent function to be a net effect of several intertwined processes rather than being caused by one component (Van Orden & Paap, 1997).

In fact, although neurobiological processes might seem complex, interrelated, and interdependent, it could be argued that a significant body of knowledge is being constructed with the aid of functional neuroimaging techniques that can demonstrate significant correlations between brain neural structures and cognitive functions. Ivey et. al. (2012) suggest that scientists have not yet reported a *direct causal* relationship between certain brain structures and specific manifest behaviors, feelings, moods, or thoughts. However, recently, there is more engagement with the concepts, challenges, and models of causality in cognitive neuroscience (Weichwald & Peters, 2021). Still, the complexity of how the brain functions is undeniable, as the manifest reactions are resultant of carefully linked biological processes occurring in several areas of the brain. What neuroscientists usually concur on is the presence of significant *correlational* effects between the intensities of neural activity in different brain areas and the manifestations of human reactions (Ivey et. al., 2012). Better understanding of cognition through its neural correlates can be realized but not necessarily through achieving absolute causality. In other words, defining single or multiple neurobiological structure(s) to be the absolute cause for a certain cognitive function may not be all what neuroscience is about, which drives the need for digging deeper into the field’s ontological assumptions.

As reviewed in the history of neuroscience, Descartes is believed to have shifted the paradigm of thought at his time from the Aristotelian *realism*, where reality is believed to be objective, and the focus is on the physical world (body/objects) and on what we observe independent of whether we are aware of it or not, to *dualism* where a clear distinction is made between humans’ physical bodies and their non-physical mind which is responsible for their unobserved mental activities including reasoning and language (Bechtel, 2008). For Descartes, the natural world, including living things, was to be explained through a series of mechanical processes even humans' behaviors (Bechtel, 2008). However, some human functions were resistant to his mechanistic strategy of explanation, for he failed to break them down into a plausible set of procedures (Bechtel, 2008). These were probably functions that he could not visualize, like language and reasoning, because they did not seem to have any sort of physical existence. For instance, what leads humans to be able to speak different sentences each suitable to the relevant situation? Questions like this led him to consider that there must be a non-physical substance that succeeds in resisting the mechanistic explanations of the physical world, which is the mind (Bechtel, 2008). Thus, according to Cartesian dualism, it is assumed that the mind and the brain are two distinct substances where the former is non-physical and the latter is physical.

This mind-body (mind-brain) dilemma set the scene for the theory of reduction to rise in neuroscience contexts. On the intertheoretical level, theories of the mind were thought to be reduced by the developing theories about the brain (Churchland, 1982). In this mind-brain (psychology-neuroscience) reduction model, mental explanations/causes were eliminated by physical neurobiological explanations/causes in the brain. Unable to demonstrate empirical validity, this model has probably fallen out of favor (Brigandt, 2010; Gold & Roskies, 2008).

Reductionism, in the philosophy of mind, calls for understanding human behavior through breaking it down into its smaller simpler constituents while believing they are the source of the more complex behavioral phenomenon (McLeod, 2008). And, when the complex behavioral phenomenon is reduced to its variables or component structures, determining the cause and effect becomes conceivable (McLeod, 2008). There are several forms of reductionism in the philosophy of mind, like the biological, behavioral, and cognitive forms; however, the biological approach is the most reputed. For example, in the behavioral approach which is common in psychology, complex behavior is supposed to be reduced to and explained via simple environmental components (Stimulus-Response). This approach is often referred to as *environmental reductionism* (McLeod, 2008). However, in the biological approach, the studied phenomenon is claimed to be reduced to its neurochemical structures (McLeod, 2008). Meanwhile, *machine reductionism* is a cognitive form of reductionism in which mental faculties are resembled by and reduced to machine systems that process information. Thus, reductionism can manifest itself at different levels of analysis and forms of explanation. In the next section, the relationship between mechanism and reductionism in the context of neuroscience will be analyzed.

To date, mechanistic explanations are common in life sciences (Bechtel, 2008; Calzavarini & Viola, 2020). For example, it is ubiquitous in biology to find scientists explaining blood clotting or any other biological phenomenon through a set of mechanisms and operations. Also, on explaining mental activities, psychologists, neuroscientists, and cognitive scientists seem to widely use the term *mechanism.* However, some reject the *dual* aspect of the Cartesian strategy (Bechtel, 2008). That is to say, they reject the separation between the mind and the brain, and they regard the *mind* as what the *brain* does (Bechtel, 2008). And, unlike Descartes, they use the mechanistic strategy to explain mental or psychological phenomena, for they considered these phenomena to be inseparable from the physical brain. This *materialistic mechanistic* approach to cognitive sciences is, however, contested (Bechtel, 2008). Mechanistic explanations are often rejected by humanist critics for how they see it implying responsiveness rather than active autonomy (Bechtel, 2008). Almost since Descartes proposed his mechanistic strategy in the 17th century, mechanism was perceived as the anti-thesis of vitalism (Brandon, 1984). In this regard, Hogben (1930) states that

> the mechanist is concerned with how to proceed to a construction which will represent as much about the universe as human beings with their limited range of receptor organs can agree to accept. The vitalist or holist has an incorrigible urge to get behind the limitations of our receptor organs and discover what the universe is really like. (p. 100)

On the other hand, Brandon (1984) argues that vitalism and holism are ontological paradigms whose contrary would be reductionism not mechanism and that mechanism is a methodological paradigm. In other words, mechanism does not in principle oppose holism. He further clarifies that the

> mechanistic methodology has been seen as implying (or somehow supporting) a reductionistic ontology. But this is a mistake. Some mechanistic explanations of the behavior of an entity are given in terms of the behavior of the parts of that entity. For instance, the behavior of a watch may be explained in terms of the behavior of its springs and gears. This may support gear-spring reductionism, but it does not imply that everything is explainable in quantum mechanical terms. (Brandon, 1984, p.347)

That is to say, explaining a phenomenon through proposing the plausible mechanism by which it occurs does not deny the fact that other non-mechanical variables might shape the studied phenomenon. Not all *mechanistic* explanations are *reductionist* ones, and *mechanism* does not entail one-level ontology (Brandon, 1984). In summary, a *pluralistic* ontology can still be realized through implementing *mechanistic* methodology (Brandon, 1984).

It can be argued that, ontologically, reductionism in its different forms may cater for our need for understanding *what* is happening; however, it might not satiate our need for understanding *why* it is happening. That is to say, a behavior like running away at the sight of a dog, according to reductionists, might be caused by the activation of the fear response (McLeod, 2008). Both environmental (behavioral) and neurochemical reductionist approaches would explain this fear response in terms of its simple constituents but just at different levels of reduction. However, both might not be able to answer *why* the person felt afraid in the first place. This in turn might have necessitated the rise of alternative philosophies beyond reduction.

An alternative philosophy to *reductionism* for approaching cognitive and behavioral sciences is *interactionism*. In this paradigm, the focus is on how the diverse levels of analysis are interacting together and whether this interaction is unidirectional or bidirectional (Lundh, 2015). In other words, it examines the nature of interaction between biological, cognitive, behavioral, and social explanations (McLeod, 2008). Through multiple and different levels of explanations cognitive neuroscience is capable of offering help in understanding the causes and mechanisms involved in a cognitive phenomenon (Craver, 2005).

Holism, contrary to reductionism, is the belief that human behavior has its own unique characteristics that make it impossible to be explained through summing up the properties of its parts (McLeod, 2008). It also holds that one level of analysis cannot be reduced to another since each owns local characteristics (McLeod, 2008). Humanists, in this paradigm, argue against all forms of reductionism, for they believe it is dehumanizing and undermining the indivisible unity of human psyche (McLeod, 2008). Both interactionism and holism are thought to be person-oriented philosophies (Lundh, 2015). Calling for interdisciplinary integration, this study advocates for a pluralistic ontology. That is to say, the nature of reality of a given phenomenon can be described using different systems of concepts that may have different emphasis or goals but are still consistent and not contradicting (Jilk et al., 2008). This study also supports interactionism in examining the nature of interactions between the different forms and levels of explanation. After understanding some of the philosophical assumptions that may affect the way we study the science of the brain, various disciplines that relate to it will be examined.

2.3. Neuroscience, Psychology, and Education

This section will be describing the pillars of three overarching domains: neuroscience, psychology, and education. This was thought to help better account for the nuances. In fact, the choice of these three domains is purposeful in order to serve the aims of the study. Also, psychology and education appear to have established reinforced connections to neuroscience (even through heated debates) in literature. The existing arguments on the relevance of neuroscience and cognitive neuroscience to education will be discussed under the educational neuroscience part. This section will tackle some of the sub-disciplines of these domains and how they might be interconnected. Some keywords are made in italics, and two Venn diagrams are provided with commentaries for illustration.

Firstly, as previously defined, neuroscience is the science that studies the *nervous system* (Domitrovich & Merlino, 2009). As broad as this definition might seem, neuroscience (also referred to as *brain science* and as *neurobiology*) encompasses many fields of research within. From its overarching umbrella many branch sciences developed including cognitive neuroscience, behavioral neuroscience, social neuroscience, educational neuroscience, organizational neuroscience, cultural neuroscience, consumer neuroscience, motivational neuroscience, functional neuroscience, and much more. As a result of its multi-disciplinary nature and numerous applications, neuroscience overlaps with other disciplines yielding a multitude of research areas. Attending to the focus of this study, only some of its sub-disciplines and intercepting research areas will be tackled. It is worth mentioning that neuroscience is a well-defined (yet not a tightly bordered) discipline that differs from neurology which is the medical study of *nervous system disorders*.

Secondly, psychology is a broad discipline as well whose pillars are *behavior* and the *mind* (Fernald, 2008). It is not to be confused with psychiatry which is another medical field that studies *mental disorders*. Thirdly, education was diversely defined by philosophers and scholars, which emphasizes how rich this domain is and how open it is to innovative interpretations and takes. However, it can be argued that despite the various definitions, *learning* lies in its heart. Therefore, to sum up in simple terms, neuroscience is mainly about the *brain* (and the nervous system), psychology revolves around *behavior* and *mind/cognition*, and education aims at *learning*.

Regarding the sub-disciplines relevant to those three domains, herein some of them will be defined. To start with, cognitive neuroscience is the study of *neurobiological* processes responsible for *cognition* (Campbell, 2011). According to Bechtel (2008), cognitive neuroscience is an integrated examination of *brain* and *mind*. In other words, it mainly involves examining how *mental* processes are exhibited via neural connections in the *brain*. *Mental* (referring to the *mind)* or cognitive processes are collectively what is known as thinking and feeling. As stated above, due to the inter-disciplinary nature of the field, cognitive neuroscience may intersect with other disciplines such as cognitive psychology, behavioral neuroscience, educational neuroscience, and more. As Geake (2009) stated, “Educational neuroscience is cognitive neuroscience which investigates educationally inspired research questions” (p.12). That is to say, it studies how inputs from *brain* research can impact *learning* processes and environments. Behavioral neuroscience, however, examines the influence of *neurobiological* processes (mainly in the *brain*) on *behavior*.

At the same time, cognitive psychology is the field embracing the study of *mental* processes including perception, thoughts, attention, emotion, consciousness, and more (Robinson-Riegler & Robinson-Riegler, 2016). As for educational psychology, it is concerned with studying the *behavioral* and *mental* aspects of *learning* (Roth & Jornet, 2017). Neuropsychology, as the term implies, lies at the interface of neuroscience and psychology. That is to say, it studies the influence of the *brain* (and the nervous system) on *mental* and *behavioral* processes. Figure 1 and Figure 2, designed by the author, illustrate the three domains as well as their intercepting sub-disciplines.

Figure 1

Neuroscience, Psychology, and Education

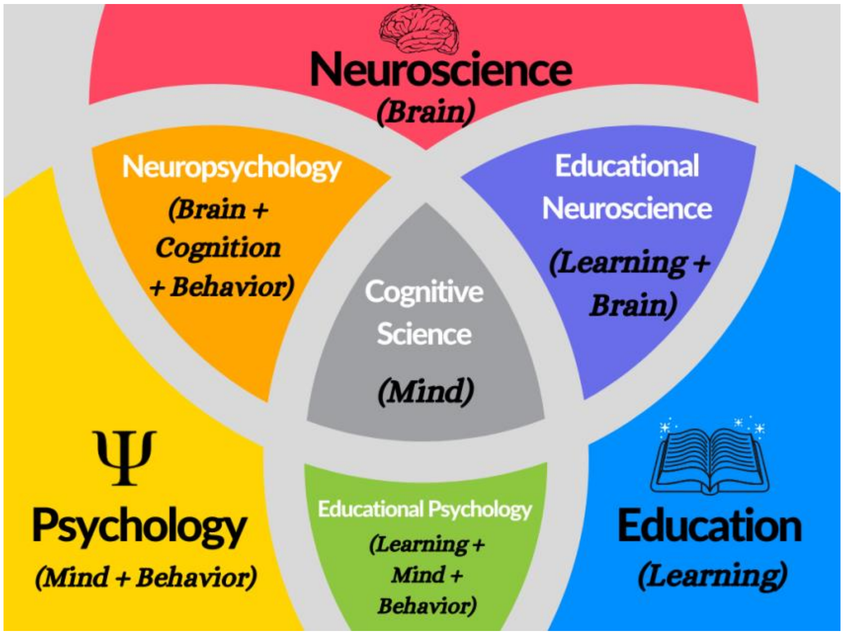
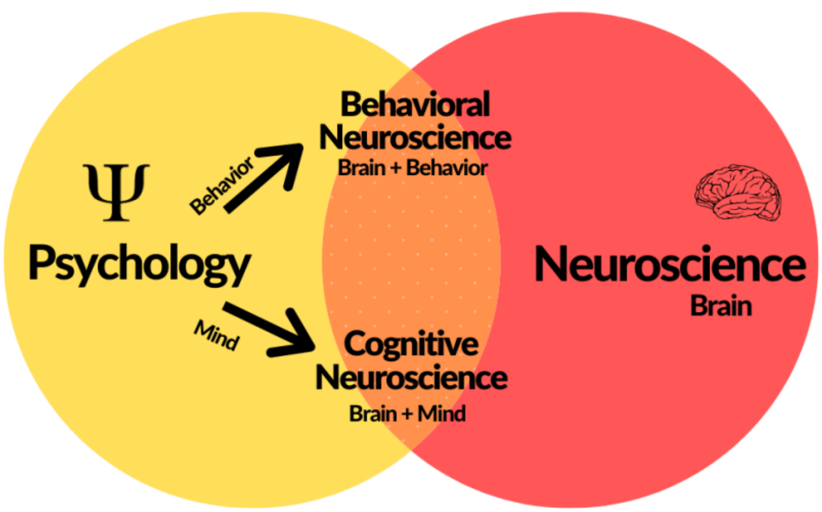


Figure 2

Neuroscience and Psychology



2.4. Neuroinformatics, Neurotechnologies, and Artificial Intelligence

As a result of the huge advancements in the fields of neuroscience and information science, the sub-specialty of neuroinformatics evolved in the late 1980s (Ascoli & Halavi, 2009). The field combines findings from neuroscience with those from physics, mathematics, computer sciences, and engineering (Sabbatini & Cardoso, 2002). It aspires to foster our use of the mounting neuroscience data through the development of computational models as well as electronic tools to handle and manage such data. In 2002, the Neuroinformatics Working Group of the Global Science Forum of the Organization for Economic Cooperation and Development (OECD) suggested establishing an international organization that can globally coordinate and integrate our mounting body of knowledge through Neuroinformatics. As an answer to their call and with the aspiration of providing fair, open, and citable neuroscience, the International Neuroinformatics Coordinating Facility (INCF) was established in 2004 (https://www.incf.org/). An example of neuroinformatics advancements is EBRAINS. Powered by the EU-cofunded Human Brain Project, the goal of EBRAINS is to offer a digital platform that provides services and tools for brain research and technology development. Most importantly, it aims at collecting, analyzing, integrating, and disseminating data from brain research, and it is supposed to be developed by, with, and for researchers (https://ebrains.eu/). Other brain-related databases include the Brain Resource International Database (BRID) which aspires to standardizing and centralizing data obtained from neuropsychological tests, neuroimaging scans, genomics, demographics, and more (Gordon et al., 2005).

Another sub-discipline of neuroscience that intercepts with neuroinformatics is neurotechnology. It is the assembly of techniques and tools that can yield a direct connection between the nervous system and technical components (Müller & Rotter, 2017). These components include intelligent prostheses, electrodes, and computers, and they usually aim at recording and translating brain signals into technical commands or at manipulating brain activity (Müller & Rotter, 2017). Neurotechnologies are employed for a wide range of purposes such as research, diagnosis, management, intervention, and more. Neural computing and artificial neural networks (ANNs) are highly dependent on neuroscience for what they know about processes like learning, memory, attention, and so forth (Sabbatini & Cardoso, 2002). Such interdisciplinary integration gave rise to breakthrough applications like recognizing human faces, simulations of human speech, head bands to monitor attention, and much more (Hassabis et al., 2017; Sabbatini & Cardoso, 2002). The production of artificial systems/devices that can function in a comparable fashion to that of human brains (intelligence) is probably a common interest between neurotechnologies, neuro-robotics, and artificial intelligence. Interestingly, more advances in machine learning and artificial intelligence reciprocally benefit the field of neuroscience as well, for they improve the tools and techniques by which neuroscience collects and analyzes the data (Hassabis et al., 2017).

2.5. Neurochemistry

As the term implies, the intersection between neuroscience and chemistry yields the field of neurochemistry. In this field, the brain, being an electrochemical organ, is studied in terms of its basic molecular components, receptors, and neurotransmitters at the intracellular or intercellular level (Hoffmann, 2016). The first published reference to a substance inside the brain was probably by Johannes Thomas Hensing on phosphorus in 1719 (Boullerne et al., 2020; Hensing, 1719). Thereafter, discoveries of chemical substances that are correlated with regulation of neural functions have been made (Boullerne et al., 2020). Behavioral neurochemistry is a subset of neurochemistry which is interested in studying the neurochemical processes and neuro-regulators that affect behavior (Barchas et al., 1978). The organic approach of neurochemistry has been widely acknowledged in the treatment of neuropsychiatric diseases (Hoffmann, 2016). Moreover, the neurochemistry of cognition provides insights on the role of chemical neurotransmitters and neuropeptides in mental processes like attention and learning (Robbins, 2016).

2.6. Educational Neuroscience

In this section, the intersection between neuroscience and education, which is represented by the field of educational neuroscience, will be examined, and the arguments about the relevance of neuroscience to education will be analyzed. Connections between education and neuroscience have different labels across the globe, such as (*Mind, Brain, and Education)*, e*ducational neuroscience,* and n*euroeducation*. Such connections caught the attention of international research bodies, and new groups and societies were established accordingly such as EARLI (European Association for Research on Learning and Instruction)'s special interest group 'Neuroscience and Education' and the International Mind, Brain and Education Society (IMBES). Moreover, new journals interested in studying this nascent field were produced like 'Educational Neuroscience', 'Mind, Brain, and Education', and 'Trends in Neuroscience and Education' (Thomas et al., 2019). Over and above, post-graduate degrees in this field are being offered from top-notch international universities such as the University of Bristol and Harvard University (Dhawan, 2014; Thomas et al., 2019). Also, several higher education institutions (HEIs) like Harvard, Stanford, Oxford, Cambridge, and Bristol have established centers dedicated for research on neuroscience and education (Dhawan, 2014). Multi-lateral organizations as the OECD (Organization for Economic Cooperation and Development) and the

Royal Society invest on researching the field and issue reports with their findings (Royal Society, 2011; Thomas et al., 2019).

Educational neuroscience is a trans-disciplinary field where findings from neuroscience pertinent to learning are sought in order to be applied to educational practices and policies; thus, it may be considered a translational field (Thomas et al., 2019). The two fields, education and neuroscience, might directly intercept or indirectly interact via psychology. Through the indirect route, psychology and its theories are shaped by inputs from neuroscience, and education is influenced by psychological theories including behavioral data (Willingham, 2009). The relevance of neurobiology to education is not a novel notion. For instance, Thorndike (1913) in the early 20th century embarked on studying how the exercise of neurons and making cerebral connections could influence learning activities. Moreover, he attempted at explaining how emotions and their expressions are manifested as a result of neural responses. Still, an intense debate on the relevance of neuroscience to education sparked off.

Four Positions on Educational Neuroscience

So far, four main positions on educational neuroscience probably developed in literature. These are: misguided enthusiasm, pessimistic skepticism, hesitant optimism, and cautious optimism (Flobakk, 2011). By the end of the 20th century, cognitive neuroscience became popular for how it was thought to provide evidence for best practices (Flobakk, 2011). However, misguided enthusiasm led to the prevalence of “brain-based” teaching formulas and programs like “Brain Gym” and “Brain Buttons” that turned out to follow a for-profit model (Goswami, 2006). Such misguided enthusiasm led to shaping “neuromyths” because it was not guided with a reciprocal or two-way collaboration between neuroscience and education (Flobakk, 2011). In other words, reducing the course of action to be from cognitive neuroscience to educational practice in a linear downward fashion would be similar to forcing individual behavior to fit the biological explanations of the brain (Howard-Jones, 2007). Also, the hasty generalization and application of findings without adequate verification or empirical validation could be another reason for the formation of 'neuromyths'. Therefore, according to Flobakk (2011), misguided enthusiasts were almost leaping the "gap" too swiftly. However, before accusing the reductive approach with being the only cause for developing 'neuromyths' and for the failure of the so-called brain-based initiatives, we have to consider other factors that may come into play. One of those primary factors is the commercial exploitation of data from neuroscience studies that were not designed to be generalized in the first place (Thomas, 2019). Misguided enthusiasm, prevalence of reductive philosophy, commercial exploitation, and lack of effective collaboration all together might have challenged the usefulness of such a field.

As a result of the negative reputation and misconceptions that started growing around the field, the camp of pessimistic skepticism was set up. Unlike the misguided enthusiasts, skeptics believe the "gap" is way too far to be crossed (Flobakk, 2011). They direct their criticism to the educational reductionism of the enthusiasts that led to the evolution of "misguided learning industry" and "neuromyths" (Flobakk, 2011, p.25). Their censure extended to dismiss the entire notion of educational neuroscience and any link made between the two fields (Howard-Jones, 2007).

A third camp of hesitant optimists took a middle position from the argument (Flobakk, 2011). They agree with skeptics on condemning 'neuromyths'; however, they still think neuroscience should be considered in education, and building bridges is possible although educational neuroscience alone might be inadequate (Flobakk, 2011). The role of psychology in bridging this "gap" is thought to be paramount and indispensible. In other words, the only way education and neuroscience can interact is indirectly through psychology. The fourth camp of cautious optimists believe the “gap” can be crossed via educational neuroscience to which they take a more positive position (Flobakk, 2011). At the same time, optimists forcefully call for the urgency of refining the field entirely from neuromyths through two-way collaboration between both disciplines (Flobakk, 2011).

It can be argued that the metaphor of the “gap” is a linguistic illusion that is reinforced by discourse, and we may need to stop using the bridge metaphors (Flobakk, 2011; Thomas, 2019). That is because “the repetitively talk of a gap creates a gap” (Flobakk, 2011, p.55). Stressing on the power of linguistic structures, Olssen et al. (2004) earlier highlighted that “not only do these structures shape discursive practices, but they also are shaped by discourse” (p.68). That is to say, the relationship between a field’s discourse and its linguistic structures is bidirectional. That is why, the more terms like “gap” and “bridge” are used, the more the notion of island disciplines is reinforced. Even when critics of such notions attempt at combating isolation of disciplines, they should not surrender to the terms imposed by the counter-argument because they would eventually consolidate the existence of such counter-argument. Moreover, speaking of a “gap”, there is no clear cut line between education and neuroscience or even social and natural science (Flobakk, 2011). It is proposed that the dissimilarities between both sciences are and should be acknowledged; however, we should not stay trapped within their individual hypothetical borders (Flobakk, 2011). Consistent with the integrative approach, this study advocates for cautious optimism.

Establishing the Necessity for the Integrative Approach to Multi-Disciplinary Sciences

In this section, educational neuroscience, one of the most promising sub-disciplines of neuroscience, will be presented as an example of how integration and collaboration is indispensable for overcoming the challenges facing multidisciplinary fields. One of the most prominent pessimist skeptics of the direct relationship between neuroscience and education is John T. Bruer. He referred to it as "the neuroscience and education argument" (Bruer, 1997, p. 4). And, he contended that such an argument fails because it aims at building a bridge too far. According to him, it is too far because we know too little and would probably never know enough to apply directly to the classroom (Bruer, 1997). However, it can be maintained that if we gave up on studying how the brain influences and is influenced by classroom practices, it would be expected that we may never know enough.

At the same time, Bruer's (1997) second argument was that neuroscience applications may ultimately find their way to education, however, through cognitive psychology. In other words, cognitive psychology, a well-established discipline, is the only link between neuroscience and education, and only through this link mental functions are mapped onto brain structures. He asserted that an applied science of learning and pedagogy should be founded on cognitive science, which he thinks is a basic science, and not on neuroscience since, in practice, there are well-established examples of the former's applications (Bruer, 1997). He further stressed that educational experts ought to be concerned with the mind more than they are fascinated by the brain. That is to say, they should advocate for behavioral research instead of brain-fascinated projects since only the former, according to him, proved to improve educational policy and practice. In the same regard, Bruer (1997) critiqued the Carnegie Task Force (1996) report, Years of Promise, one of the most reputable U.S. reports at that time focusing on the significance of early childhood education. He based his critique on the little number of cited articles in the report that are pertinent to neuroscience in comparison to those related to psychology. If behavioral sciences have been around for quite enough time, would not it be predictable to find more readily available literature on them? Also, if, in certain instances, brain research confirmed what behavioral science has asserted, this should not undermine its role, and we should not fall prey into the fallacy of jumping into conclusion that neuroscience is not capable of offering us more than a confirmatory role. Neuroscientific insights do not need to be exclusively original in order to be legitimate. And, we have to bear in mind that in order to improve educational interventions we have to first understand how and why what currently works is working (Thomas, 2019). This is not meant to imply that there are no studies where neuroscience and education interact without depending on psychological data (the direct route) (e.g. Kelley & Whatson, 2013; Utomo, 2016). However, what is more significant than whether psychology is indispensable for realizing any interaction between education and neuroscience is how such interaction is studied, revised, and evaluated. Therefore, it is not the dependence of one field on the other that we should try to prove; however, it is the interdependence (or rather interaction) between the diverse levels of analysis of a certain phenomenon that we may need to prioritize.

Still, this study acknowledges Bruer (1997)'s argument that results from brain science may be misinterpreted by educators who might draw invalid conclusions from them. One reason for this is the methodological issues associated with biological studies which educators are not necessarily aware of. A case in point is the studies that tackle synaptic proliferation and pruning. In these phenomena, a sharp increase in the number of synapses that join nerve cells in the brain is succeeded by elimination of some of these connections depending on experiences (Bruer, 1997). In studies of synaptic proliferation and pruning, the synapse gain and loss maybe measured by "synaptic density" which is the "number of synapses per unit volume of brain tissue" or by the number of synapses per neuron which might serve as a better reflection (Bruer, 1997, p.6). Both, however, might not accurately and directly portray what is happening inside the brain (Bruer, 1997). Although this argument might sound plausible, it has nothing to do with having cognitive psychology and its theories as the only link between education and neuroscience since neither educators nor psychologists are meant to account for such nuances. However, it has to do with the indispensability of the collaborative interdisciplinary approach for coming up with valid interpretations and interventions that are based on rigorous valid data. And, it has to do with systemic reviewing and meta-analyzing brain studies before inferring and drawing conclusions from them.

This process of scrutinizing, rectifying, carefully interpreting, and managing the output from individual or group studies before making it possible to make use of their results is not unique to the field of neuroscience. However, it is a process integral to research inquiry across disciplines. Thus, it should not lead us to turn away from studying the research questions this endeavor is trying to respond to. Moreover, even if the measures of synapse gain and loss are indicative and not directly measuring the phenomenon while it is happening, they can still provide significant correlations as earlier discussed. Over and above, due to the huge advancements in this field, the same phenomenon can be studied and measured using multiple techniques on the macroscopic, microscopic, anatomic, and functional levels that when combined would aid in substantiating the validity of interpretations (Sabbatini & Cardoso, 2002). The more the field develops, the more accurate estimates would probably be devised.

It is interesting to find Dougherty and Robey (2018) restating Bruer's same arguments almost twenty years later. They alleged that understanding behavior could be enough on devising educational interventions; however, understanding the brain could not be. Their main concern, as they explicitly mentioned, is the funding climate that is becoming more attentive to neuroscience than it is to behavioral research. They gave an example of the White House workshop in

Washington, DC, January 2015, where scientists from education, cognitive psychology, developmental psychology, and neuroscience met to discuss the topic of whether the field of neuroscience is mature enough to bring about neuroscience-based educational interventions. They highlight that none of the participants of the workshop could name an intervention that was based solely on neuroscientific findings (Dougherty & Robey, 2018).

Even if this was true, how does this serve as a measure of the legitimacy of the field? We should first contemplate the ultimate goal of the field of educational neuroscience; is it to produce brain-based educational interventions? The mission of this interdisciplinary field is and should be to help us face more educational challenges through gaining more insights from how mental activities are manifested inside the brain (Ansari, & Coch, 2006; Thomas et al., 2019). We need this field to revise findings from both brain and educational research including behavioral research. Findings from neurobiological studies are invited to be examined, critiqued, reviewed, and tested for relevance to practice. In fact, neuro-myths, lack of brain-based interventions, and the like render the field more legitimate because it uncovers the need that educational neuroscience is supposed to fulfill.

As humans discover, create, and invent more, branch sciences and sub-disciplines would continue to emerge, and it is and will be difficult to draw clear cut lines between such offshoots because of multiple intersections between them. Consider the case of nanoscience or nanotechnology. Though this field started from physics, it diffused to biology, chemistry, material science, and engineering (Poole & Owens, 2003). How far would it be appropriate to allege that because nanoscience started off through physical explanations, it is irrelevant to chemistry or biology? Would it be a bridge too far? Should it be solely built on the ground of material science? As technology advances and endows us with more information, we need to regulate and manage the created body of knowledge. One way of realizing this would be through the creation of multidisciplinary sub-fields that focus on certain research queries through collaboration. We would probably continue to observe proliferation of a myriad of specialties and sub-specialties that were not thought to exist before, like artificial intelligence, machine learning, robotics, cyber security, astronautics, genomics, bioinformatics, mechatronics, and more. Even Bruer (1997) admitted that sooner or later neurobiological findings would find their way to education. Whether we want it or not, it would diffuse from and through many disciplines (Sabbatini & Cardoso, 2002), so we might be better off making good use of time instead of wasting it arguing the relevance of the field.

Interdisciplinarity and Learning Sciences

Thomas (2019) similarly views interdisciplinary research as the hope for the advancement of learning sciences and calls for rejecting the arguments that divorce disciplines and set them in competition. Other voices that called for an integrated science of learning were Ansari and Coch (2006) and Morris and Sah (2016). Such interdisciplinary research integrates constraints from several levels of analysis or description and thus is thought to create improved theories at all levels (Thomas, 2019). A pure psychological approach that is unconstrained by neuroscience is risky, and positing theoretical models with disregard to what might be actually happening inside the brain could be misleading (Thomas, 2019; Thomas et al., 2019). A case in point is how Dougherty and Robey (2018) fell prey to contradiction when they highlighted the failure of brain-training initiatives; nevertheless, they argued that it is the cognitive conceptual models that provide the landing spot for the idea of employing brain training to achieve better education. In this regard, Thomas (2019) argues that the failure of brain-training initiatives stems from chasing psychology with disregard to neuroscience. Also, exploiting the brain as a marketing tool without real relevance to neuroscience adds to the misconceptions, myths, and arguments against neuroscience.

Bidirectional dialogue is indispensable between the two fields (Thomas, 2019). That is to say, the goal is not to convey neuroscience findings to education; however, it is to co-design studies to meet the needs of educators and increase the relevance of research. We should cease being consumed in debating the relevance of neuroscience to education more than we are embarking on discovering such relevance pragmatically. Daniel Willingham, Professor of Psychology at the University of Virginia, brought to the fore the cogent argument of the scarcity of empirical studies on the merits of marrying neuroscience to education as compared to those theorizing such relation (Willingham, 2018). After establishing the need for neuroscience interdisciplinary integration and exemplifying it through the case of educational neuroscience, the next section will tackle the methodological alternatives of such integration.

2.7. Models of Neuroscience Interdisciplinary Integration

As discussed before, neuroscience is primarily a multi-field discipline that gathers insights from biochemistry, anatomy, molecular biology, computer science, electrophysiology, experimental psychology, psychiatry, pharmacology, radiology, and much more (Craver, 2005). When international organizations first embarked on this field as earlier mentioned, their primary aim was collaboration. For example, the Society for Neuroscience (SfN), established in 1969, approached the aim of understanding the brain and nervous system by coalescing diverse research backgrounds and facilitating all-levels and all-forms of integration including translation and application of knowledge (Society for Neuroscience [SfN], n.d.). It is interesting to realize that ever since its early establishment as a discipline through journals, societies, multi-lateral organizations, initiatives, departments, books, and so forth, the pursuit of collaboration was the main mission of neuroscience. Opponents of cognitive science argue that the field has not reached a unitary cohesive theory of its own (e.g. Núñez et al., 2019). Such an argument was heavily rejected by many scholars for they highlighted that such multidisciplinary field was not meant to and should not pursue a unified theory; however, pluralism serves the openness of its inquiry well (e.g. Cooper, 2019; Gentner, 2019; McShane et al., 2019). But, how should neuroscientific findings get integrated with insights from other disciplines? This section attempts at studying this question. Understanding and scrutinizing the methodology of integration is paramount for successfully achieving collaboration. That is to say, studying the way diverse fields come together despite their dissimilar assumptions, goals, vocabularies, and methods is central to a multidisciplinary field like neuroscience.

However, what is integrative research or interdisciplinary integration in the first place? Integration in research has diverse meanings and interpretations (Stock & Burton, 2011; Van

Kerkhoff, 2014). The context in which integration is mentioned would undeniably affect what integration implies and how it is interpreted. Multi-, inter-, and trans-disciplinary (MIT) projects are usually considered integrative research approaches (Stock & Burton, 2011). However, it is of paramount importance not to confuse interdisciplinary integration with unification of sciences (Brigandt, 2010). In reductive unification, theories of different fields are reduced to more fundamental ones (e.g. Churchland, 1982), and this is only one model for integration. An earlier-mentioned example of such a model is that of psychology being eliminated by neuroscience. The aspiration of integration is thus not necessarily to completely dissolve the identities of fields and merge them into unity. Other models of integration include the development of interfield theories where traditional fields are connected via the synthesized theories attempting to respond to certain queries (Brigandt, 2010). In this regard, Brigandt (2010) argues that "integration does not require a unification or stable synthesis of different fields. Instead, it is sufficient to relate items from different traditional disciplines solely for the purposes of a specific problem" (p. 309). This problem-specific and problem-centered model of integration is neither reductionist nor pluralist; however, it is context dependent. After reviewing the literature for integrative research approaches, it can be claimed that integration on the coarse level usually implies collaboration rather than unity of science.

Reductive and Non-Reductive Models of Integration

Several models for interfield integration held their premise on intertheoretic reduction in a deductive nomological fashion (Craver, 2005). Examples for these include Churchland's (1982) reduction of psychology to neuroscience and Bickle's (2003) reductionist account on memory and long-term potentiation (LTP). These models are probably approaching interlevel interfield integration in a downward manner that may overlook "intralevel forms of interfield integration" (Craver, 2005, p.375). However, attempting to solve the riddles of the brain, we need to recruit all the help we might get; thus, a reductionist approach to this kind of research might not serve us well in this century (Martin, 2002). In other words, a precise conception of the functions of the brain's constituent parts needs deep understanding of the contexts in which the parts operate. Accordingly, we need interdisciplinary research that involves much collaboration from different fields such as Education, Psychology, Engineering, Chemistry, Physics, Computer Science, and Neuroscience (Martin, 2002). We also need such collaboration for successful applications and implementation of the output from brain research.

The non-reductionist approach revolves around the principle of multiple realizability which asserts that the same type of phenomenon or mental state can be realized by diverse kinds of states, parts, or processes instead of being reduced to counterparts of fundamental states (Craver, 2005). Such multiple realizability provides space for linking the explanations offered by the various states, parts, or processes integrally in a pluralistic fashion. And, it allows for not only int*e*rlevel but also intr*a*level interfield integration.

Figure 3

Interfield Integration

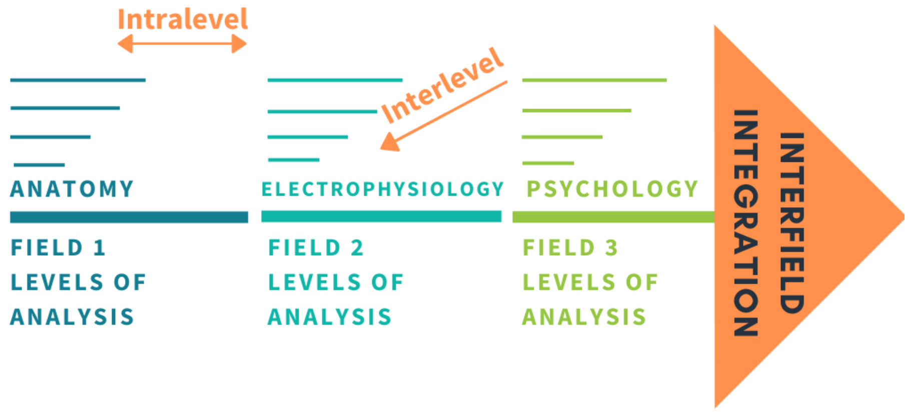


Figure 3 depicts two types of int*e*rfield integration the first of which is the reductionist interlevel interaction which usually occurs in a unidirectional top-down fashion where theories explaining a phenomenon at a higher level (e.g. memory) are reduced to lower-level theories (e.g. electrons). The figure also reveals how intr*a*level interfield integration occurs by inviting different perspectives/tools/methods for investigating a phenomenon at the same level of analysis. For example, synaptic plasticity at the hippocampus was discovered through combining anatomical and electrophysiological perspectives (Craver, 2005). Anatomists employed Golgi staining to disclose neuronal connections whereas electro-physiologists engaged microelectrodes to trace neural excitation (Craver, 2005). Both experiments worked at the same level of analysis which is the nerve cell and its connections, and this form of integration did not involve interlevel reduction (microreduction) (Craver, 2005). Unfortunately, this discovery, which later led to coining the phenomenon of LTP, is often referred to as a reductionist exemplar as mentioned earlier in the historical review claiming that it came into being while searching for the neural correlate of memory in a downward manner (e.g. Bickle, 2003). This assumption might not be valid, for it ruthlessly undermines the constructive nature of discoveries.

Multi-level Constraint-Based Mechanistic Model of Integration

In this model, gradual accumulation of constraints occurs on mechanisms by virtue of the findings at different levels. A mechanism is an organized collection of entities as well as activities with the aim of doing a certain function, performing some process, or producing an end product (Craver, 2005). The entities, like neurotransmitters, carry out certain activities, like binding. The mechanism, which is described in terms of entities and activities, is shaped by findings from multiple levels. These findings, as they emerge, place restrictions on how the entities and activities are organized. Thus, the components of the mechanism are not from one level of analysis (e.g. neurobiological or mental), and complex processes are not decontextualized and reduced to their basic constituents. In other words, interlevel interactions are no longer unidirectional and are coupled with the intralevel interactions in a non-reductionist approach. It is to be noted that this mechanistic model for integration is different from the reductionist mechanistic philosophy discussed earlier where non-physical phenomenon are reduced to mechanistic physical causes. On the other hand, it seconds what Brandon (1984) earlier highlighted, which is using methodological mechanisms to achieve a pluralistic ontology. What governs the process of mechanism formation are the constraints added by emerging findings from different levels. This sounds consistent with the constructive models where our knowledge about a certain phenomenon is continuously refined through new findings. In this regard, Martin (2002) highlights the importance of humility in the 21st century. That is to say, we should acknowledge that our current body of knowledge is susceptible to continuous revision, confirmation, and disconfirmation. And, it is probable that in ten or twenty years, what we do know might seem oversimplified or naïve (Martin, 2002). Fortunately, pluralistic ontology together with multi-level constructive and constraint-based explanations provides the room for continuous revision and rectification. The following is an example of a constructive model for integrating neuroscience as part of the science of learning.

Anderson's Model of Constructivist-Based Cognition Grounded in Neuroscience

In his integrative model of learning, Anderson (2009) attempts at multidisciplinary theorizing. He explains how knowledge is dynamically constructed during learning and reconstructed during recall. He synthesized his model drawing insights from three dimensions of inquiry: neurophysiological, cognitive, and educational constructivist perspectives, where he emphasizes that the three perspectives are interdependent and mutually influencing one another

(Anderson, 2009). That is to say, the latter two are not defined by or reduced to neurophysiological states. In a pluralistic approach, it appears that he integrated three different philosophical assumptions regarding how we learn. While delving into the biological states that try to explain learning, he still emphasizes the importance of socially constructed culture and individually constructed personalities to learning.

After reviewing the literature for the emergence, nature, related disciplines, and methodology of integration of neuroscience, it may be now evident that this study approaches neuroscience from a cautious optimistic standpoint. With a pluralistic ontology, it calls for non-reductive multi-level interdisciplinary integration, and it supports interactionism. In the next chapter, the study's conceptual model will be synthesized from the reviewed literature.

Chapter Three

3. Methodology

After establishing the need for an interdisciplinary approach to neuroscience and reviewing the different models for integration, this section will provide the conceptual framework for neuroscience interdisciplinary integration this study proposes. Next, it will provide information on the mixed-method survey design, participants, setting, data collection, data analysis, rigor, and ethical considerations.

3.1. Research Framework

A Pluralistic Interdisciplinary Approach to Neuroscience

Reductionist approaches to neuroscience (and science in general) usually argue that although a certain phenomenon might accommodate diverse ways of description, only one description would be "*ontologically privileged*" since it depicts the reality of things (Jilk et al., 2008). That is to say, their usual viewpoint would be that "while the theories of others may be *useful*, mine is *true"* (Jilk et al., 2008, p.199). However, it is worth considering that a description of a phenomenon might not equate the phenomenon in hand and is rather an "abstraction" of it (Jilk et al., 2008, p.199). As Jilk et al. (2008) delineated it,

> any finite description must omit some details in favor of others that are more predictive, more revealing, more important for our current purposes. Thus for any such description, there is another that elects to incorporate some of the omitted details and leave out others that were previously included; this second description is no less *true* – it merely has different *priorities*. (p.199)

Thus, different descriptions would inevitably prioritize certain aspects while attempting to describe a certain phenomenon at fine or coarse levels of analysis. This is why a pluralistic interdisciplinary framework that advocates for mutual multilevel (interlevel and intralevel) integration of various disciplines was sought in this study. It also advocates for implementing Repko's (2008) interdisciplinary research process whose organized steps are: primarily identifying the relevant disciplines that can provide adequacy in researching the problem; analyzing the problem; evaluating different disciplinary insights to it; recognizing conflicts in insights; establishing common ground; finally creating an interdisciplinary understanding. Such process would be useful to follow when it comes to convening scholars from different disciplines with the aim of researching a common problem.

The Integrative Research Cloud Model

Figure 4 represents the model of integration this study suggests, and it is based on and synthesized from the previous sections. This model sets the research question(s) that the interdisciplinary field is trying to answer at the center, for it is the research inquiry that drives different disciplines to integrate. Thus, in the case of neuroscience, research questions would usually be related to the brain. Instead of linear straight lines (unidirectional or even bidirectional) connecting multiple disciplines together and to the research inquiry (see Figure 5), a cloud that is continuously fed by insights from the different disciplines was designed. This was thought to better represent how integration is constructed and can sometimes be synergistic not just additive. That is to say, findings from behavioral psychology, for example, may not only interact with neurobiological findings bi-directionally, but also upon realizing this mutual interaction multiple interactions with other disciplines, like education, may be realized. Therefore, linear unidirectional or bidirectional modes of interaction may not be sufficient upon representing integration between several disciplines (more than two). Whether the research question(s) revolve(s) around understanding cognitive phenomenon, designing successful interventions, or any other common problem, different tools, methods, and levels of inquiry are employed to effectively address the research problem. Findings from such pluralistic multi-methodological query are continuously embedded within the continuum (represented by a homogenous cloud). Whether this integrative project is synthesizing from previous studies or co-designing new ones, insights from individual disciplines would diffuse through the cloud and get constrained by the process of multidisciplinary cross-validation. That is to say, findings are continuously revised and built upon by all the concerned disciplines as the cloud is growing wider. It is to be noted that, upon designing the model diagram, the choice of gradient colors was purposeful to account for intersections between individual fields as well. For example, chemistry and biology interact through biochemistry, biology and information technology interact through bioinformatics, and together all the disciplines and sub-disciplines integrate towards responding to the research question(s).

Figure 4

Integrative Research Cloud

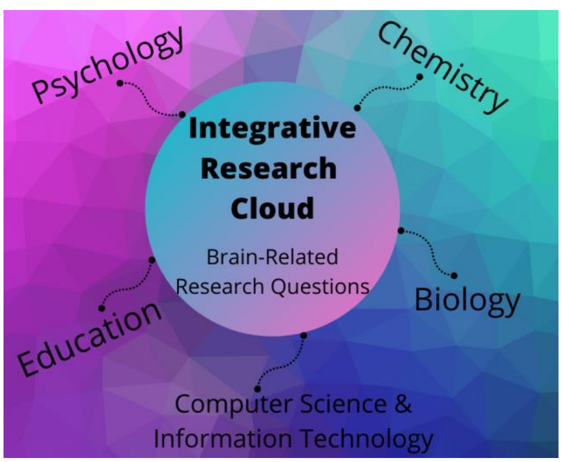
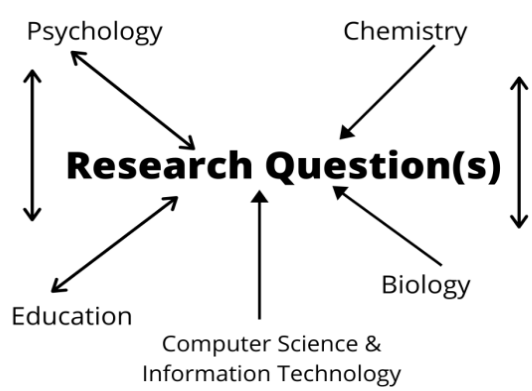


Figure 5

Linear Model for Integration



Practical Considerations

In addition to the methodological concerns discussed earlier, interdisciplinary initiatives might face other challenges on the ground (Sabbatini & Cardoso, 2002). These include: training of scholars from different backgrounds and building their capacities, effectively organizing research projects and making all team players feel they add value, managing the mounting body of knowledge which includes data collection, evaluation, sorting, and distribution. Language and communication barriers must be crossed in order to realize effective collaboration (Stock & Burton, 2011). Also, funding interdisciplinary projects might be challenging. Thus, establishing the project's legitimacy, necessity, urgency, usefulness, and its return on investment (ROI) is indispensable for mobilizing fund. Also, obtaining political support is substantial especially when it comes to recommendations for setting, modifying, or transforming policies. That is why, the more effective and successful the model of integration is, the more capable the integrative approach would be in addressing these challenges.

3.2. Participants and Setting

As discussed earlier, AUC is the chosen setting for carrying out this study owing to its vision, capacities, and facilities. According to the AUC online directory, the number of faculty members is 331 at the time of conducting this study. They include members from 4 different schools: Business, Global Affairs and Public Policy (GAPP), Humanities and Social Sciences (HUSS), and Sciences and Engineering (SSE). Also, faculty from the Center for Learning and Teaching (CLT) as well as the Social Research Center (SRC) participated. Males make up the majority of the population with a male to female ratio (M: F) that is nearly 1.88. The proportion of professors in the population exceeds that of associate professors which exceeds that of assistant professors.

3.3.Study Design and Data Collection

This is a mixed- method study, for it gathers both qualitative and quantitative data and uses different techniques for data analysis. Since the research problems call for describing opinions, attitudes, and behaviors of the participating faculty members, survey research was employed (Plano Clark & Creswell, 2015). Thus, it is also a descriptive cross-sectional study. The attitudinal online survey was administered through Survey Monkey and consisted of a total of 34 questions: 4 demographic questions, 23 Likert questions, 7 open-ended questions. The complete survey is provided in Appendix A. Qualitative questions were used to understand the quantitative data more as well as to help answer the research questions. The 331 faculty members were personally invited via their official institutional emails with the survey URL, and two reminders followed up. Due to the unavailability of studies with similar focus and design to this study, the survey content is not adopted from other studies. Instead, it is tailored to convey the study's research questions.

Although qualitative data was sought in this study, interviews with the participants were not planned for due to the nature, type, and duration of the study. Also, the relatively large population would not make it feasible to have one-to-one meetings with faculty. Finally, focus groups were not needed since the mixed-method survey sufficiently answered the research questions.

3.4. Data Analysis

Since this study is a mixed-method, data analysis is biphasic (Plano Clark & Creswell, 2015). Quantitative data was analyzed with the aid of SPSS® (Statistical Package for the Social Sciences) as well as Jamovi (2021) version 1.6. The second phase of analysis was thematic for the answers from the open-ended questions. Together, both analyses are thought to be effective in responding to the study's research questions.

There is probably no consensus in the literature over the type/level of measurement of Likert data (Sullivan & Artino, 2013; Wu & Leung, 2017). That is to say, some researchers argue that Likert data should be treated at the ordinal level not the interval level since the numbers assigned to the alternatives entail a certain order; however, the distance of each alternative relative to the other on the scale may not be as equal or meaningful as the numbers are (Boone & Boone, 2012; Sullivan & Artino, 2013). For example, it cannot be maintained that a respondent who choses *agree* (represented by score 2) agrees twice as much as the respondent who choses *disagree* (represented by score 3).

However, it is substantial to decide on the level of measurement because it determines the suitable analytical tests to be performed on the data. Non-parametric tests are suitable for ordinal data whereas interval data usually meet the assumptions of parametric tests. In this respect, individual Likert-type items and composite Likert-scales could be treated differently. Responses to single questions are usually considered at the ordinal level; meanwhile, mean composite scores that result from combining several Likert- type items can be analyzed at the interval scale (Boone & Boone, 2012). This is how the study treats both Likert-items and Likert-scales.

On the one hand, some researchers agreed that Likert-scales can be analyzed using parametric tests when the data follows a normal distribution (Sullivan & Artino, 2013). However, other researchers argue that, empirically, even with non-normal distributions and relatively small sample sizes Likert data can be robustly analyzed with parametric tests (Mircioiu & Atkinson, 2017; Norman, 2010). This study takes a middle position from the argument as it follows the rule of thumb that says that testing the normality of Likert data is inessential with large enough samples (DeWees et al., 2020; Pek et al., 2018). Although there seems to be no consensus over what makes samples large enough, they usually ranged from ≥ 15 to ≥ 50 (Pek et al., 2018), and thus given a sample of 70 complete responses, it can be argued that assumption for parametric testing is met (DeWees et al., 2020; Mircioiu & Atkinson, 2017; Norman, 2010).

After the respondent answers to the demographics, the first Likert statement (Q5) asks them about their familiarity with neuroscience where those who consider themselves totally unfamiliar with the field are taken to the end of the survey because they are not expected to form an opinion about it. However, those who continue the survey should presumably have the basic knowledge needed to take a position from the succeeding statements. That is why, the use of a midpoint on the scale was not necessary, for the type of questionnaire statements the participant is asked to form an opinion about does not provoke a neutral reaction. In other words, respondents who would be allowed to continue the survey are not expected to take a “neutral’ or “don’t know” position from the statements. Another reason for avoiding the midpoint is that “respondents may use a midpoint as a dumping ground when they are responding to survey items that are unfamiliar to them” (Chyung et al., 2017, p.17). Accordingly, a 4-point agreement scale was chosen to encourage the respondent to discover (or form) their real opinion instead of thoughtlessly choosing a neutral alternative.

Likert-scale Formation and Validation

In the conceptual space, there exists constructs (or latent variables, factors, dimensions) represented by Likert-scales. Meanwhile, in the measurement space, there exists indicators or observed variables represented by Likert-items. The construct model this survey adopts in its design is validated by Confirmatory Factor Analysis (CFA) in the next chapter. Figure 6 portrays the four latent variables of the model in the conceptual space, which the study intends to describe and explore their relationships in the measurement space. Table 1 reports the four constructs to be measured by the tool with their corresponding items. The familiarity scale measures whether faculty think they know about the new field and its applications, whether they find it relevant and intersects with their own disciplines, and finally whether their teaching and research practices are/can be influenced by the field. The collaboration scale describes respondents' attitudes towards interdisciplinarity at large and towards collaborative brain research in particular. Meanwhile, the willingness scale tells whether faculty members are willing to participate in brain interdisciplinary research at the AUC. Eventually, AUC trust scale measures their beliefs regarding the ability of AUC to lead such an initiative and provide for what it takes.

Figure 6

Conceptual Construct Model

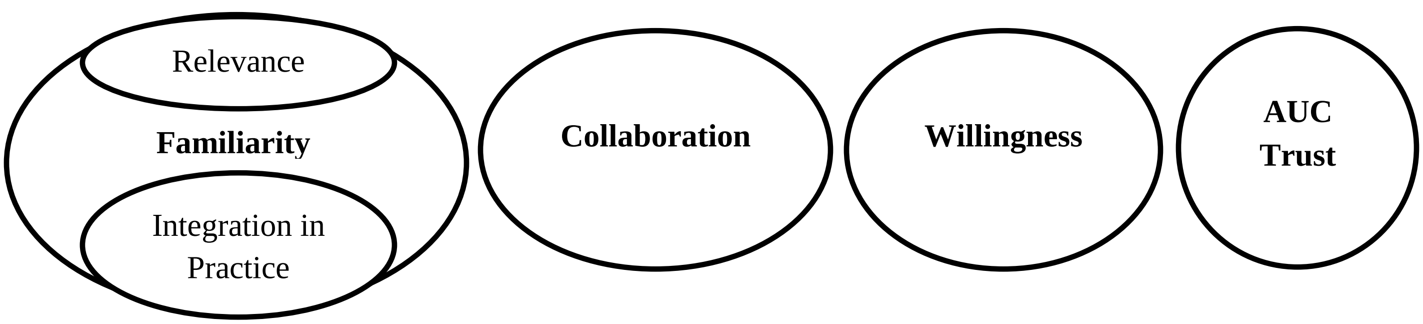


Table 1

Likert-scales and Likert-items

Construct/ latent variable/ scale	Sub-scale	Likert-item/ indicator
Familiarity	Relevance	Q6: The applications of neuroscience are by far medical. Q8: Neuroscience is irrelevant to fields other than biology. Q9: Neuroscience provides useful insights that can impact my discipline. Q14: The way my discipline and neuroscience interact is reciprocal. (i.e. neuroscience informs and is informed by my field) Q15: Neuroscience has no relevant applications in my discipline. Q19: Brain research significantly intersects with my discipline.
	Integration in Practice	Q11: Findings from neuroscience can affect my teaching practices. Q13: Insights from neuroscience can affect my research practices. Q16: I consult insights about how the brain learns while developing my teaching philosophy. Q22: I have been/ am currently part of neuroscience research. Q23: I have been/ am currently part of neuroscience collaborative research.
	Q5: I am familiar with the emerging field of neuroscience.	
Collaboration		Q12: The best way to explain a phenomenon is by opening up to connecting relevant descriptions from diverse fields. Q17: I believe interdisciplinary initiatives pertinent to brain research are worth the investment. Q25: I believe collaboration is integral to brain research. Q26: I believe collaborative brain research initiatives are timely. Q27: I believe collaborative brain research initiatives are significant.
Willingness		Q7: If AUC inaugurated a brain interdisciplinary research center, I am willing to be part of it. Q18: I am willing to participate in neuroscience interdisciplinary initiatives.
AUC Trust		Q20: I believe AUC is capable of providing the capacities and facilities needed for brain collaborative research. Q24: I believe AUC can lead the region in neuroscience interdisciplinary integration.

3.5. Rigor and Ethical Considerations

Reliability and Internal Consistency

The latent/underlying variables of beliefs and attitudes are referred to as constructs. Since they tend to be multifaceted and complex, the survey was designed to measure each aspect of the construct using a group of related questions that are randomly distributed across the survey. The answers to these related questions are compared to check their reliability and combined to yield a scale that should be indicative of the construct of interest. The internal consistency of the scale is measured using Cronbach's coefficient alpha. According to Nunnally (1978), it is recommended that Cronbach alpha is at least 0.7. However, for scales with a few number of items (usually less than 10), Cronbach alpha can get really small since its value depends on the number of items in a scale (Pallant, 2011). In such cases, the mean inter-item correlation is reported which is recommended to optimally lie between 0.2 and 0.4 (Briggs & Cheek, 1986; Pallant, 2011). In the next chapter, Cronbach's alpha of each construct is reported.

Validity

Reliability is a prerequisite for validity; however, it is not solely adequate to assume a data collection tool is valid. Face and content validities were ensured by reviewing the questionnaire by two experts; one of them is from the AUC. In order to ensure each scale truly measures the latent construct of interest (construct validity), both discriminant and convergent validities of the measure were upheld through Confirmatory Factor Analysis (CFA) which will be presented in details in the fourth chapter.

The survey was designed to be user-friendly and of suitable length in order to encourage faculty participation which should increase the response rate (Evans & Mathur, 2005). Moreover, missing value analysis and non-response analysis were conducted to ensure the data representativeness and validity of inferences. See the next chapter for more details. The attitudinal measure is designed to allow for summed scores as mentioned above. That is to say, the same attitude or opinion will be measured by summing the scores of multiple questions addressing it. This is thought to increase the validity and reliability of the measure (Plano Clark & Creswell, 2015).

Regarding the ethical considerations, an IRB approval (Appendix D) was obtained before data collection, and consent from the participating members was gained. The results are reported anonymously and stored confidentially.

Chapter Four

4. Results and Discussion

In this chapter, the results of the mixed-method survey will be presented, analyzed, and discussed in light of what has been reviewed. As earlier highlighted, individual Likert items are preferably analyzed using descriptive statistics, while Likert scales could be inferentially examined. Thus, in the first part of the chapter, quantitative data will be analyzed descriptively and inferentially, where answers to research question (RQ) one, two, and three will be discussed. Next, in the second part of the chapter, qualitative data will be thematically coded and analyzed, which will complement and explain the results of the quantitative analysis and provide answers to RQ4 and RQ5. Finally, both quantitative and qualitative analyses are combined in a summary of the answers to the study's five research questions.

4.1. Quantitative Data Analysis

This part of the chapter consists of four main sections. The first section reports on the survey response rates, response representativeness, and completion rates, and it provides an analysis of the incomplete responses. In the second section, insights into faculty's familiarity with neuroscience and their willingness to be part of collaborative brain research (RQ1) are gained through descriptive frequencies of the answers of the different schools and departments to some survey questions.

The third section links the survey results to the literature review by highlighting faculty's attitude towards reduction and towards opening up to diverse explanations of a given phenomenon. These results connect to the philosophical underpinnings and models of integration reviewed in chapter two and to the study's pluralistic research framework proposed in chapter three. It also demonstrates faculty's opinions on the relation between neuroscience and AI since it is one of the major advances of technology as reviewed earlier. Moreover, whether faculty's familiarity and willingness are linked to their research interests is examined. In the last section, facets of the validity and reliability of the tool are presented, and answers to RQ1, RQ2, and RQ3 are given through inferential statistics and parametric tests.

Section I: Survey Response Rates and Response Representativeness

The survey was sent to all faculty members registered on the AUC directory (331) at the time of the study through their institutional emails. Two of them replied rejecting the invitation of participation by e-mail without declaring any reasons. A third member stated the reason for rejection which is their lack of knowledge about the field as well as their belief of its irrelevance to their domain (Film Making). Another member did not receive the invitation or the reminders due to their full mailbox. A fifth member was on an unpaid leave. Out of the 331 members, 99 took the survey (n=99, response rate of 29.91 %). At a 95% confidence level, the margin of error for this response rate is 8%.

Currently, survey fatigue is a commonly reported phenomenon in higher education institutions to refer to respondents feeling overwhelmed with receiving many survey invitations leading to decreasing response rates (Fosnacht et al., 2017; Van Mol, 2017). That is to say, target individuals become reluctant to respond to the questionnaires they consider non-essential (Baruch & Holtom, 2008). They may be too busy or may find it irrelevant. Also, at the organizational level, they may not be intrinsically motivated to respond to surveys if they do not feel their participation will bring about real change or personal benefit.

Also, several survey characteristics and respondent characteristics might affect response rates. Survey structure, length, respondent's interest, and email checking habit are amongst these factors (Saleh, & Bista, 2017). Therefore, several actions were taken to maximize the response rate including inviting faculty via personalized emails addressing each faculty, ensuring the anonymity of data, designing the survey to be as concise (the average time spent by respondents to complete the survey was 6 minutes) and as interesting as possible, and finally sending two reminders.

However, the long-standing assumption of the dependency of data robustness on survey response rates is currently being revised since it is becoming not uncommon to find response rates lower than 10% (Van Mol, 2017). Some researchers suggest that extra efforts to push response rates higher might not significantly affect survey results in higher education settings given a minimum number of responses (Fosnacht et al., 2017). Moreover, nonresponse bias is usually minimal if those who responded are not different than those who did not in aspects that could be significant to the objectives of the study (Fulton, 2018). Thus, the response representativeness might be a better estimate of the validity of inferences rather than mere response rates (Baruch & Holtom, 2008; Cook et al., 2000; Fulton, 2018).

Accordingly, in order to ensure the external validity of results, a nonresponse analysis was conducted by matching the distribution of respondents to non-respondents in terms of school, gender, and years of experience in academia which are the variables used by the study to group participants. This is one of the methods of nonresponse analysis recommended by Fulton (2018). The male to female ratio (M: F) of the population is 1.88 and that of the respondents is 1.65. All schools were represented and all departments as well, with the exception of the Applied Linguistics Department where none of its three members responded. Moreover, veteran and novice faculty were represented. Table 2 and Table 3 depicts that the approximate percent of mid-level and senior-level faculty in the population is more than entry-level faculty, and so is the case with the respondents.

Table 2

The Representation of Entry-, Mid-, Senior-Level Faculty in the Population

Proportion of assistant professors	Proportion of associate professors	Proportion of professors
28.5%	33.63%	37.84%

Table 3

The Representation of Entry-, Mid-, Senior-Level Faculty in the Sample

Respondents with (0-10) years of experience	Respondents with (11-15) years of experience	Respondents with (>15) years of experience
23.23%	25.25%	51.52%

Section I: Survey Completion Rates

It is worth mentioning that the response rate is different than the completion rate. The former represents the percent of participants who took the survey relevant to those who received it. However, the latter refers to the percentage of complete responses obtained from those who already responded. In other words, occurrence of missing data may be at the unit-level or at the item-level (Dong & Peng, 2013). Several measures were taken to maximize the completion rate as well. The survey was made into two pages only (after the consent page) since several studies suggest that as the number of webpages of the survey increases, the completion rate decreases (Liu & Wronski, 2018). Also, the number and type of questions were carefully devised to satisfy the needs of the survey and increase its completion rate at the same time.

Out of the 99 responses, 17 were incomplete (completion rate 82.83%). In those 17 incomplete responses, the participants started the survey, but they did not continue it till the end. 12 participants out of the 99 (12.12%) indicated that they were very unfamiliar with neuroscience (Q5), and those were intentionally led to the end of the survey, as justified earlier.

According to Enders (2003), it is common to find a missing rate of 15% to 20% in psychological and educational studies. However, in literature, there is no agreed upon cutoff percentage of missing data that can render the statistical inferences invalid or biased (Dong & Peng, 2013). Moreover, there is growing evidence to suggest that the patterns and mechanisms of missing data might affect the results more than the proportion of missingness (Tabachnick & Fidell, 2012). That is why a missing value analysis was conducted.

Section I: Missing Value Analysis

An analysis of the patterns of missing values was conducted to ensure the robustness of tests and to ensure that the missing values would not significantly affect the representativeness of data. In Figure 7, the missing value patterns are assigned numbers, and the frequency of occurrence of each pattern is illustrated. Meanwhile, in Figure 8, the patterns, entitled numbers, are portrayed in terms of the missing/non-missing variables (individual Likert responses). As shown, most of faculty's responses (cases) are value pattern number 1 which, referring to Figure 8, has all variables as non-missing. However, the most frequent missing value pattern is number 11 where all variables after Q5 (familiarity) are missing and marked in red. Pattern 12 occurred only once, and the only difference between this pattern and pattern 11 is that the respondent skipped one more question along with the others.

Figure 7

Frequencies of Missing Value Patterns

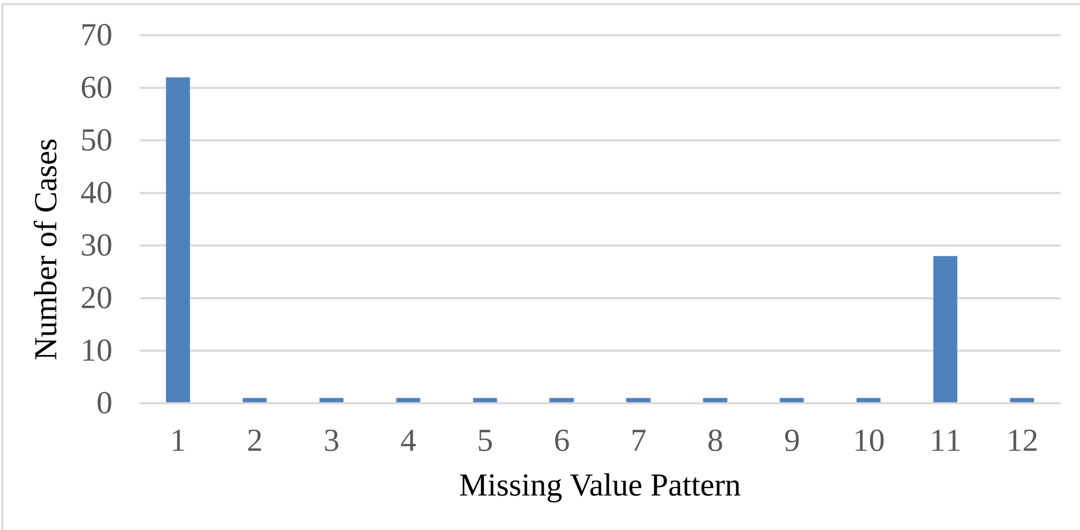
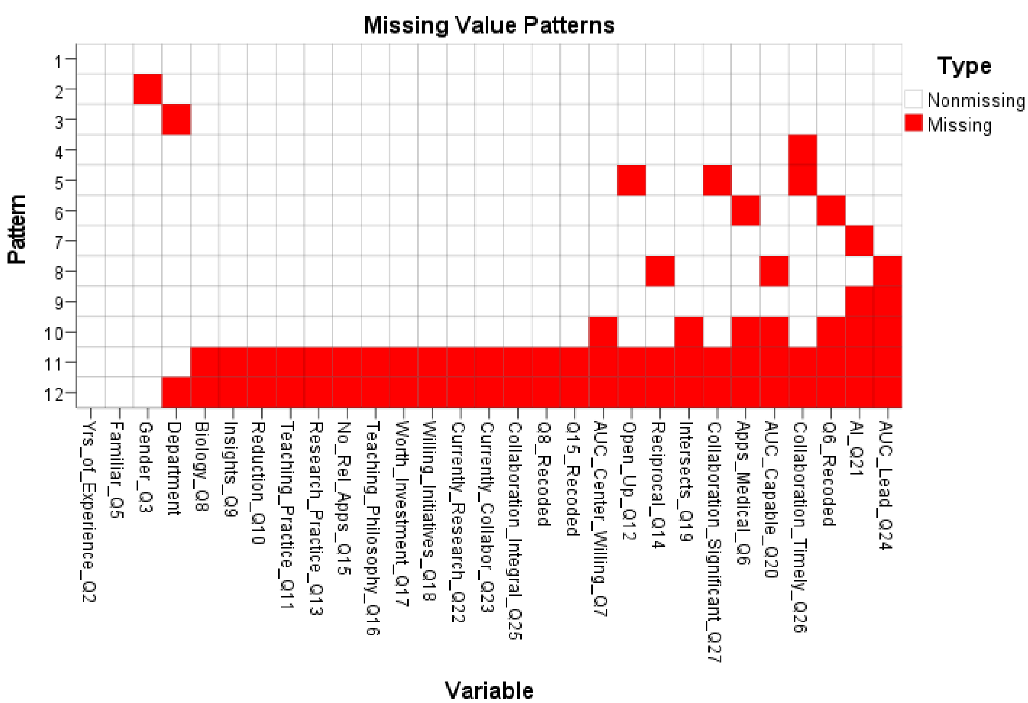


Figure 8

The Patterns of Missing Variables



As shown, the 29 cases with pattern 11 and 12 are Missing Not At Random (MNAR). That is to say, the mechanism by which data is missing does not solely depend on the observed data; on the other hand, it depends on the missing data itself. Therefore, the degree of validity of using the observed data to predict the absent data remains questionable in MNAR cases (Jakobsen et al., 2017). Since the majority of missing data was MNAR, Multiple Imputation (MI) and Maximum Likelihood (ML)-based methods are not suitable when it comes to handling missing data since the assumption of randomness is violated (Dong & Peng, 2013, p.3). Missingness in the rest of cases (n= 70) occurred infrequently (1%) and completely at random (MCAR). This qualifies them to be treated in list-wise deletion (LD) and pairwise deletion (PD).

The following paragraphs will help understand the 29 MNAR cases more. Twelve of these cases were totally unfamiliar with neuroscience and thus were purposefully not allowed to continue the survey. In other words, these cases are not really missing. The remaining 17 cases, however, are worth examining. Table 4 shows the number of missing cases for respondents who chose *agree*, *strongly agree*, and *disagree* on the familiarity question (Q5). The percent of missing response describes the proportion of respondents who chose a certain response in Q5 then willingly did not continue the survey in relation to all those who chose the same response. This measure is a better estimate of whether there is a relationship between the degree of familiarity of the respondent and their completion of the survey. Figure 9 and Figure 10 depicts the negative relationship between the degree of familiarity and the number of missing cases/responses. In conclusion, as faculty were more familiar with the field, they tended to have less incomplete responses.

Table 4

Number of Missing Cases and the Degree of Familiarity

Number of missing cases	Frequency of missing cases (number of missing cases / 17)	Q5 response	Frequency of missing cases (number of missing cases/ total number of cases with the same response)
9	52.94%	*Disagree*	25%
6	35.29%	*Agree*	17.14%
2	11.76%	*Strongly Agree*	12.5%

Figure 9

Missing Responses and Degree of Familiarity

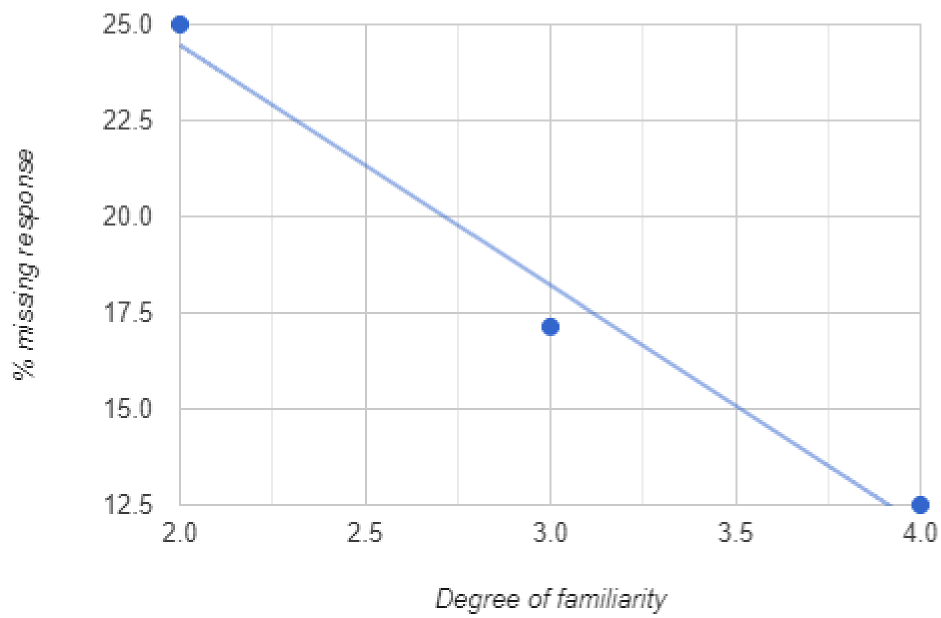
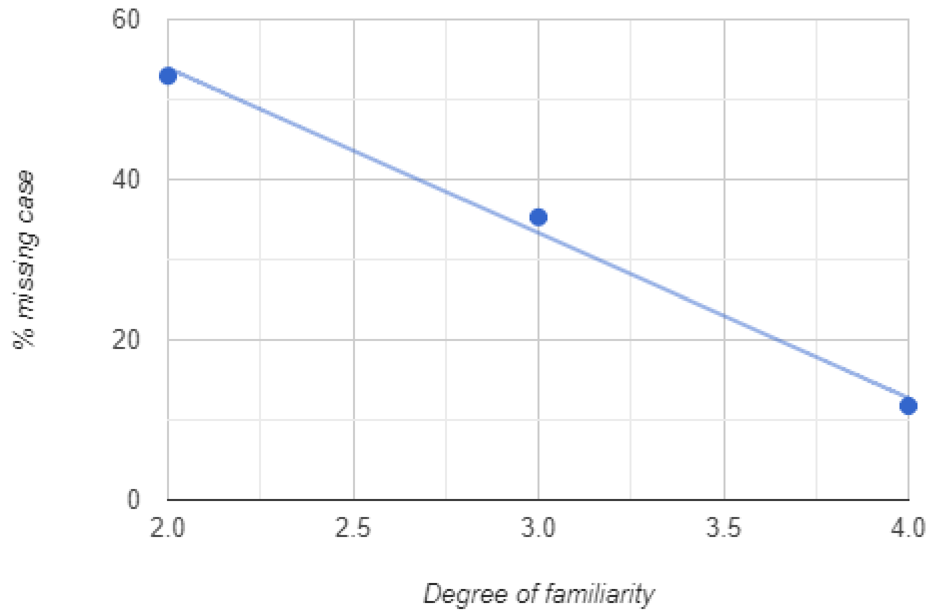


Figure 10

Missing Cases and Degree of Familiarity



To gain more insights about whether there is a relationship between faculty's affiliation and their completion behavior, Table 5 provides the number of incomplete responses per school. Moreover, Figure 11 provides the number of missing responses from each department against respondents' answers to Q5 where 1 = *strongly agree*, 2 = *agree*, and 3 = *disagree*. The 8 respondents who disagreed they are familiar with neuroscience and did not complete the survey may have actually been similar to those who strongly disagreed, and the only difference is that they were not led to the end of the survey. Their departments are shown in red, and such departments have a low familiarity % which will be demonstrated in Section II.

The rest of the respondents, who agreed or strongly agreed they are familiar yet did not complete the survey, belong to both familiar and unfamiliar departments which are shown in blue and green. The actual reason behind such phenomenon cannot be explained; however, one possible reason could be the respondent's feeling of embarrassment if he/she were to mark themselves as unfamiliar. So, they recognize themselves as familiar with the field, yet they could not or were not interested enough to continue the survey.

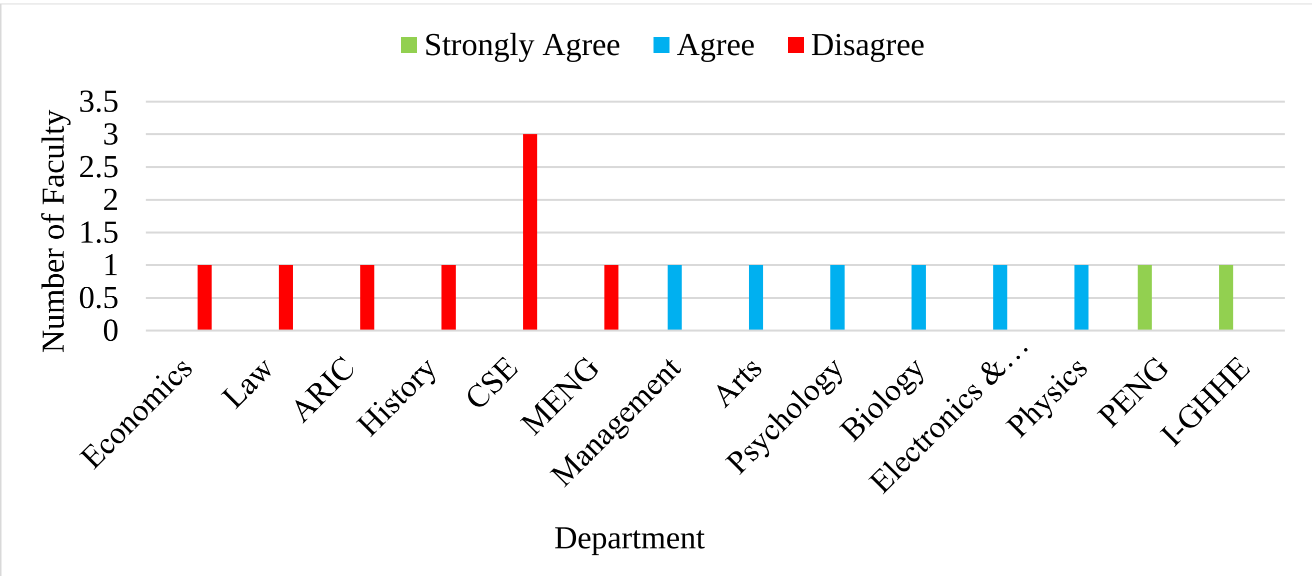
Table 5

Number of Incomplete Responses per School

School/center	Number of incomplete responses	Number of familiar incomplete cases	Number of unfamiliar incomplete cases
Business	2	1	1
GAPP	1	0	1
HUSS	4	2	2
SSE	9	5	4
SRC	1	0	1
Total	17	8	9

Figure 11

Degree of Familiarity of Faculty with Incomplete Responses from Different Departments



Section II: Familiarity and Willingness of Faculty from the Different Schools and Departments

Q5 of the survey asks the participants whether they think they are familiar with neuroscience, whereas Q7 asks them whether they are willing to be part of an interdisciplinary research center at the AUC. Q5: Familiarity% represents the percentage of faculty members who agreed or strongly agreed they are familiar with neuroscience. Q7: Willingness% is the percentage of respondents to Q7 who agreed or strongly agreed that they are willing to be part of an interdisciplinary research center at the AUC. Since both questions provide direct answers to RQ1, their results are previewed here. See Appendix B for the frequencies of the responses to all Likert-items. Table 6 provides the overall response rates, completion rates, Q5: Familiarity%, and Q7: Willingness% for each school where n = number of respondents to Q5/Q7 of each school/center.

Table 6

Rates and Frequencies for Each School/Center

School/Center	Total no. of faculty	Response rate	Completion rate	Q5:familiarity	Q7:willingness
GAPP	32	43.75%	92.86%	64.29% (n= 14)	75.00% (n= 12)
HUSS	112	34.82%	89.74%	56.41% (n= 39)	67.86% (n= 28)
SSE	120	24.17%	68.97%	55.17% (n= 29)	88.89% (n= 18)
Business	63	20.63%	84.62%	15.38% (n= 13)	55.56% (n= 9)
SRC	2	100%	50%	0% (n=2)	NA (n= 0)
CLT	2	100%	100%	100% (n=2)	100% (n=2)
Overall	331	29.91%	82.83%	51.52% (n=99)	73.91% (n=69)

RQ1: How **familiar** are faculty members with neuroscience as an emerging field of research and with its applications and to what extent are they **willing** to be part of neuroscience interdisciplinary initiatives?

As Table 6 shows, 51.52% of respondents agreed or strongly agreed that they are familiar with the field. Interestingly, a higher percentage (73.91%) of respondents were willing or strongly willing to participate in interdisciplinary brain research. That is because despite their unfamiliarity, some faculty members developed interest in the topic (i.e., they are willing to explore the field in spite of not knowing much about it). As for schools, GAPP had the highest response rate, completion rate, and familiarity %. This finding is worth reflecting upon since it might have been expected to find the highest response rate and familiarity % with SSE instead due to the medical/biological origins of the field. However, SSE's response rate (24.17%) was nearly half of GAPP's (43.75%), and the familiarity % was also lower (55.17%). Still, it is to be mentioned that the number of faculty members of GAPP (n=32) is almost the quarter of that of SSE (n= 120), and there is usually an inverse relationship between response rate and sample size (Shelley et al., 2012). That is to say, the larger the sample size is, the less response rate is reported.

Although both engineering and science are hard sciences, faculty within the two domains might differ in their level of exposure to neuroscience, which might, in turn, influence the overall response and familiarity measures of SSE. That is to say, chemistry and biology faculty are generally more familiar with the field than engineering members. This showed up in the departmental analysis which will be previewed in a few paragraphs. Also, the breadth of the GAPP domain (especially JRMC) and the possible acquaintance of its faculty with the up-to-date global trends might explain their relatively high familiarity with neuroscience.

Still, despite its relatively low response rate, SSE seemingly had the highest willingness % amongst all schools. One possible reason for this is that although faculty's willingness to be part of interdisciplinary brain research is influenced by their familiarity with the field, there are several other variables that would affect such willingness. In other words, there is no causal relationship between both variables. For example, a faculty member who is not knowledgeable about the science of the brain might be willing to participate in this kind of research for he/she finds it significant, trendy, promising, or rewarding. This might be the case with some engineering departments whose respondents were willing despite being unfamiliar. This explanation is further supported by the findings of the regression model that will be tackled under section IV.

The lowest response rate, familiarity %, and willingness % were recorded by the School of Business. Despite the departmental variations, familiarity (15.38%) of Business faculty was found to be almost one quarter of the average familiarity of the other schools (58.42%). This significant decline, especially when compared to a school with nearly similar number of respondents like GAPP, might imply that the nascent fields of neuro-economics and neuro-marketing might not have yet been popular within the academic community at the AUC.

Each of the Social Research Center **(**SRC) and the Center for Learning and Teaching (CLT) has only two faculty members which explains their 100% response rates. On the one hand, both SRC members were not familiar with the field. On the other hand, both CLT members were familiar and willing which is explained by the direct connection between brain science and learning sciences.

In order to capture the departmental variations within each school, Tables number 7 to 10 provide the response rates, completion rates, Q5:Familiarity%, and Q7:Willingness% for the departments where n = number of respondents to Q5/Q7 of each department. Faculty at the department of management are the most familiar and willing (28.57%, 66.67%) within the School of Business. At the school of GAPP, PPAD department had the highest response rate (61.54%) and a 100% completion rate. However, JRMC faculty were all familiar with neuroscience (100%) with double the percent of PPAD and Law departments (50%). At the same time, all respondents from JRMC and Law departments (100%) were willing to participate in neuroscience interdisciplinary research with nearly twice the percentage of PPAD (57.14%).

Within each of the HUSS and SSE, there exist two extremes. That is to say, there are certain HUSS and SSE departments where respondents were totally unfamiliar or totally familiar. On the one hand, the totally unfamiliar departments (0%) are ARIC, English and Comparative Literature, Political Science, Architecture, and Construction Engineering. On the other hand, the totally familiar departments (100%) are International and Comparative Education (ICED), Psychology, Biology, Chemistry, and I-GHHE. This suggests that the dichotomy of soft and hard sciences probably does not significantly affect faculty's familiarity. That is to say, studying either soft or hard sciences is not probably a predictor of being familiar with neuroscience. It appears that respondents whose disciplines have a relatively direct, predicted, and well-established connection to the neuroscience were the most familiar.

Although 40% of Sociology, Egyptology and Anthropology (SEA) respondents were familiar with neuroscience, none of them was willing to be part of this kind of research. That is probably because they believe it is irrelevant to them, for all the respondents disagreed that brain research significantly intersects with their own discipline (Q19). As mentioned earlier, the highest percentage of willing respondents was in SSE. That is because with the exception of Architecture (0%), Petroleum and Energy Engineering (PENG) (0%), and Electronics and Communications Engineering (50%) all respondents from the other SSE departments were willing to participate (100%).

Table 7

Departmental Rates and Frequencies of the School of Business

Department	Total no. of faculty	Response rate	Completion rate	Q5:familiarity	Q7:willingness
Accounting	9	11.11%	100.00%	0.00% (n=1)	NA (n= 0)
Economics	22	22.73%	80.00%	0.00% (n= 5)	33.33% (n=3)
Management	32	21.88%	85.71%	28.57% (n= 7)	66.67% (n= 6)
Overall for School of Business	63	20.63%	84.62%	15.38% (n=13)	55.56% (n= 9)

Table 8

Departmental Rates and Frequencies of GAPP

Department	Total no. of faculty	Response rate	Completion rate	Q5:familiarity	Q7:willingness
Journalism and Mass Communication (JRMC)	15	26.67%	100.00%	100.00% (n= 4)	100.00% (n= 4)
Law	4	50.00%	50.00%	50.00% (n=2)	100.00% (n=1)
Public Policy and Administration (PPAD)	13	61.54%	100.00%	50.00% (n= 8)	57.14% (n=7)
Overall for GAPP	32	43.75%	92.86%	64.29% (n= 14)	75.00% (n=12)

Table 9

Departmental Rates and Frequencies of HUSS

Department	Total no. of faculty	Response rate	Completion rate	Q5:familiarity	Q7:willingness
Applied Linguistics	3	0%	NA	NA (n=0)	NA (n=0)
Arab and Islamic Civilizations (ARIC)	12	16.67%	50.00%	0.00% (n=2)	0.00% (n=1)
Arts	21	28.57%	83.33%	50.00% (n= 6)	50.00% (n= 4)
English and Comparative Literature	7	14.29%	100.00%	0.00% (n= 1)	NA (n= 0)
History	8	75.00%	83.33%	33.33% (n= 6)	50.00% (n=2)
International and Comparative Education (ICED)	7	85.71%	100.00%	100.00% (n= 6)	100.00% (n=6)
Philosophy	10	30.00%	100.00%	66.67% (n= 3)	100.00% (n= 3)
Psychology	12	58.33%	85.71%	100.00% (n= 7)	100.00% (n= 6)
Political Science	15	20.00%	100.00%	0.00% (n= 3)	50.00% (n= 2)
Sociology, Egyptology and Anthropology (SEA)	17	29.41%	100.00%	40.00% (n=5)	0.00% (n= 4)
Overall for HUSS	112	34.82%	89.74%	56.41% (n= 39)	67.86% (n= 28)

Table 10

Departmental Rates and Frequencies of SSE

Department	Total no. of faculty	Response rate	Completion rate	Q5:familiarity	Q7:willingness
Architecture	10	10.00%	100.00%	0.00% (n= 1)	NA (n= 0)
Biology	10	20.00%	50.00%	100.00% (n= 2)	100.00% (n= 1)
Chemistry	10	10.00%	100.00%	100.00% (n= 1)	100.00% (n= 1)
Computer Science and Engineering (CSE)	14	28.57%	25.00%	25.00% (n= 4)	100.00% (n= 1)

Department	Total no. of faculty	Response rate	Completion rate	Q5:familiarity	Q7:willingness
Construction Engineering	12	8.33%	100.00%	0.00% (n= 1)	100.00% (n= 1)
Electronics and Communications Engineering	8	37.50%	66.67%	33.33% (n= 3)	50.00% (n= 2)
Mathematics and Actuarial Science (MACT)	7	28.57%	100.00%	50.00% (n= 2)	100.00% (n= 2)
Mechanical Engineering (MENG)	19	21.05%	75.00%	25.00% (n= 4)	100.00% (n= 2)
Petroleum and Energy Engineering (PENG)	8	25.00%	50.00%	50.00% (n= 2)	0.00% (n= 1)
Physics	12	33.33%	75.00%	75.00% (n= 4)	100.00% (n= 3)
Institute of Global Health and Human Ecology (I-GHHE)	10	50.00%	80.00%	100.00% (n=5)	100.00% (n= 4)
Overall for SSE	120	24.17%	68.97%	55.17% (n= 29)	88.89% (n= 18)

Section II: Faculty's Current Participation in Brain Research

One of the important findings that needs to be highlighted here is that most of faculty members previously were not and currently are not participating in research or collaborative research relevant to the brain. Around 16% (n=70) engage or have engaged with neuroscience research, and the percentage is even lower when it comes to participating in collaborative brain research (around 10%, n=70). See Figure B20 and Figure B21, Appendix B. Respondents (16%, n=70) who mentioned they are/were part of brain research belonged mainly to I-GHHE as well as to the psychology and arts departments. See Figure B26, Appendix B for all departments. These percentages would probably get lower if we considered the number of faculty in terms of the population and not the respondents with the assumption that most of the faculty who practice neuroscience research have taken the survey. In other words, if we considered the 11 respondents who mentioned they are/were part of brain research in terms of the 331 members of the population, the participation of faculty in brain research will almost reach 3%.

This finding would be one of the major challenges to interdisciplinary integration. That is because they would probably lack the knowledge and expertise needed despite being willing to participate. This was interestingly highlighted through one of the qualitative themes (knowledge) that will be discussed in the second part of the chapter. However, it is better to interpret this finding with regard to the contexts and to other findings. In other words, being willing to participate yet lacking the knowledge and experience in the field justifies the need for such a project. It probably means that faculty need to be provided with more opportunities, knowledge, resources, and orientation.

Section III: Faculty's Attitude towards Reduction

Figure 12 depicts how the different schools along with the CLT responded when they were asked whether they think the best way to explain a phenomenon is through reducing it to its basic constituents (1 = *strongly agree*, 4 = *strongly disagree*). Table 11 highlights that the highest percentage of rejection of the statement (red and dark red columns in Figure 12) among schools was from HUSS, whereas the lowest was from SSE. This interesting finding coincides with what has been discussed earlier in the literature review regarding the abundance of reductionism and mechanism in natural sciences. Such paradigms influence faculty's perspectives, opinions, and probably behaviors. In this regard, a faculty member from SSE advocated that "it is a global problem the fact that all research areas in the medical field suffers from lacking the contribution of the VERY fundamental field, PHYSICS, where the underlying mechanisms for all natural phenomena, in its simplest version, is the topic of interest". This viewpoint might combine both reductionist and mechanistic perspectives, but most importantly, it highlights the need for interdisciplinarity even more.

Figure 12

The Attitude of Faculty from Different Schools & CLT towards Reduction

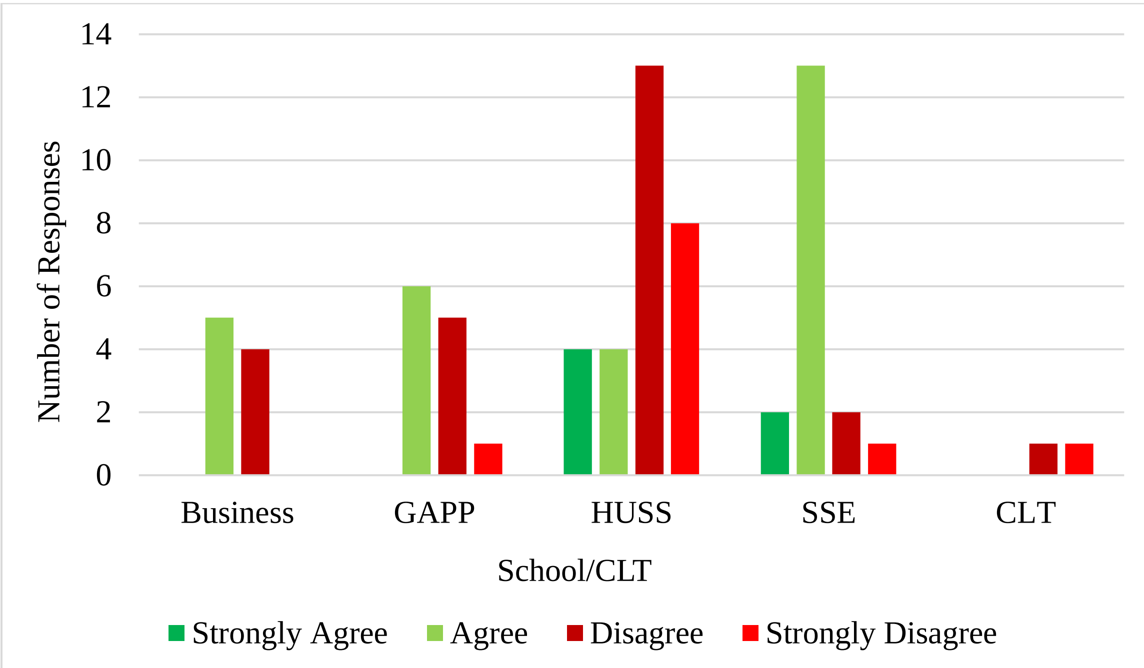


Table 11

The % Rejection of Faculty from Different Schools & CLT towards Reduction

School	Total number of respondents	Rejection Proportion (*disagree* and *strongly disagree*)
HUSS	29	72.41%
GAPP	12	50%
Business	9	44.44%
SSE	18	16.67%
CLT	2	100%
Overall	70	51.43%

On the one hand, almost all of faculty who disagreed/strongly disagreed to the reduction statement agreed/strongly agreed that the best way to explain a phenomenon is by opening up to connecting relevant descriptions from diverse fields (48.57%, n=70). Only two members disagreed on both. On the other hand, all members who agreed/strongly agreed that the best way to explain a phenomenon is by reducing it to its basic constituents still agreed/strongly agreed to opening up (45.71%, n=70) except two. One member from the physics department agreed to reduction and disagreed to opening up. The other member from SSE who agreed to reduction did not answer the other question.

Agreeing on both reduction and opening up to diversity as being the best ways to explain a given phenomenon suggests how faculty might perceive reduction. It proposes that they do not see reduction as opposing to accepting diversity of explanations which coincides with the pluralistic model of integration this study calls for.

Section III: Neuroscience and AI

Nearly all respondents (98.51%) believed neuroscience will lead to more advances in AI. This significant agreement probably suggests that the positioning of neuroscience in faculty's minds is mainly towards being a science of artificial intelligence. Although this perception might limit the potentials of the field and its applications, it highlights how timely it is that AUC with its forward-looking strategy should engage significantly with the field and lead research that is in alignment with the current national strategy towards digitalization and AI in various fields.

Section III: Are Faculty's Familiarity and Willingness Linked to their Research Interests?

It is worth mentioning that the research interests of faculty were diverse and pertinent to their domains, and they were not typically linked to their own familiarity or willingness with the exception of Education, Psychology, and Biology departments and I-GGHE. As suggested in the literature review, psychology, education, and brain science are all learning sciences that have the mind in center, so it is expected to find faculty's interests congruent with brain research (e.g. cognitive education, mental health, critical thinking, design thinking). Biology and I-GHHE faculty's research interests (e.g. cell and molecular biology) are also reasonably linked to their familiarity for how the field emerged from a biological grounding. Meanwhile, some faculty members from other departments were willing to participate and explore the field even when their current research interests are not directly connected to neuroscience (e.g. political economy, theatre and social justice, entrepreneurship).

Section IV: Parametric Tests

After describing Likert-items using frequencies, in the next section, the conducted parametric tests will be demonstrated. When data was fed into SPSS and Jamovi, responses of the negatively worded statements (Q6, Q8, and Q15) were recoded.

Confirmatory Factor Analysis (CFA) and Construct Validity

After establishing confidence in the data representativeness, the construct model proposed in chapter 3 was validated. The different methods for factor extraction or dimensionality reduction including Principal Component Analysis (PCA), Principal Axis Method, and Exploratory Factor Analysis (EFA) were not needed due to the presence of a hypothesized model of the underlying variables. What is required is a Confirmatory Factor Analysis (CFA) to validate the interpretation of the observed variables (Orcan, 2018). CFA assesses two facets of construct validity which are *convergent validity* and *discriminant validity* (Sun, 2005). The former evaluates how cohesively the indicators measure the underlying construct and not something else by computing its structure coefficients, whereas the latter estimates how the latent variables measured by the various sets of items can exist distinctly by ensuring the constructs are not extensively correlated (Sun, 2005).

The results of CFA established the validity of the construct model employed by the study. Table 12 provides the factor loadings which are all significant ($> .3$, $p < .001$). The model fit was good since $\chi 2/ df = 1.61$, $p < .001$, CFI= 0.902, SRMR= 0.0768, and it excludes missing cases list-wise as justified earlier. Comparative Fit Index (CFI) and Standardized Root Mean Square Residual (SRMR) are the indices reported since the first is most sensitive to loading misspecification and accordingly is a reliable estimate of convergent validity, whereas the second is most sensitive to factor covariance misspecification and thus is a good estimate of discriminant validity (Sun, 2005). The cut-off for good model fit is CFI ≥0.90 and SRMR <0.08 (Kline, 2015). Figure 13 illustrates the confirmed model and shows a lack of cross-loading between constructs which demonstrates discriminant validity. Still, each latent variable is in significant correlation with the other variables.

It is to be noted that four items (Q6, Q8, Q15, and Q23) were eliminated from familiarity scale and one item (Q25) from the collaboration scale of the hypothesized model, for they had relatively lower factor loadings.

Table 12

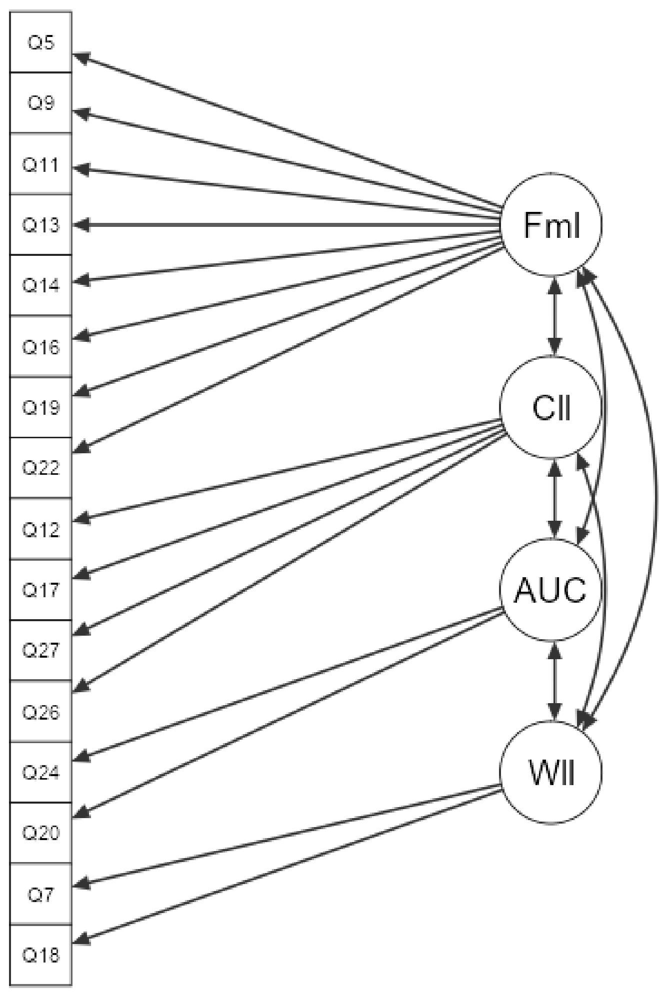
Factor Loadings

				95% Confidence Interval			
Factor	**Indicator**	**Estimate**	**SE**	**Lower**	**Upper**	**Z**	**p**
Familiarity	Q5	0.413	0.0851	0.246	0.580	4.85	< .001
	Q9	0.423	0.0612	0.303	0.543	6.91	< .001
	Q11	0.517	0.0798	0.361	0.673	6.48	< .001
	Q13	0.565	0.0712	0.425	0.704	7.93	< .001
	Q14	0.586	0.0902	0.410	0.763	6.50	< .001
	Q16	0.588	0.0971	0.398	0.779	6.06	< .001
	Q19	0.678	0.0834	0.514	0.841	8.13	< .001
	Q22	0.431	0.1088	0.217	0.644	3.96	< .001
Collaboration	Q12	0.327	0.0692	0.191	0.462	4.72	< .001
	Q17	0.509	0.0713	0.369	0.649	7.14	< .001
	Q27	0.522	0.0661	0.392	0.651	7.90	< .001
	Q26	0.572	0.0712	0.432	0.712	8.03	< .001
AUC	Q24	0.602	0.0918	0.422	0.781	6.55	< .001
	Q20	0.658	0.0874	0.487	0.829	7.53	< .001

				95% Confidence Interval			
Factor	**Indicator**	**Estimate**	**SE**	**Lower**	**Upper**	**Z**	**p**
Willingness	Q7	0.642	0.0783	0.488	0.795	8.19	< .001
	Q18	0.648	0.0733	0.504	0.791	8.83	< .001

Figure 13

Path Diagram of CFA



Section IV: Cronbach's Alpha and Reliability of the Tool

In interpreting and reporting Likert-scale scores, Warmbrod (2014) recommendations were consulted where he suggests computing and reporting Cronbach's alpha not only for the summated scale but also for the summated subscales. Thus, the mean scores for the scales and sub-scales were calculated, and Cronbach's alpha for each was computed to ensure their reliability. Table 13 provides the reliability coefficients and means of the six scales with standard deviation. The minimum possible value is 1 (*strongly agree*) and the maximum possible value is 4 (*strongly disagree*). However, it is to be reminded that these scores were calculated based on list-wise deletion; thus, totally unfamiliar responses and incomplete responses were not computed. Since totally unfamiliar responses (*strongly disagree*) were dismissed, the actual reference range for the following mean scores is 1 (*strongly agree*) and 3 (*disagree*). The survey can be deemed reliable, for all reliability coefficients of its scales are above .7. The values of the six variables are arranged ascendingly in the table according to their mean scores.

Table 13

Reliability Coefficients and Mean Scores of the Scales

Scale	Cronbach's Alpha	Mean Score	Standard Deviation
Collaboration	.835	1.63	0.517
Willingness	.862	1.93	0.714
Relevance	.762	1.97	0.622
AUC Trust	.800	2.06	0.699
Familiarity	.873	2.16	0.566
Integration in Practice	.745	2.31	0.598

RQ2: To what extent do faculty members believe neuroscience and its applications are **relevant** to their respective disciplines and can affect their **teaching** and **research** practices?

The mean scores of the six variables ranged from 1.63-2.31 which places them on the agreeing continuum. Faculty members believed neuroscience and its applications are mostly relevant to their respective disciplines. Integration of neuroscience in faculty's teaching and research practices, however, had the highest score (2.31, sd = 0.598) indicating less prevalence of practices that is relevant to brain research among faculty if compared to their own willingness (1.93, sd= 0.714) or to their beliefs of relevance of the field (1.97, sd= 0.622). Most importantly, faculty were supporting the need for collaboration and interdisciplinarity (1.63, sd= 0.517) even when they were not so familiar with neuroscience or having it within their teaching and/or research practices.

RQ3: To what extent do faculty trust that **AUC** is capable of leading the region in neuroscience interdisciplinary integration?

Most faculty members trust that AUC could lead an interdisciplinary brain initiative and cater for its needs (mean= 2.06, sd= 0.699). However, more insights into their fears and the challenges they perceive will be provided through the qualitative analysis.

Section IV: Correlations between Faculty's Familiarity, Integration in Practice, Willingness, Beliefs of Relevance, Beliefs of Collaboration, and AUC Trust

The magnitude and direction of correlation between the latent variables is described using Pearson correlation. A significant (p value is <.001) and positive relationship exists between the six scales, and Table 14 demonstrates the degree of association between each pair. It is to be noted that Familiarity-Relevance and Familiarity-Integration in Practice are not reported, for running the test in this case is logically incorrect. That is because relevance and integration in practice are already subsets from familiarity, and their strong correlation to it would be due to that rather than a real association. Instead, their correlation to one another is reported.

The strongest correlation lies between familiarity and willingness (.828) which implies that respondents who were familiar with neuroscience were mostly willing to be participate in brain research; however, the opposite might not be true where not all those who were willing were familiar as earlier highlighted. The strength of this correlation is probably due to their belief of its relevance (.825) more than their integration of neuroscience in their practices (.737). The two sub-scales (relevance and integration in practice) are also strongly correlated (.783) which suggests that the more faculty believed the field is relevant to them, the more likely they are to have it affecting their practices. It was interesting to find that AUC trust moderately correlates with all the other variables (.493-.566). That is probably rational, for trusting AUC to lead such project would depend on other factors more than faculty's beliefs and attitudes towards the field.

Table 14

Pearson Correlation between the Scales

Scales	Pearson Correlation	Sig
Familiarity – Willingness	.828	<.001
Relevance – Willingness	.825	<.001
Relevance - Integration in Practice	.783	<.001
Integration in Practice – Willingness	.737	<.001
Collaboration – Willingness	.631	<.001
Willingness - AUC Trust	.566	<.001
Familiarity – Collaboration	.551	<.001
Familiarity – AUC Trust	.543	<.001
Integration in Practice - AUC Trust	.540	<.001
Collaboration – Integration in Practice	.523	<.001
Relevance – Collaboration	.518	<.001
Relevance - AUC Trust	.500	<.001
Collaboration – AUC Trust	.493	<.001

Section IV: The Effect of Demographic Independent Variables on the Six Outcome Variables

Correlation between the variables and demographics was examined using ANOVA test. ANOVA test was chosen since it is the most suitable when it comes to examining the relationship between a continuous dependent variable and nominal independent variable.

Independent sample one-way ANOVA test was conducted for the different sets grouped by school, gender, years of experience in academia (demographics/independent) to highlight whether there is a statistically significant difference between the groups in terms of the six variables (dependent). It was found that being in a certain group does not significantly affect the value of the outcome variables. Appendix C provides the mean scores of the six variables for each group with standard deviation (SD).

Section IV: Can Faculty's Willingness be Predicted?

Multiple regression was conducted to explore whether faculty's willingness (as the dependent variable) can be predicted in terms of their attitude towards collaboration and their familiarity (as independent variables) since those were the most correlated variables. The possibility of having multicollinearity within the data was rejected (Variance Inflation Factor (VIF) = 1.44) where VIF > 5 would suggest multicollinearity (Vatcheva et al., 2016). Shapiro-Wilk normality test could not reject the hypothesis which means the data is normally distributed (p= .670). These estimates are important for ensuring the validity of the inferences from the model of regression. The regression model fits strongly where R2 = .729 and the coefficients of both predictors are significant (Collaboration: p =.003; Familiarity: p <.001).

This suggests that faculty's willingness to participate in brain collaborative research was not only dependent on their familiarity with the field, but also with their attitude towards collaboration at large. In other words, faculty's willingness cannot be predicted or caused by their familiarity alone, which showed in the discrepancy between SSE's familiarity % and willingness %. Believing in the value of collaborative brain research despite lacking adequate knowledge about it suggests that faculty need to be provided more opportunities to engage with the field and justifies the need for this project.

4.2. Qualitative Data Analysis

Through open-ended questions, faculty members were provided sufficient room for expressing their own thoughts, feelings, and experiences. They were first able to share their own definitions of neuroscience and later to cite any relevant piece(s) they read or pertinent event(s) they attended. The reason for this was to help gain deeper insights on the level of their engagement with the field as well as their perspectives. Moreover, they added their views on the possible advantages and challenges of neuroscience interdisciplinary integration in order to help better understand their motives and fears. Finally, they shared the capacities and facilities they think are needed to achieve effective collaboration in order to aid in planning and evaluating the feasibility of such an initiative. The responses were thematically analyzed using Braun and Clarke (2006) six-step framework in an inductive approach to analysis and coding. Figure 14 provides a thematic map of six emerging themes (cautious interest, leadership, dedicated resources, culture, knowledge, outcomes) with their codes. It starts with faculty's cautious interest in the initiative and their beliefs in the significant role leadership plays to realize it through dedicating resources and nurturing the channels of interdisciplinary culture and knowledge. These, together, will lead to the success of the initiative with its outcomes. This part of the chapter provides answers to the following research questions:

RQ4: What challenges do faculty think might face neuroscience interdisciplinary initiatives?

RQ5: What capacities and facilities do faculty think they need to help them achieve neuroscience interdisciplinary integration?

Figure 14

Thematic Map with Codes

4.2.1. Cautious Interest

The first emerging theme was respondents' interest in the field and their belief that it is timely and worth the investment. They mostly thought that AUC, as one of the most influential leaders of higher education in the region, should get real and effective engagement with neuroscience through an interdisciplinary framework. However, sometimes, a latent discouraged voice is heard behind their enthusiasm. The unspoken words might be calling for more attention to and realization of their needs, hopes, and ambitions. For some, it seems like their fears took over. They are particularly afraid of the feasibility of achieving what they are hoping for. The following are some of their spoken words:

- “This is a great initiative and I strongly hope it will be possible to integrate neuroscience at AUC! Good luck!”
- “I hope my suggestions will be heard and be considered”
- “The US started the decade of brain research in 1990. We are lagging by ~30 years.”
- “This is a spot-on domain, timely, important, and worth investment and attention because the potential impact is invaluable.”
- “Neuroscience is discussed in almost every psychology conference I attend.”
- “I am looking for opportunities for interdisciplinary collaboration.”
- “This does not only apply to neuroscience: interdisciplinary integration has become critical in almost all fields.”
- “This is super important to have as a facility within AUC.”
- “Very happy to see an interest in this area.”
- “I already have ideas for interdisciplinary projects.”
- “AUC should take a leading role here”

It was interesting to learn more about the efforts done by some of the faculty members in order to bring more engagements with neuroscience at the AUC. Among the pebbles thrown into stagnant water is that some lectures covering topics like neuro-ethics and Dewey and cognitive science were held at the AUC. One of the participants remarkably summarized the struggle with bringing more engagement with neuroscience at the AUC through the following words, which introduces the next theme:

> The Psychology and Biology departments have been arguing for years that we need to build up a jointly administered behavioral neuroscience concentration and research

> center. We were successful in hiring a professor (Dr. Patricia Correia), and to introduce new courses, but we have not yet been able to push for more institutional changes. We have a concept note for building a behavioral neuroscience suite of labs that would be of use to faculty and students of multiple disciplines (including psych [psychology], bio, [biology], chem [chemistry], applied linguistics, chemistry, journalism, etc.). This is aside for the need for the animal house to be up and running. As for scanning like MRI, we studied and found the matter to not be physically feasible.

4.2.2. Leadership

"Interdisciplinary studies are difficult to manage, fund, and coordinate", one of the participants remarked. In other words, the realization of interdisciplinary integration would definitely be challenging; thus, it has to be supported by organizational leadership through decision-making, successful management, and resource dedication. It is strongly and empirically suggested that a transformational leadership style is highly influential on organizational culture, organizational citizenship behavior, and on instilling innovative behaviors in HEIs (Khan et al., 2020). Also, charismatic academic leaders tend to encourage creativity and productivity in the higher education setting which enables it to compete in the global educational market (Khan et al., 2020).

According to faculty, there is a strong need for elevating all institutional bureaucratic levels in order to realize effective collaborative endeavors. This necessitates placing the initiative as an institutional priority that is accompanied by will and commitment. Eliminating institutional bureaucracy would require organizational restructuring since it is difficult to sustain "floating" programs that are outside of a departmental arrangement. In this regard, one of the participants mentioned that there is some resistance from AUC leadership to hire joint faculty with shared roles between departments. This would probably add to the challenges facing such an initiative. Moreover, respondents stress the importance of having mentorship and coordination as cornerstones of effective leadership of interdisciplinary projects.

The significance of academic leadership does not cease at planning for the initiative, managing, or coordinating it; however, it is of drastic importance when it comes to nurturing the culture and providing the tools and resources needed for realizing interdisciplinarity. Accordingly, the Leadership theme is in great connection with the following themes.

4.2.3. Dedicated Resources

The need for different types of resources was evident in the responses including financial resources, physical resources, and human resources. Regarding the financial resources, much work could be done to attract investments and grants to cover the costs of facilities. Respondents also believed that international partnerships are vital for encouraging funding and enhancing collaborative practices. Thus, university's leaders should aim at establishing partnerships that would add to the success of such project.

As for human resources, according to the respondents, the expertise of the current faculty members might not be sufficient; thus, hiring few experts in the field would be necessary. That is to say, there should be faculty amongst the team who specialize only in neuroscience to be able to complement any missing knowledge. Time dedication is one of the major fears experienced by respondents since their existing workload might not allow them to willingly accept additional roles. As one of the respondents described, "At AUC, we often do not hav(e) the time to collaborate". Another respondent highlighted the importance of dedicating resources to this initiative through the following words, "Faculty at AUC are not ready for such demanding initiative on top of everything else they do. If we want to make a significant or simply a contribution to brain research we need to dedicate sizable resources to this initiative (funding, dedicated faculty, etc)". These words resonate with the discouraged voice discussed earlier and adds to its explanation.

The committed interdisciplinary team of faculty, staff (including technicians to help run the facilities), researchers, and graduate students need physical resources as well. Faculty called for state-of-the-art infrastructure including labs, computing facilities, a biometric platform, and brain scanners. The following are some of the neuro-tools that faculty suggested: a top quality MRI scanner (e.g., Siemens), eye tracker, repetitive trans-cranial magnetic stimulation (rTMS), fMRI, EEG headsets. As the vision and mission of the interdisciplinary project is set, tools that could serve the needs of different participating disciplines would become clearer.

Several models for realizing integration were suggested by faculty. These ranged from simply starting a group/community of learning or practice of neuroscience and arranging outreach events to educate faculty, staff, and students about the topic to post-graduate programs and research centers. The following are some excerpts of the faculty's suggestions:

- "Start small; get bigger after you prove successful. I think AUC should start an interdisciplinary research project on brain research: biology, physics, engineering, economics, business, anthropology, sociology, psychology. It can start as one pilot project, and if successful, then can expand to become a brain lab, and then brain program."
- "Coalition or critical mass of researchers from various fields are needed to incubate future collaboration"

- “I think before going into the scope of creating an interdisciplinary neuroscience program, I'd suggest first building a solid team of neuroscientists and facilities for neuroscience research. Those will be crucial for establishing a strong neuroscience foundation at AUC.”
- “A strong and well-structured interdisciplinary project, in which the role of each participant is clearly underlined and the inputs of each participant clearly defined.”

4.2.4. Culture

Organizational culture is a broader construct than organizational climate that encompasses employees’ shared assumptions and experiences (Ehrhart et al., 2014). Organizational leadership and trust are essentially amongst the most influential factors that govern organizational climate and academics’ behaviors (Al-Kurdi et al., 2020). Fostering the culture of openness, curiosity, acceptance of paradigmatic differences, and belief in the interdisciplinary approach and its significance should be a priority to leaders. It appeared that some of the faculty members were experiencing low morale, as they explicitly mentioned it or highlighted the need for motivation. Willingness to learn from others and being able to work in a team without disciplinary biases or resistance to change are some of the pivotal characteristics of faculty members engaging with interdisciplinary integration.

Disciplinary Silos

Faculty called for widening the collaboration circle to include members from diverse backgrounds, and they were afraid of limiting research to specific pathways. On the micro-level, one of the most common challenges that faculty highlighted is the silos mentality which they thought should be combated by openness and respect. Moreover, some faculty were concerned about reductionist perspectives and found them challenging when it comes to collaboration. This explains why the majority of respondents disagreed that reducing a phenomenon to its basic constituents is the best way for its explanation (see section III: faculty's attitude towards reduction). They insisted on the fact that there is no superior discipline, view, or paradigm and that different philosophies of study should be respected. On the meso-level, inter-departmental tensions and conflict of priorities might jeopardize the realization of interdisciplinarity. Challenges on both levels could be met through effective communication.

Communication

Participants highlighted that low teamwork and collaborative skills among faculty might be challenging. Being from diverse academic backgrounds, members of the interdisciplinary team would probably speak different languages. Thus, without clear and effective communication, it would be difficult to reach mutual understanding and agreed-upon solutions. Team members should be flexible and should listen carefully to others without prejudice. Moreover, some members suggested having a shared platform to communicate synchronously and asynchronously. Interdisciplinary focus group discussions and outreach seminars should be held periodically to facilitate knowledge sharing.

4.2.5. Knowledge

Besides, the possible distant relevance of neuroscience to some fields, faculty suggested that there is a typical lack of knowledge of researchers in areas other than theirs. However, in order to realize neuroscience interdisciplinary integration, faculty should have adequate background in neuroscience, wide knowledge base, good grounding on their own fields, and willingness and ability to explore others. Moreover, they should be aware of the limits of and misconceptions about neuroscience. Furthermore, they should be able to articulate the reasoning behind the selected research approaches and methodologies because lack of coherence and empirical focus could threaten the outcomes of collaboration.

Interestingly, it was found that the emerging themes from faculty's perspectives are powerfully supported by literature that tackles interdisciplinarity within various domains. For example, Nancarrow et al. (2013) delineated ten principles to achieve effective interdisciplinary teamwork. These included clarity of vision, positive leadership and management qualities, appropriate resources and processes, communication strategies and structures, personal rewards, training and development, individual characteristics that support interdisciplinary team work, supportive team climate, and respecting and understanding roles (Nancarrow et al., 2013).

According to Morss et al. (2018), the signs of effective interdisciplinary integration include leading people to think differently about a topic of interest and generation of new research questions, strategies, and interpretations. Success of such integration also involves innovation not only at the intersections of the contributing disciplines but also within them (Morss et al., 2018). Moreover, the intellectual participation of each field should be balanced (not necessarily equal) so as to avoid the domination of one discipline (Morss et al., 2018).

4.2.6. Outcomes

The outcomes of neuroscience interdisciplinary integration according to faculty seemed to fall under two categories: Understanding and Applications. Both themes seemed to be influenced by faculty's definition of neuroscience which revolved around the brain and nervous system and how they inform all human activities. Most of their definitions described neuroscience as a multidisciplinary study or as a field that provides the opportunity for interdisciplinary work and students' interest. Examples of such definitions include:

- "Study of neural systems, which could be studied in a multidisciplinary approach; not just through biology",
- "The study of the brain and how it impacts learning, behaviours, human interactions...which all impact how we construct certain social understandings and build interventions based on these assumptions",
- "An interdisciplinary science that bridges biology chemistry anatomy, psychology etc. both a theoretical and applied science that can have medical, social and environmental impacts",
- "It is an interdisciplinary field of study that provides insights and applications to learning, cognition and other fields where brain and nervous system are core",
- "Neuroscience attempts to map the structure and function of the human brain, and connect it to cognitive, affective, volitional and pathological issues, among others".

Fewer definitions were more specific and seemed to develop from faculty's understanding of the interaction of neuroscience with their own areas of specialization. Examples of such definitions include:

- "Study of the CNS [Central Nervous System] physiology and pathophysiology. For ex, memory formation (long/short term), diseases of CNS (Alzhemier, PD, Epilepsy, etc)",
- "Experimenting psychology".

Understanding

Faculty think that such endeavor could bring about deeper understanding of complex and novel concepts and provide multiple perceptions for the same phenomenon. For example, it can lead to great advances in our understanding of learning, behavior, emotion, and cognition. Furthermore, upon effective integration, tangible and intangible phenomena would be tackled from new angles. One of the faculty members exemplified why collaboration is indispensable through the following words:

> As a holder of PhD in education, cognitive neuroscience affects my work because of how neuroscience explains human attention, motivation, learning, but I don't believe it's enough on its own to explain complex phenomena like learning. That's why I like your foundational question about collaboration so that we can see how neuroscience knowledge combined with other ways of looking at education from a sociological perspective can work together to better understand and improve learning and conditions for learning.

Applications

Faculty believed that neuroscience interdisciplinary integration would not just deepen our understanding but would also help reaching groundbreaking solutions for real-life problems and big challenges. These solutions are hardly reached through one discipline. Some of the mentioned applications were innovative teaching and assessment practices, better therapeutics and prevention therapies, achieving SDGs, expanding the job market, and a possibility of attracting more women to study which could help close the gender gap and alleviate the glass ceiling effect. Interestingly, one of the faculty members is trying to initiate a startup at the AUC that engages neuroscience for providing HR, marketing, and education solutions through a biometric platform. This is of special importance when it comes to fostering the entrepreneurial functions of the university. It is also worth mentioning that faculty believed that the applications would not cease at solving problems but would extend to their prevention.

However, some faculty warned against the temptation of applying neuroscience findings that are not yet fully comprehended upon transforming evidence into practice. This coincides with what is highlighted in the literature review regarding jumping into conclusions too soon. In expression of his/her concern, one of the faculty members stressed that “there is a tendency to leap from the experimental to the practical, such as the so-called "science of reading."

Neuro-ethics evolved as a sub-theme when faculty raised an important flag regarding the cultural and ethical concerns of the future applications of neuroscience. Such concerns may lead to resistance against AI and human experiments. Accordingly, they emphasized the significance of holding the advancement of neuroscience from disturbing the perceptions of justice and equality of humankind.

4.3. The Bigger Picture

In this section, answers to the study’s five research questions will be summarized in light of both the quantitative and qualitative analyses. The proportion of participating faculty who are familiar with neuroscience and its applications and those who are not is almost the same. However, this familiarity does not always imply participation in brain research or expertise in the field. Faculty’s current participation in brain research is relatively low especially if considered in terms of the population (3%, n=331) with the assumption that most of the faculty interested in brain research would have taken the survey. The majority of participants thought neuroscience was relevant to their very diverse disciplines and can impact their teaching and research practices. Nearly all respondents believe neuroscience will lead to more AI advances. Despite the challenges of bureaucracy, time, commitment, lack of expertise, resources, and silos mentality that may face them, faculty are willing to participate in brain interdisciplinary research, and they trust that AUC can effectively lead such a project and cater for the necessary capacities and facilities.

Chapter Five

5. Implications, Recommendations, and Limitations

This chapter places the discussed findings within the wider organizational and national contexts, provides some recommendations, and highlights the limitations of the study.

5.1. Implications

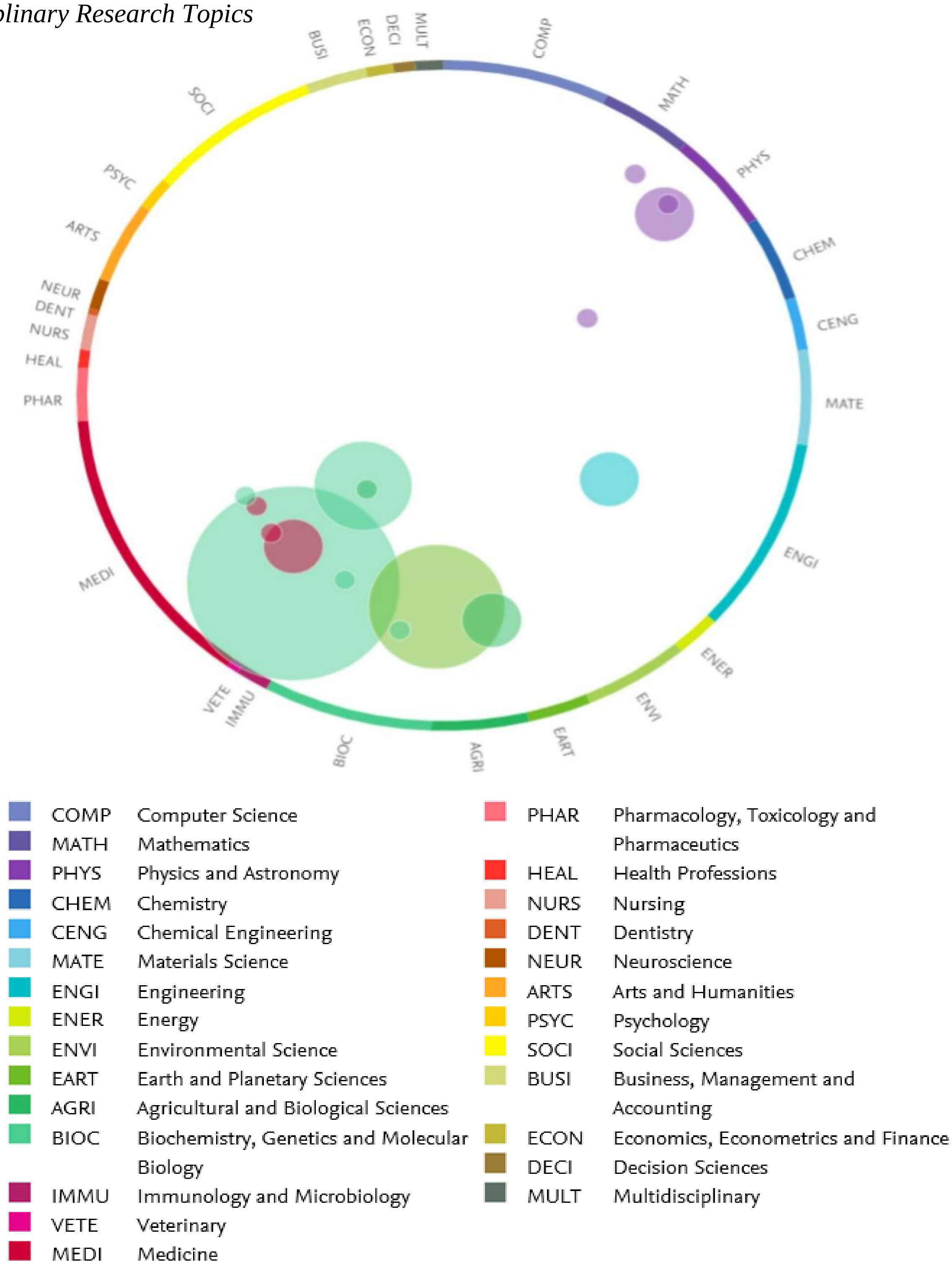
In order to evaluate the organizational multidisciplinary output, SciVal was used to examine AUC's multidisciplinary publications within Scopus database from the year 2017 up to the 14th of February, 2021. The overall scholarly output throughout that period was found to be 1,741 publications, 44 of which were multidisciplinary. That is to say, given the mentioned factors, the estimated multidisciplinary research performance is around 2.5%. The most prominent multidisciplinary research topics are shown in Figure 15 and they include:

- Biochemistry, Genetics and Molecular Biology.
- Environmental Science
- Physics and Astronomy
- Immunology, Microbiology, and Medicine
- Materials Science

20 out of the 44 publications were produced through international collaboration (45.5%). 14 publications were only national collaboration (31.8%), and the share of institutional collaboration was 10 publications only (22.7%). In alignment with the socio-economic roles of fourth generation universities as mentioned earlier, it might be insightful to also examine the academic-corporate collaboration of such multidisciplinary output. The number of publications with both academic and corporate author affiliations is 1 out of the 44 (2.3%).

Figure 15

Multidisciplinary Research Topics



Note. The size of the bubble reflects the number of publications, whereas the colors represent the multidisciplinary topics.

Being a research institution with over 10 interdisciplinary research centers, it can be argued that AUC’s multidisciplinary scholarly output with institutional collaboration over the four years may not be as aspired (10 publications). Reasons for this need to be scrutinized through organizational studies. Upon analyzing the topics of these publications, about 9 publications lie at the interface between Physics, Nanoscience, and Material Science. One publication is probably within the boundaries of Biochemistry, Genetics and Molecular Biology. Research conducted in Yousef Jameel Science and Technology Research Center and the Institute of Global Health and Human Ecology (I-GHHE) probably shared in producing these publications since they are among the multidisciplinary facilities at the AUC.

The higher education sector in Egypt is currently highly competitive with numerous international universities and branch campuses opening their doors. With an international forum and exhibition held biannually (EduGate), Arab, foreign, state, and private higher education investments are evident and so is the competition towards educational quality and state-of-the-art technologies. Accordingly, offering interdisciplinary programs is no longer optional, and nurturing an interdisciplinary culture through different channels should be an organizational priority. In other words, universities should be proactive and prepared to deal with it as a change of state and not as a trend (Penof et al., 2020). That is because if they engaged with it as a trend, they might not be compelled to drift away from the traditional domain-specific approaches to higher education. However, HEIs should be careful while approaching interdisciplinarity so as not to fall prey to disciplinary fragmentation instead of integration (Penof et al., 2020).

For well-established universities like the AUC, sustainability of success in a highly competitive and dynamic market might be challenging. Therefore, the needs and interests of faculty, staff, graduate and undergraduate students as well as labor market needs should be met.

The value of such interdisciplinary initiative should be evident in order to drive the interest of the university's administration which this study hopes to push forward (Leal Filho, 2020). As this study unraveled, faculty at the AUC are interested in the field, and they think AUC should engage with such timely endeavor believing it is worth the investment. Nearly all faculty respondents believe that neuroscience will lead to more AI advances.

5.2. Recommendations

Finally, it is suggested that a steering committee, which may already be organized, would study the different possibilities of successful interdisciplinary organizational structuring. The structure should suit the benefit of AUC at large while simultaneously enabling it to be an open space for innovation with impactful interdisciplinary output that is relevant to the national and global challenges. Whether through an initiative, project, or program, AUC should take a leading role in neuroscience interdisciplinary research. This would take much will, patience, and persistence because it might be challenging; however, it is definitely rewarding.

5.3. Limitations

The study lacks in-depth analysis of the discrepancies between faculty's perceptions and viewpoints which they expressed through the self-administered survey on the one hand and their actual behaviors, attitudes, and multidisciplinary activities on the other hand given the presence of many multidisciplinary centers at the AUC yet little multidisciplinary research output. Whether faculty act according to their perceptions may need to be examined in a real interdisciplinary project or setting, which can be the scope of future studies.

Being beyond its focus and scope, this study did not propose a comprehensive interdisciplinary organizational structure for the project. That is because this requires other organizational studies that focus mainly on this research question and draws in knowledge from AUC leaders, students, faculty, and staff. This is also a recommendation for future research.

References

Abd-Allah, F., Kissani, N., William, A., Oraby, M. I., Moustafa, R. R., Shaker, E., ... & Shakir, R. (2016). Neuroscience research in Africa: Current status. *Eneurologicalsci*, *3*, 7-10.

Al-Kurdi, O. F., El-Haddadeh, R., & Eldabi, T. (2020). The role of organisational climate in managing knowledge sharing among academics in higher education. *International Journal of Information Management*, *50*, 217-227.

Alvino, L., Pavone, L., Abhishta, A., & Robben, H. (2020). Picking your brains: Where and how neuroscience tools can enhance marketing research. *Frontiers in Neuroscience*, *14*.

Anderson, O. R. (2009). Neurocognitive theory and constructivism in science education: A review of neurobiological, cognitive and cultural perspectives. *Brunei International Journal of Mathematics and Science Education*, *1*(1), 1-32.

Ansari, D., & Coch, D. (2006). Bridges over troubled waters: Education and cognitive neuroscience. *TRENDS in Cognitive Sciences*, *10* (4), 146-151. doi:10.1016/j.tics.2006.02.007

Ascoli, G. A., & Halavi, M. (2009). Neuroinformatics. In L. R. Squire (Ed.), *Encyclopedia of neuroscience* (pp. 477- 484). Elsevier.

Barchas, J. D., Akil, H., Elliott, G. R., Holman, R. B., & Watson, S. J. (1978). Behavioral neurochemistry: Neuroregulators and behavioral states. *Science*, *200*(4344), 964-973.

Baruch, Y., & Holtom, B. C. (2008). Survey response rate levels and trends in organizational research. *Human Relations*, *61*(8), 1139-1160.

Bassett, D. S., Cullen, K. E., Eickhoff, S. B., Farah, M. J., Goda, Y., Haggard, P., ... & Ueda, H. R. (2020). Reflections on the past two decades of neuroscience. *Nature Reviews Neuroscience*, *21*(10), 524-534.

Bechtel, W. (2008). *Mental mechanisms: Philosophical perspectives on cognitive neuroscience*. Taylor & Francis.

Bennett, M. R., & Hacker, P. M. S. (2008). *History of cognitive neuroscience*. Wiley-Blackwell.

Bickle, J. (2003). *Philosophy and Neuroscience: A ruthlessly reductive account*. Kluwer Academic Publishers.

Boon, H. S., Mior, S. A., Barnsley, J., Ashbury, F. D., & Haig, R. (2009). The difference between integration and collaboration in patient care: Results from key informant interviews working in multiprofessional health care teams. *Journal of Manipulative and Physiological therapeutics*, *32*(9), 715-722.

Boone, H. N., & Boone, D. A. (2012). Analyzing likert data. *Journal of Extension*, *50*(2), 1-5.

Borrego, M., & Newswander, L. K. (2010). Definitions of interdisciplinary research: Toward graduate-level interdisciplinary learning outcomes. *The Review of Higher Education*, *34*(1), 61-84.

Boullerne, A. I., Foley, P., Turner, A. J., Johnston, G. A., & Beart, P. M. (2020). The origins and early history of neurochemistry and its societies. *Journal of Neurochemistry*, *152*(1), 8-28.

Bowers, J. S. (2016). The practical and principled problems with educational neuroscience. *Psychological Review*, *123*(5), 600-612. https://doi.org/10.1037/rev0000025

Brandon, R. (1984). Grene on Mechanism and Reductionism: More than just a side issue. *PSA*, *2*, 345-353.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77-101.

Brigandt, I. (2010). Beyond reduction and pluralism: Toward an epistemology of explanatory integration in biology. *Erkenntnis*, *73*(3), 295-311.

Briggs, S. R., & Cheek, J. M. (1986). The role of factor analysis in the development and evaluation of personality scales. *Journal of Personality*, *54*, 106–148.

Bruer, J. T. (1997). Education and the brain: A bridge too far. *Educational Researcher, 26*(8), 4-16.

Burns, M. S. (2020). *Cognitive and communication interventions: Neuroscience applications for speech-language pathologists*. Plural Publishing.

Calzavarini, F., & Viola, M. (2020). *Neural mechanisms: New challenges in the philosophy of neuroscience*. Springer Nature.

Campbell, S. R. (2011). Educational neuroscience: Motivations, methodology and implications. *Educational Philosophy and Theory, 43*(1), 7-16. http://dx.doi.org/10.1111/j.1469-5812.2010.00701.x

Carnegie Task Force. (1996). *Years of promise: A comprehensive learning strategy for America's children.* Carnegie Corporation of New York.

Churchland, P. S. (1982). Mind-brain reduction: New light from the philosophy of science. *Neuroscience*, *7*(5), 1041-1047.

Chyung, S. Y., Roberts, K., Swanson, I., & Hankinson, A. (2017). Evidence-based survey design: The use of a midpoint on the Likert scale. *Performance Improvement*, *56*(10), 15-23.

Cook, C., Heath, F., & Thompson, R. L. (2000). A meta-analysis of response rates in web-or internet-based surveys. *Educational and Psychological Measurement*, *60*(6), 821-836.

Cooper, R. P. (2019). Multidisciplinary flux and multiple research traditions within cognitive science. *Topics in Cognitive Science*, *11*(4), 869-879.

Craver, C. F. (2005). Beyond reduction: Mechanisms, multifield integration and the unity of neuroscience. *Studies in History and Philosophy of Science Part C: Studies in History and Philosophy of Biological and Biomedical Sciences*, *36*(2), 373-395.

DeWees, T. A., Mazza, G. L., Golafshar, M. A., & Dueck, A. C. (2020). Investigation into the effects of using normal distribution theory methodology for Likert scale patient-reported outcome data from varying underlying distributions including floor/ceiling effects. *Value in Health*, *23*(5), 625-631.

Dhawan, V. (2014). Education and neuroscience. *Research Matters*, *1*(17), 46-55. Retrieved from https://www.cambridgeassessment.org.uk/Images/466322-education-and-neuroscience.pdf

Domitrovich, S., & Merlino, M. L. (2009). Neuroscience and the law-cutting-edge issues for 21st century judges as gatekeepers. *The Judges' Journal*, *48*(1), 19-22.

Dong, Y., & Peng, C. Y. J. (2013). Principled missing data methods for researchers. *SpringerPlus*, *2*(1), 1-17.

Dougherty, M. R., & Robey, A. (2018). Neuroscience and education: A bridge astray?. *Current Directions in Psychological Science*, *27*(6), 401-406.

Eccles, J. C. (1968). The importance of brain research for the educational, cultural, and scientific future of mankind. *Perspectives in Biology and Medicine*, *12*(1), 61-68.

Ehrhart, M. G., Schneider, B., & Macey, W. H. (2014). *Organizational climate and culture: An introduction to theory, research, and practice*. Routledge.

Enders, C. K. (2003). Using the expectation maximization algorithm to estimate coefficient alpha for scales with item-level missing data. *Psychological Methods*, *8*(3), 322–337. https://doi.org/10.1037/1082-989X.8.3.322

Evans, J. R., & Mathur, A. (2005). The value of online surveys. *Internet Research*, *15* (2), 195-219.

Fernald, L. D. (2008). *Psychology: Six perspectives*. Sage Publications.

Fessard, A. (1952, July 18). *Plan for the establishment of an international brain institute*. UNESCO/NS/BR/3, Paris. Retrieved from https://unesdoc.unesco.org/ark:/48223/pf0000149004?posInSet=2&queryId=468983d4-ad44-49d5-a173-b6120a7f4455

Fulton, B. R. (2018). Organizations and survey research: Implementing response enhancing strategies and conducting nonresponse analyses. *Sociological Methods & Research*, *47*(2), 240-276.

Flobakk, F. R. (2011). Educational Neuroscience-A Critical Discourse Analysis (Master's thesis, Norges teknisk-naturvitenskapelige universitet, Fakultet for samfunnsvitenskap og teknologiledelse, Pedagogisk institutt). Retrieved from https://ntnuopen.ntnu.no/ntnu-xmlui/bitstream/handle/11250/269387/431008_FULLTEXT01.pdf?sequence=1

Fosnacht, K., Sarraf, S., Howe, E., & Peck, L. K. (2017). How important are high response rates for college surveys?. *The Review of Higher Education*, *40*(2), 245-265.

Geake, J. G. (2009). *The brain at school: Educational neuroscience in the classroom*. McGraw-Hill.

Gentner, D. (2019). Cognitive science is and should be pluralistic. *Topics in Cognitive Science*, *11*(4), 884-891.

Gold, I., Roskies, A. L. (2008). Philosophy of neuroscience. In M. Ruse (Eds.), *The Oxford handbook of philosophy of Biology* (pp. 349-380). Oxford University Press.

Goldstein, M. (1994). Decade of the brain. An agenda for the nineties. *Western Journal of Medicine*, *161*(3), 239-241.

Gordon, E., Cooper, N., Rennie, C., Hermens, D., & Williams, L. M. (2005). Integrative neuroscience: The role of a standardized database. *Clinical EEG and Neuroscience*, *36*(2), 64-75.

Goswami, U. (2006). Neuroscience and education: From research to practice? *Nature Reviews Neuroscience, 7*, 406–413.

Gross, C. G. (1987). Neuroscience, early history of. *Journal of Encyclopedia of Neuroscience*, 843- 847.

Hassabis, D., Kumaran, D., Summerfield, C., & Botvinick, M. (2017). Neuroscience-inspired artificial intelligence. *Neuron*, *95*(2), 245-258.

Hensing, J. T. (1719) Cerebri examen chemicum, ex eodemque phosphorum singularem omnia inflammabilia accendentem. Dissertation, Gießen

Hoffmann, M. (2016). Neurochemistry. In *Cognitive, Conative and Behavioral Neurology* (pp. 35-49). Springer, Cham.

Hogben, L. (1930). *The nature of living matter*. Kegan Paul, Tranch, Trubner and Co.

Howard-Jones, P. (ed.) (2007). *Neuroscience and education: Issues and opportunities. A commentary by the teaching and learning research programme*. TLRP/EDRC.

Ivey, A. E., D'Andrea, M. J., & Ivey, M. B. (2012). Neuroscience the newest force in counseling and psychotherapy. In *Theories of counseling and psychotherapy: A multicultural perspective (*pp. 49-86). Sage.

Jakobsen, J. C., Gluud, C., Wetterslev, J., & Winkel, P. (2017). When and how should multiple imputation be used for handling missing data in randomised clinical trials–a practical guide with flowcharts. *BMC Medical Research Methodology*, *17*(1), 1-10.

Jilk, D. J., Lebiere, C., O'Reilly, R. C., & Anderson, J. R. (2008). SAL: An explicitly pluralistic cognitive architecture. *Journal of Experimental and Theoretical Artificial Intelligence*, *20*(3), 197-218.

Kelley, P., & Whatson, T. (2013). Making long-term memories in minutes: A spaced learning pattern from memory research in education. *Frontiers in Human Neuroscience, 7*, Article 589.

Khan, M. A., Ismail, F. B., Hussain, A., & Alghazali, B. (2020). The interplay of leadership styles, innovative work behavior, organizational culture, and organizational citizenship behavior. *SAGE Open*, *10*(1), 1-16.

Klaassen, R. G. (2018). Interdisciplinary education: A case study. *European Journal of Engineering Education*, *43*(6), 842-859.

Kline, R. B. (2015). *Principles and practice of structural equation modeling*. Guilford publications.

Leal Filho, W., Eustachio, J. H. P. P., Caldana, A. C. F., Will, M., Salvia, A. L., Rampasso, I. S., ... & Kovaleva, M. (2020). Sustainability leadership in higher education institutions: An overview of challenges. *Sustainability*, *12*(9), 1-21.

Liu, M., & Wronski, L. (2018). Examining completion rates in web surveys via over 25,000 real-world surveys. *Social Science Computer Review*, *36*(1), 116-124.

Llinás, R. R. (2003). The contribution of Santiago Ramon y Cajal to functional neuroscience. *Nature Reviews Neuroscience*, *4*(1), 77-80.

Lundh, L. G. (2015). Combining holism and interactionism. Towards a conceptual clarification. *Journal for Person-Oriented Research, 1*(3), 185-194. doi: 10.17505/jpor.2015.19

Martin, J. B. (2002). The integration of neurology, psychiatry, and neuroscience in the 21st century. *American Journal of Psychiatry*, *159*(5), 695-704.

Martin-Araguz, A., Bustamante-Martinez, C., & Moreno-Martínez, J. M. (2002). Neuroscience in Al Andalus and its influence on medieval scholastic medicine. *Revista de Neurología*, *34*(9), 877-892.

McLeod, S. A. (2008). *Reductionism and holism*. Simply Psychology. https://www.simplypsychology.org/reductionism-holism.html

McShane, M., Bringsjord, S., Hendler, J., Nirenburg, S., & Sun, R. (2019). A Response to Núñez et al.'s (2019) "What Happened to Cognitive Science?". *Topics in Cognitive Science*, *11*(4), 914-917.

Miller, R., & Beeson, E. T. (2021). *The neuroeducation toolbox: Practical translations of neuroscience in counseling and psychotherapy*. Cognella.

Mircioiu, C., & Atkinson, J. (2017). A comparison of parametric and non-parametric methods applied to a Likert scale. *Pharmacy*, *5*(2), Article 26.

Mohamed, W. M. (2008). *History of Neuroscience: Arab and Muslim contributions to modern neuroscience*. IBRO History of Neuroscience. http://ibro.org/wp-content/uploads/2018/07/Arab-and-Muslim-Contributions-to-Modern-Neuroscience.pdf

Morris, J., & Sah, P. (2016). Neuroscience and education: Mind the gap. *Australian Journal of Education*, *60*(2), 146-156.

Morss, R. E., Lazrus, H., & Demuth, J. L. (2018). The “inter” within interdisciplinary research: Strategies for building integration across fields. *Risk Analysis*.

Müller, O., & Rotter, S. (2017). Neurotechnology: Current developments and ethical issues. *Frontiers in Systems Neuroscience, 11*, Article 93.

Nancarrow, S. A., Booth, A., Ariss, S., Smith, T., Enderby, P., & Roots, A. (2013). Ten principles of good interdisciplinary team work. *Human Resources for Health*, *11*(1), 1-11.

Nordqvist, C., (n.d.). *About neuroscience*. Georgetown University Medical Center. Retrieved April 20, 2021, from https://neuro.georgetown.edu/about-neuroscience/#:~:text=Neuroscientists%20focus%20on%20the%20brain,on%20behavior%20and%20cognitive%20functions.&text=Many%20researchers%20say%20that%20neuroscience,do%20with%20the%20nervous%20system.

Norman, G. (2010). Likert scales, levels of measurement and the “laws” of statistics. *Advances in Health Sciences Education*, *15*(5), 625-632.

Nunnally, J. O. (1978). *Psychometric theory*. New York: McGraw-Hill.

Núñez, R., Allen, M., Gao, R., Rigoli, C. M., Relaford-Doyle, J., & Semenuks, A. (2019). What happened to cognitive science?. *Nature Human Behaviour*, *3*(8), 782-791.

Olssen, M., Codd, J., & O’Neill, A. (2004). Policy as text and policy as discourse: A framework for analysis. *Education Policy: Globalization, Citizenship and Democracy*, 59-72.

Orcan, F. (2018). Exploratory and confirmatory factor analysis: Which one to use first. *Journal of Measurement and Evaluation in Education and Psychology*, *9*(4), 414-421.

Palchaudhuri, S. (2020). The mind behind the Hebbian synapse. *Resonance*, *25*(9), 1215-1230.

Pallant, J. (2011). Survival manual. *A step by step guide to data analysis using SPSS, 4.*

Pek, J., Wong, O., & Wong, A. (2018). How to address non-normality: A taxonomy of approaches, reviewed, and illustrated. *Frontiers in Psychology*, *9*, Article 2104.

Penof, D. G., Leonardo, S. B., & Farina, M. C. (2020). The challenges of interdisciplinarity in higher education: The role of the course coordinator in special projects and activities/Desafios da interdisciplinaridade no ensino superior: O papel do coordenador de curso nos" projetos e atividades especiais--paes". *Administração: Ensino e Pesquisa–RAEP*, *21*(1), 24-51.

Plano Clark, C. V., & Creswell, J. W. (2015). *Understanding research: A consumer's guide*. Pearson Education.

Poole Jr, C. P., & Owens, F. J. (2003). *Introduction to nanotechnology*. John Wiley & Sons.

Raghavan, M., Fee, D., & Barkhaus, P. E. (2019). Generation and propagation of the action potential. *Handbook of Clinical Neurology*, *160*, 3-22.

Repko, A. F. (2008). *Interdisciplinary research*. Sage.

Robbins, T. W. (2016). Neurochemistry of cognition. In *Oxford Textbook of Cognitive Neurology and Dementia* (pp. 91-104). Oxford University Press.

Robinson-Riegler, B., & Robinson-Riegler, G. (2016). *Cognitive psychology: Applying the science of the mind*. Pearson.

Roth, W. M., & Jornet, A. (2017). *Understanding educational psychology*. Springer.

Royal Society (2011). *Brain waves module 2: Neuroscience: Implications for education and lifelong learning*. Royal Society.

Russell, V. A. (2017). Notes on the recent history of neuroscience in Africa. *Frontiers in Neuroanatomy*, *11*, Article 96.

Sabbatini, R. M., & Cardoso, S. H. (2002). Interdisciplinarity in the neurosciences. *Interdisciplinary Science Reviews*, *27*(4), 303-311.

Saleh, A., & Bista, K. (2017). Examining factors impacting online survey response rates in educational research: perceptions of graduate students. *Online Submission*, *13*(2), 63-74.

Shelley, A. M., Brunton, P., & Horner, K. (2012). Questionnaire surveys of dentists on radiology. *Dentomaxillofacial Radiology*, *41*(4), 267-275.

Shepherd, G. M. (2010). *Creating modern neuroscience: The revolutionary 1950s.* Oxford University Press.

Society for Neuroscience [SfN]. (n.d.). The creation of neuroscience: The society for neuroscience and the quest for disciplinary unity 1969-1995. Retrieved from https://www.sfn.org/about/history-of-sfn/1969-2019

Stinson, C., & Sullivan, J. (2018). Mechanistic explanation in neuroscience. *The Routledge Handbook of Mechanisms and Mechanical Philosophy*, 375-387.

Stock, P., & Burton, R. J. (2011). Defining terms for integrated (multi-inter-trans-disciplinary) sustainability research. *Sustainability*, *3*(8), 1090-1113.

Sullivan, G. M., & Artino Jr, A. R. (2013). Analyzing and interpreting data from Likert-type scales. *Journal of Graduate Medical Education*, *5*(4), 541-542.

Sun, J. (2005). Assessing goodness of fit in confirmatory factor analysis. *Measurement and Evaluation in Counseling and Development*, *37*(4), 240-256.

Tabachnick, B. G., & Fidell, L. S. (2012). *Using multivariate statistics (6th ed.)*. Allyn & Bacon.

The jamovi project (2021). *jamovi*. (Version 1.6) [Computer Software]. Retrieved from https://www.jamovi.org.

Thomas, M. S. (2019). Response to Dougherty and Robey (2018) on neuroscience and education: Enough bridge metaphors—Interdisciplinary research offers the best hope for progress. *Current Directions in Psychological Science*, *28*(4), 337-340.

Thomas, M. S., Ansari, D., & Knowland, V. C. (2019). Annual research review: Educational neuroscience: Progress and prospects. *Journal of Child Psychology and Psychiatry*, *60*(4), 477-492.

Thorndike, E. L. (1913). *Educational psychology, Vol. 1. The original nature of man*. Teachers College. https://doi.org/10.1037/13763-000

Utomo, D. H. (2016). Brain based learning: Effects model A-CAR in critical thinking skills. *Advances in Social Science, Education and Humanities Research*, *79*, 339-343.

Van Kerkhoff, L. (2014). Developing integrative research for sustainability science through a complexity principles-based approach. *Sustainability Science*, *9*(2), 143-155.

Van Mol, C. (2017). Improving web survey efficiency: The impact of an extra reminder and reminder content on web survey response. *International Journal of Social Research Methodology*, *20*(4), 317-327.

Van Orden, G. C., & Paap, K. R. (1997). Functional neuroimages fail to discover pieces of mind in the parts of the brain. *Philosophy of Science, 64,* S85–94.

Vatcheva, K. P., Lee, M., McCormick, J. B., & Rahbar, M. H. (2016). Multicollinearity in regression analyses conducted in epidemiologic studies. *Epidemiology*, *6*(2). Article 1000227. DOI: 10.4172/2161-1165.1000227

Warmbrod, J. R. (2014). Reporting and interpreting scores derived from Likert-type scales. *Journal of Agricultural Education*, *55*(5), 30-47.

Weichwald, S., & Peters, J. (2021). Causality in cognitive neuroscience: concepts, challenges, and distributional robustness. *Journal of Cognitive Neuroscience*, *33*(2), 226-247.

West, C. (2011, February 21). *Neuroscience in the real world*. APS Observer. https://www.psychologicalscience.org/observer/neuroscience-in-the-real-world

Wickens, A. P. (2015). *A history of the brain: From Stone Age surgery to modern neuroscience*. Psychology Press.

Willingham, D. T. (2009). Three problems in the marriage of neuroscience and education. *Cortex*, *45*(4), 544-545.

Willingham, D. [DTWillingham]. (2018, February 2). There seem to be three times as many articles considering the *promise* of neuroscience being brought to bear on education questions as there are actual empirical articles on the subject [Tweet]. Retrieved from https://twitter.com/dtwillingham/status/959439819557560320?lang=en

Wu, H., & Leung, S. O. (2017). Can likert scales be treated as interval scales?—A simulation study. *Journal of Social Service Research*, *43*(4), 527-532.

Zargaran, A., Mehdizadeh, A., Zarshenas, M. M., & Mohagheghzadeh, A. (2012). Avicenna (980–1037 AD). *Journal of Neurology*, *259*(2), 389-390.

Appendix A

Neuroscience and Interdisciplinarity

Thank you for choosing to participate in this research project. Please read the information below carefully before proceeding to the survey questions.

The research project title: Faculty Perspectives on Neuroscience Interdisciplinary Integration: A Descriptive Study in the American University in Cairo
The Principal Investigator (PI): Sondos Mohamed Moshtohry

You are being asked to participate in a research study. Its purpose is to explore what AUC faculty from diverse backgrounds know and feel about neuroscience and whether the recently expanding field has something to do with their own disciplines. It also examines whether faculty think it is important to collaborate through different fields on neuroscience-related topics.

The research findings may be published and/or presented. The information you provide for purposes of this research is anonymous.

The expected duration of your participation is few minutes for answering the survey. The procedures of the research involves administering a survey to all AUC faculty members.

There will not be certain risks or discomforts associated with this research. However, participants may benefit from the content of the survey. It may drive them to consider the topic and how it might be connected to their domains.

Questions about the research, your rights, or research-related injuries should be directed to (Sondos Moshtohry) at (01141427028).

Participation in this study is voluntary. Refusal to participate will involve no penalty or loss of benefits to which you are otherwise entitled. You may discontinue participation at any time without penalty or the loss of benefits to which you are otherwise entitled.

By clicking next, you agree that you have read and understood the above information and agree to participate in this study.

Neuroscience and Interdisciplinarity

* 1. Please mention your department/school/institute/center

* 2. Years of experience in academia

○ 0-5

○ 6-10

○ 11-15

○ > 15

* 3. Gender

○ Male

○ Female

* 4. Please state your favorite areas of research

*5. I am familiar with the emerging field of neuroscience.

- Strongly agree
- Agree
- Disagree
- Strongly disagree

* 6. The applications of neuroscience are by far medical.

- ❍ Strongly agree
- ❍ Agree
- ❍ Disagree
- ❍ Strongly disagree

* 7. If AUC inaugurated a brain inter disciplinary research center, I am willing to be part of it.

- ❍ Strongly agree
- ❍ Agree
- ❍ Disagree
- ❍ Strongly disagree

* 8. Neuroscience is irrelevant to fields other than biology.

- ❍ Strongly agree
- ❍ Agree
- ❍ Disagree
- ❍ Strongly disagree

* 9. Neuroscience provides useful insights that can impact my discipline.

- ❍ Strongly agree
- ❍ Agree
- ❍ Disagree
- ❍ Strongly disagree

* 10. The best way to explain a phenomenon is by reducing it to its basic constituents. (e.g. attention explained in terms of brain chemistry)

- Strongly agree
- Agree
- Disagree
- Strongly disagree

* 11. Findings from neuroscience can affect my teaching practices.

- Strongly agree
- Agree
- Disagree
- Strongly disagree

* 12. The best way to explain a phenomenon is by opening up to connecting relevant descriptions from diverse fields.

- Strongly agree
- Agree
- Disagree
- Strongly disagree

* 13. Insights from neuroscience can affect my research practices.

- Strongly agree
- Agree
- Disagree
- Strongly disagree

* 14. The way my discipline and neuroscience interact is reciprocal. (i.e. neuroscience informs and is informed by my field)

- Strongly agree

- ❍ Agree
- ❍ Disagree
- ❍ Strongly disagree

* 15. Neuroscience has no relevant applications in my discipline.

- ❍ Strongly agree
- ❍ Agree
- ❍ Disagree
- ❍ Strongly disagree

* 16. I consult insights about how the brain learns while developing my teaching philosophy.

- ❍ Strongly agree
- ❍ Agree
- ❍ Disagree
- ❍ Strongly disagree

* 17. I believe interdisciplinary initiatives pertinent to brain research are worth the investment.

- ❍ Strongly agree
- ❍ Agree
- ❍ Disagree
- ❍ Strongly disagree

* 18. I am willing to participate in neuroscience interdisciplinary initiatives.

- ❍ Strongly agree
- ❍ Agree
- ❍ Disagree
- ❍ Strongly disagree

* 19. Brain research significantly intersects with my discipline.

- ❍ Strongly agree
- ❍ Agree
- ❍ Disagree
- ❍ Strongly disagree

* 20. I believe AUC is capable of providing the capacities and facilities needed for brain collaborative research.

- ❍ Strongly agree
- ❍ Agree
- ❍ Disagree
- ❍ Strongly disagree

* 21. Neuroscience leads/will lead to more advances in Artificial Intelligence (AI).

- ❍ Strongly agree
- ❍ Agree
- ❍ Disagree
- ❍ Strongly disagree

* 22. I have been/ am currently part of neuroscience research.

- ❍ Strongly agree
- ❍ Agree
- ❍ Disagree
- ❍ Strongly disagree

* 23. I have been/ am currently part of neuroscience collaborative research.

- ❍ Strongly agree

- Agree
- Disagree
- Strongly disagree

* 24. I believe AUC can lead the region in neuroscience interdisciplinary integration.

- Strongly agree
- Agree
- Disagree
- Strongly disagree

* 25. I believe collaboration is integral to brain research.

- Strongly agree
- Agree
- Disagree
- Strongly disagree

* 26. I believe collaborative brain research initiatives are timely.

- Strongly agree
- Agree
- Disagree
- Strongly disagree

* 27. I believe collaborative brain research initiatives are significant.

- Strongly agree
- Agree
- Disagree
- Strongly disagree

* 28. What is your definition of neuroscience?

* 29. From your own point of view, what are the possible advantages of neuroscience interdisciplinary integration?

* 30. From your own point of view, what are the possible challenges of neuroscience interdisciplinary integration?

* 31. What capacities do you think are needed to achieve effective collaboration?

* 32. What facilities do you think are needed to achieve effective collaboration? (tools, equipment, …etc.)

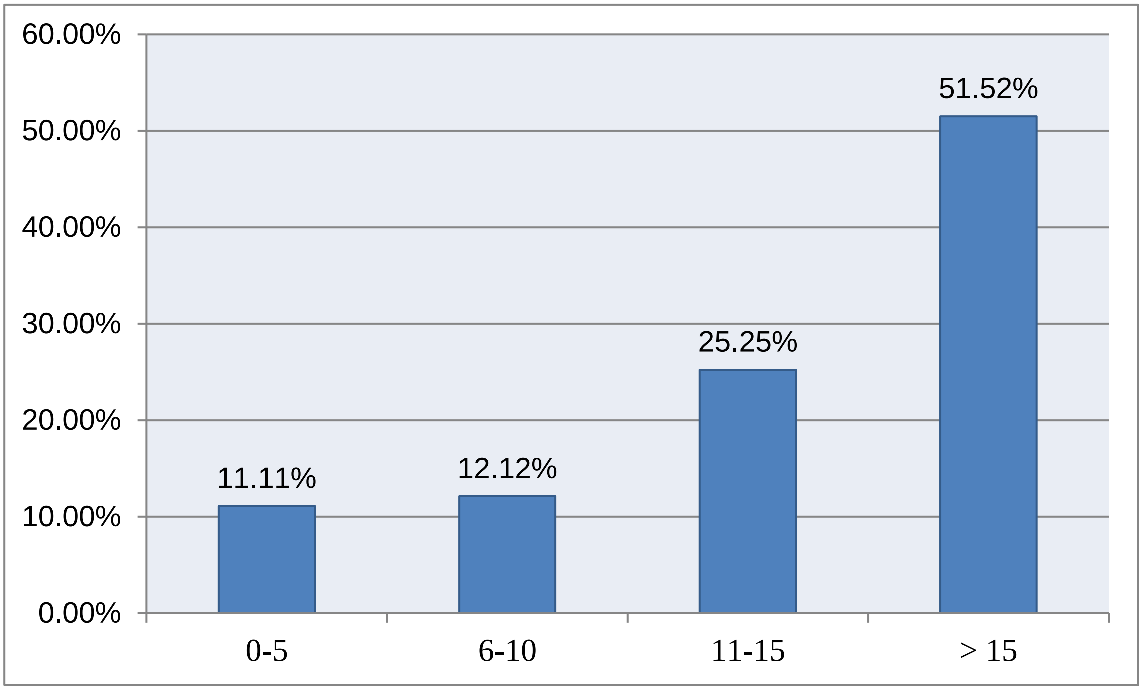
33. Please cite any reading, meeting, or event relevant to neuroscience that you have come across or attended in the last 5 years, if any.

34. Is there anything you want to add about the topic?

Appendix B

Figure B1

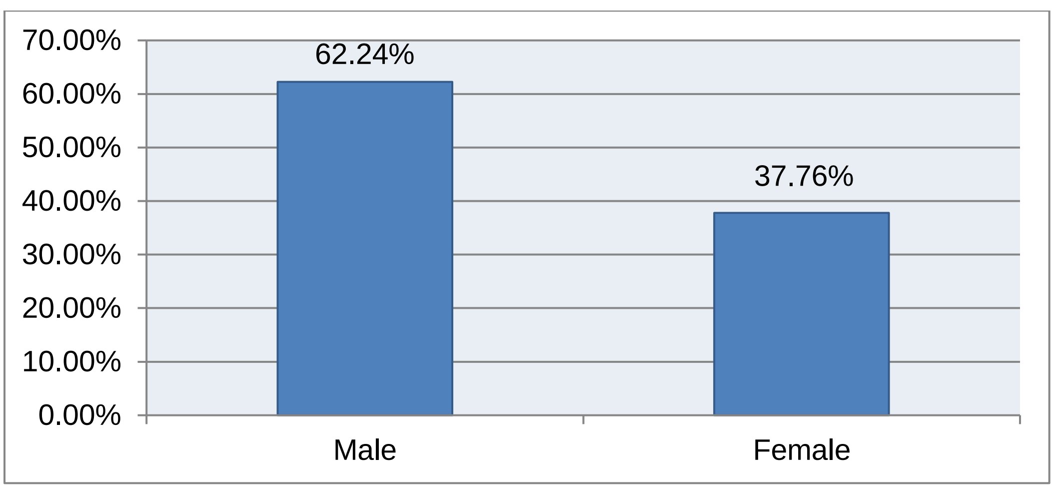
Q2: Years of Experience in Academia



Note. Answered = 99, Skipped = 0

Figure B2

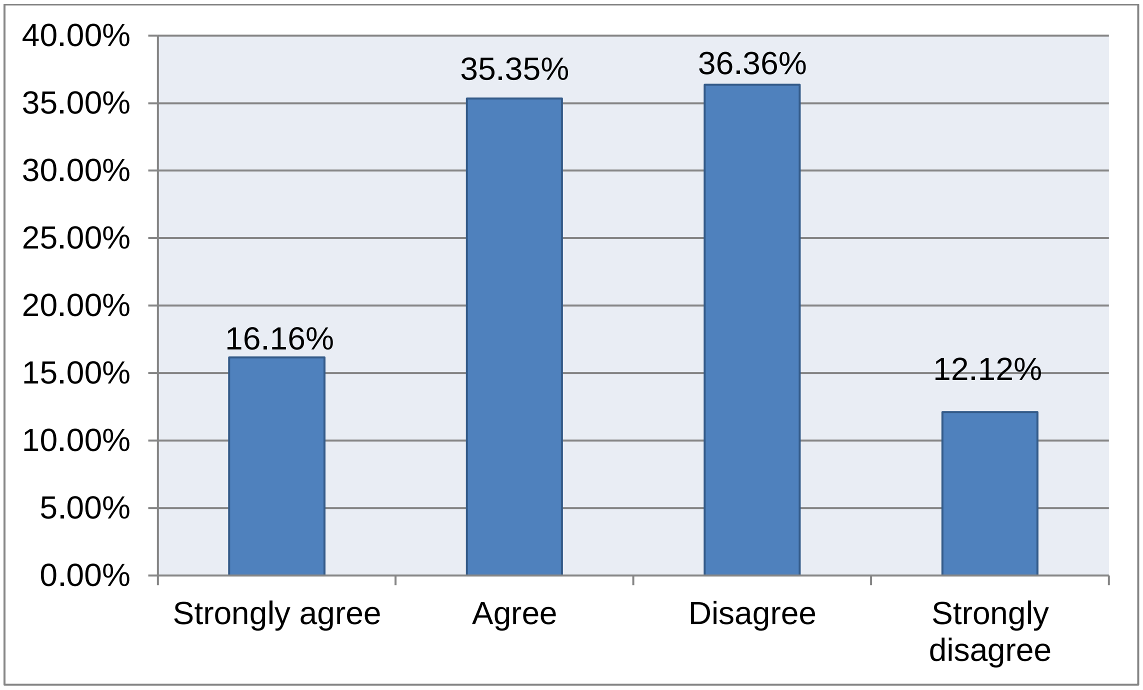
Q3: Gender



Note. Answered = 98, Skipped = 1

Figure B3

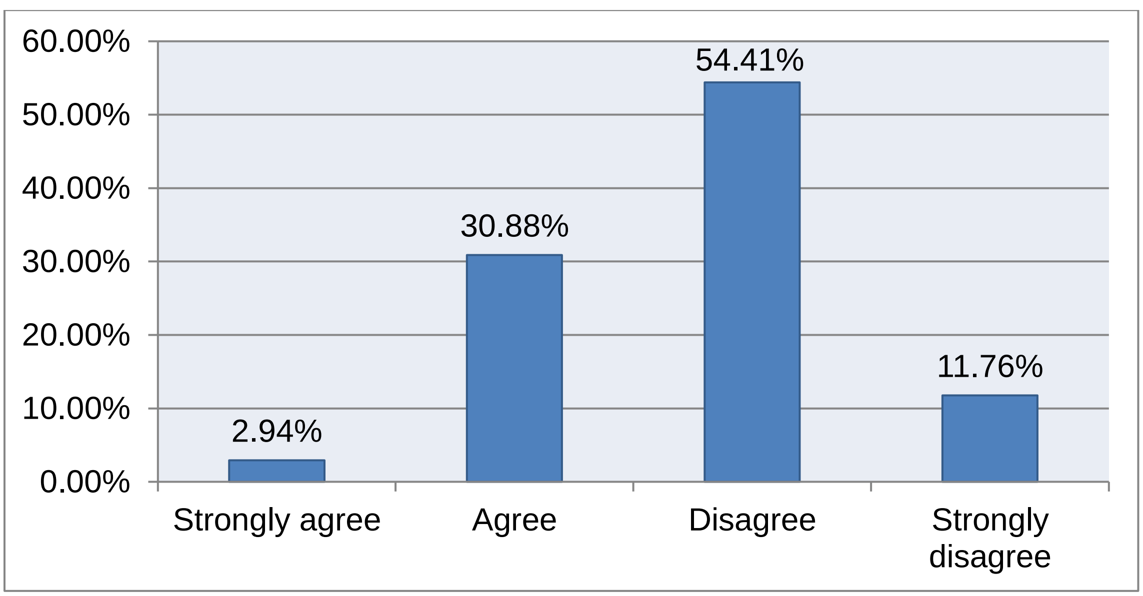
Q5: I am familiar with the emerging field of neuroscience.



Note. Answered = 99, Skipped = 0

Figure B4

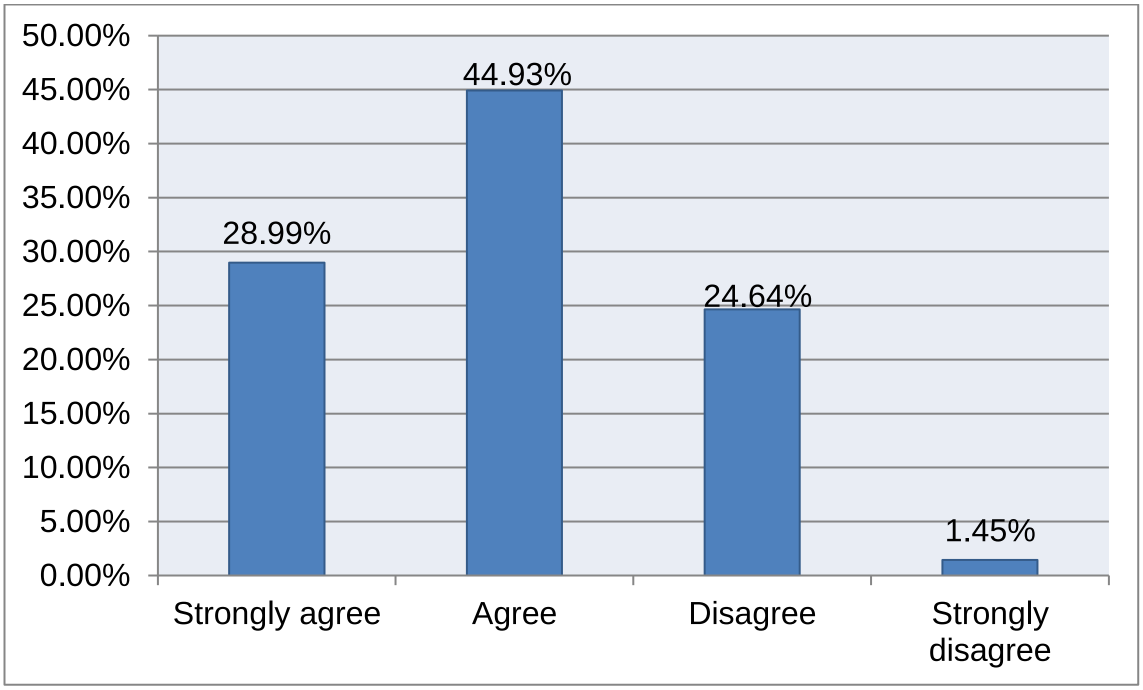
Q6: The applications of neuroscience are by far medical.



Note. Answered = 68, Skipped = 31

Figure B5

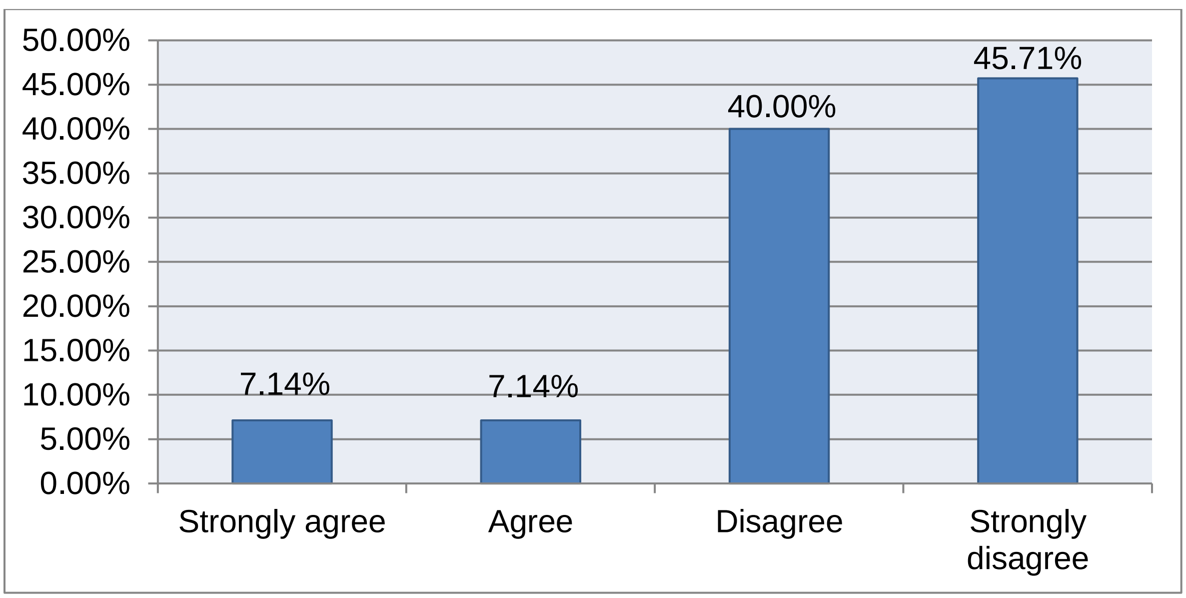
Q7: If AUC inaugurated a brain interdisciplinary research center, I am willing to be part of it.



Note. Answered = 69, Skipped = 30

Figure B6

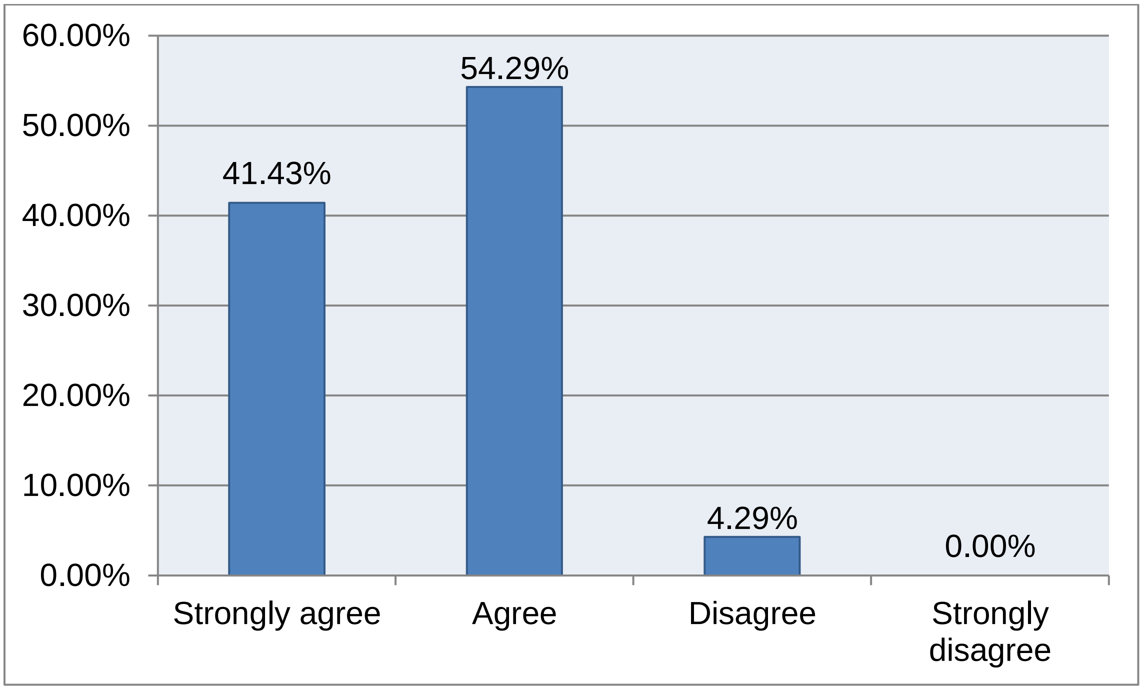
Q8: Neuroscience is irrelevant to fields other than biology.



Note. Answered = 70, Skipped = 29

Figure B7

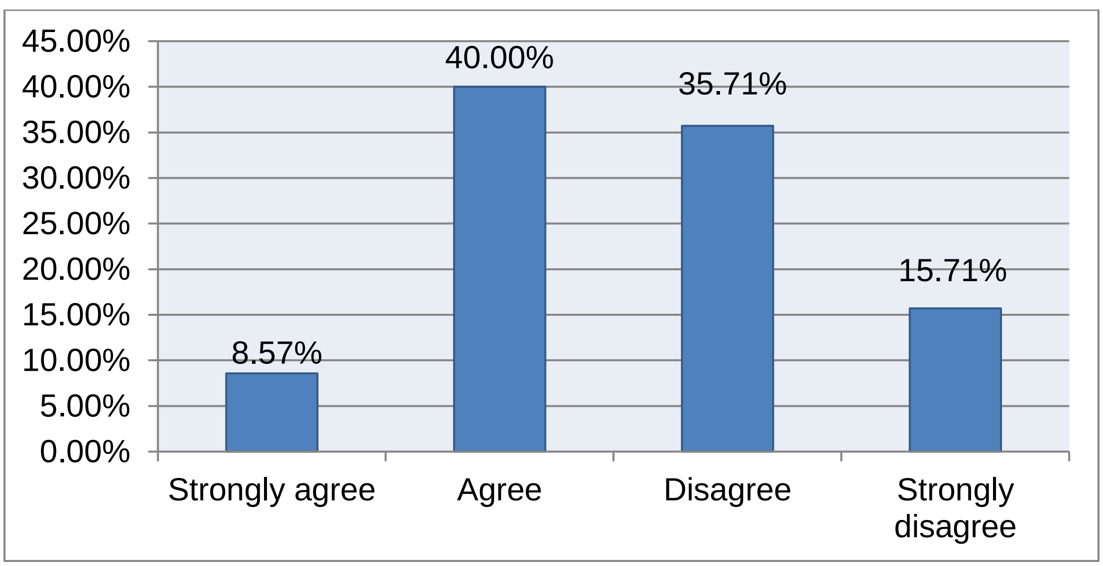
Q9: Neuroscience provides useful insights that can impact my discipline.



Note. Answered = 70, Skipped = 29

Figure B8

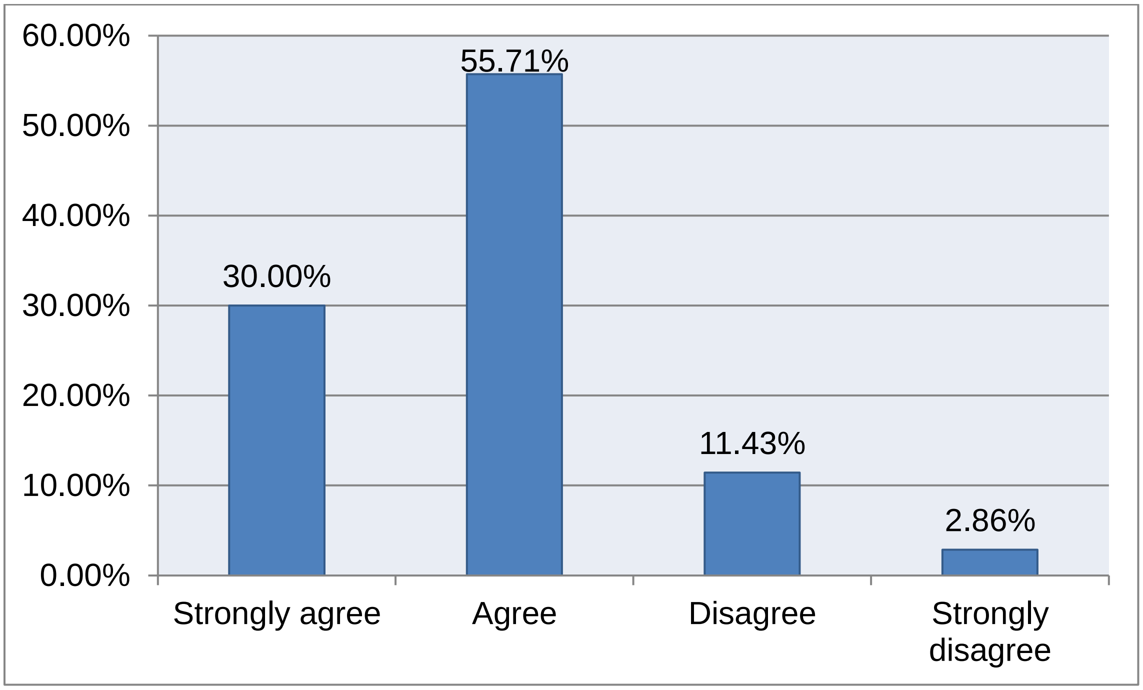
Q10: The best way to explain a phenomenon is by reducing it to its basic constituents. (e.g. attention explained in terms of brain chemistry)



Note. Answered = 70, Skipped = 29

Figure B9

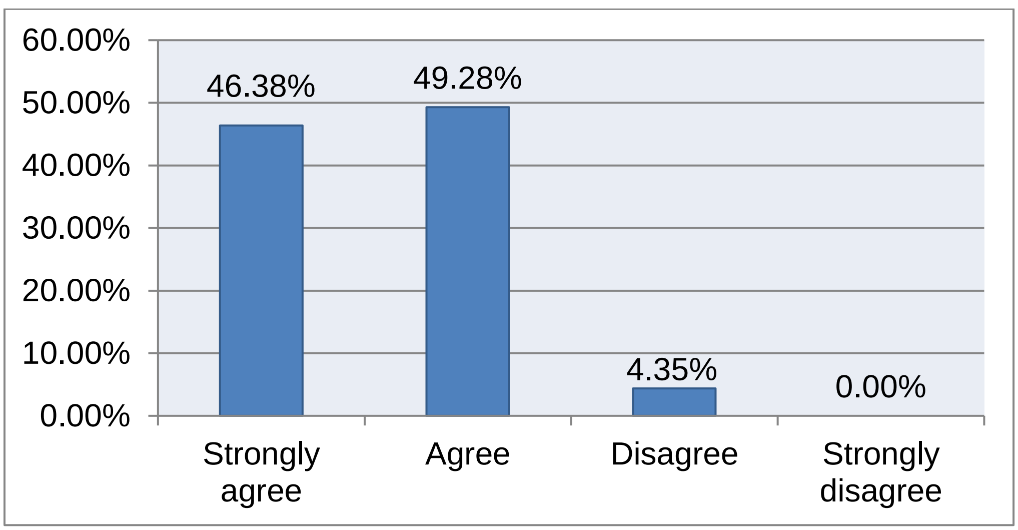
Q11: Findings from neuroscience can affect my teaching practices.



Note. Answered = 70, Skipped = 29

Figure B10

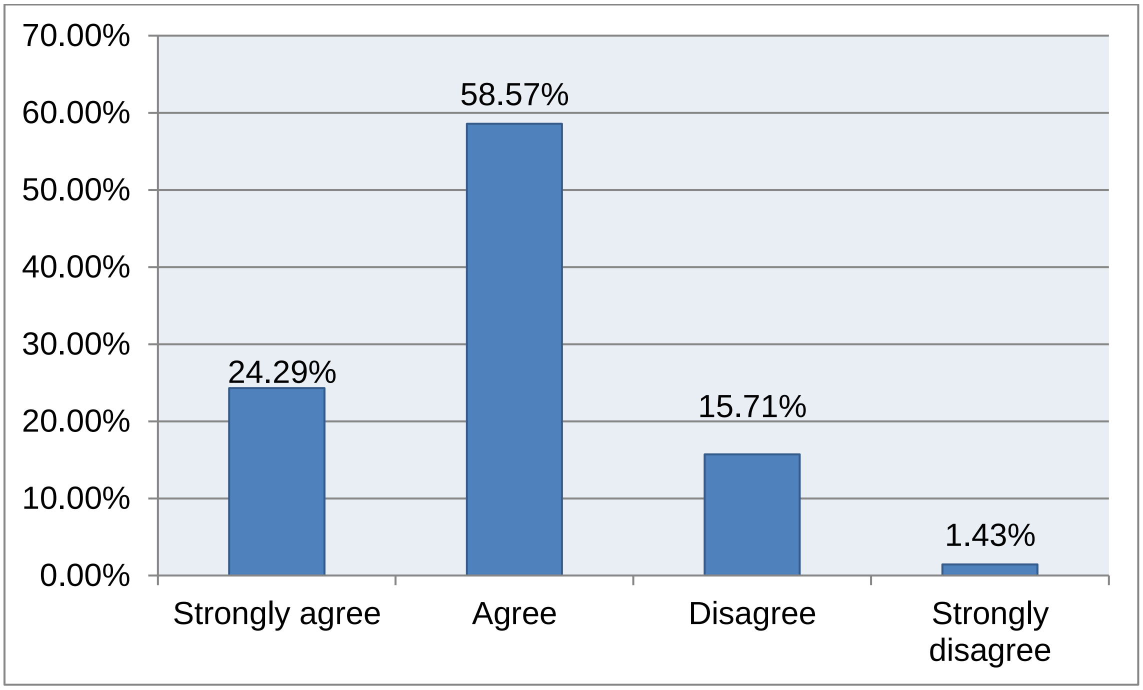
Q12: The best way to explain a phenomenon is by opening up to connecting relevant descriptions from diverse fields.



Note. Answered = 69, Skipped = 30

Figure B11

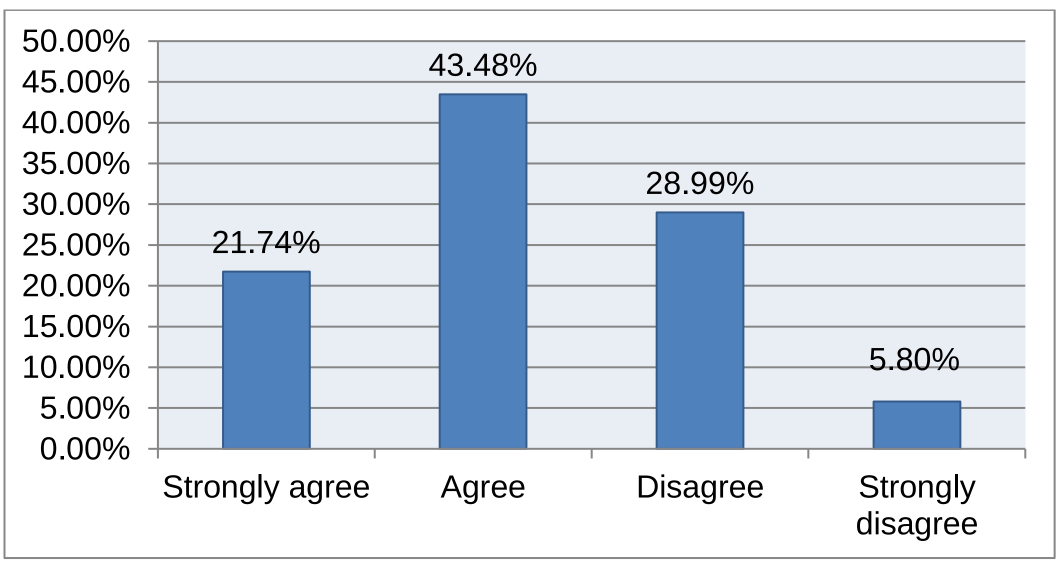
Q13: Insights from neuroscience can affect my research practices.



Note. Answered = 70, Skipped = 29

Figure B12

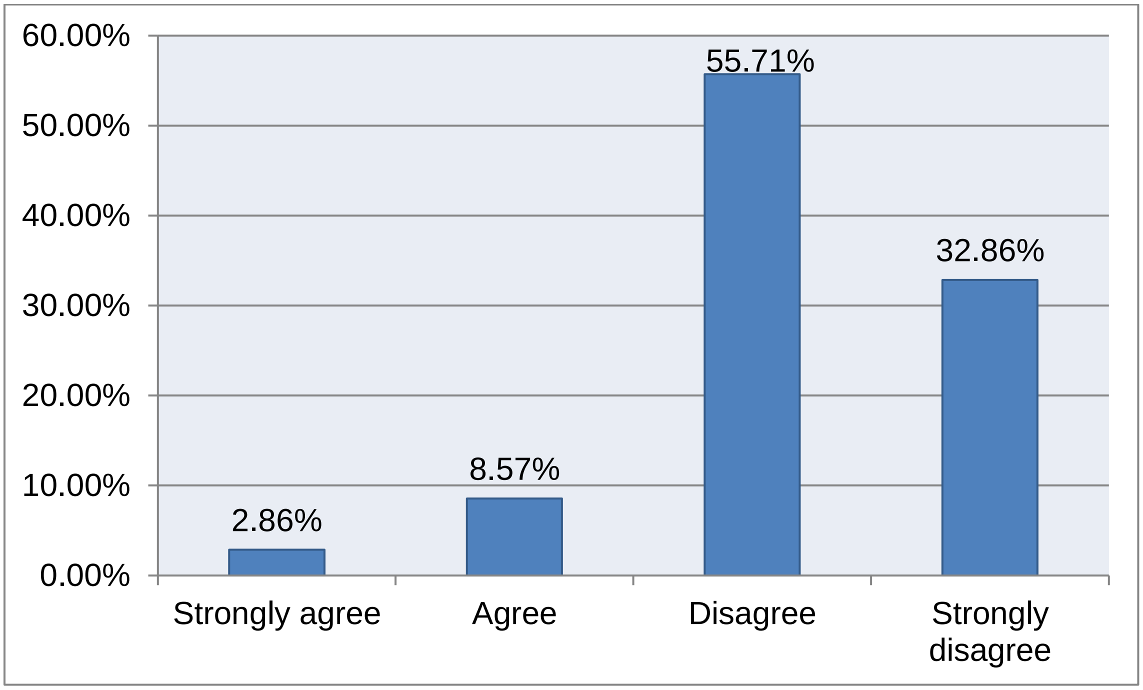
Q14: The way my discipline and neuroscience interact is reciprocal. (i.e. neuroscience informs and is informed by my field)



Note. Answered = 69, Skipped = 30

Figure B13

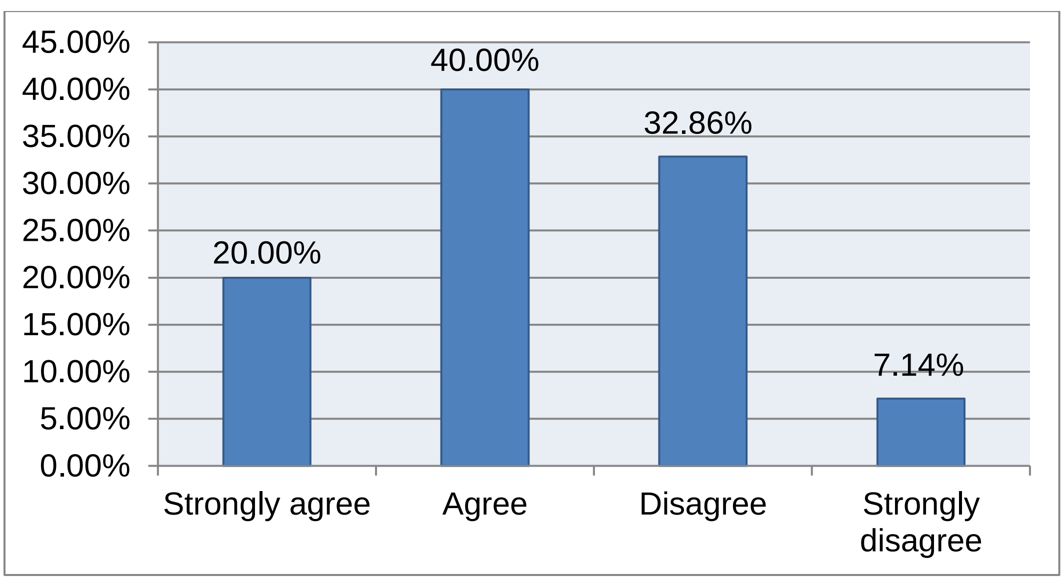
Q15: Neuroscience has no relevant applications in my discipline.



Note. Answered = 70, Skipped = 29

Figure B14

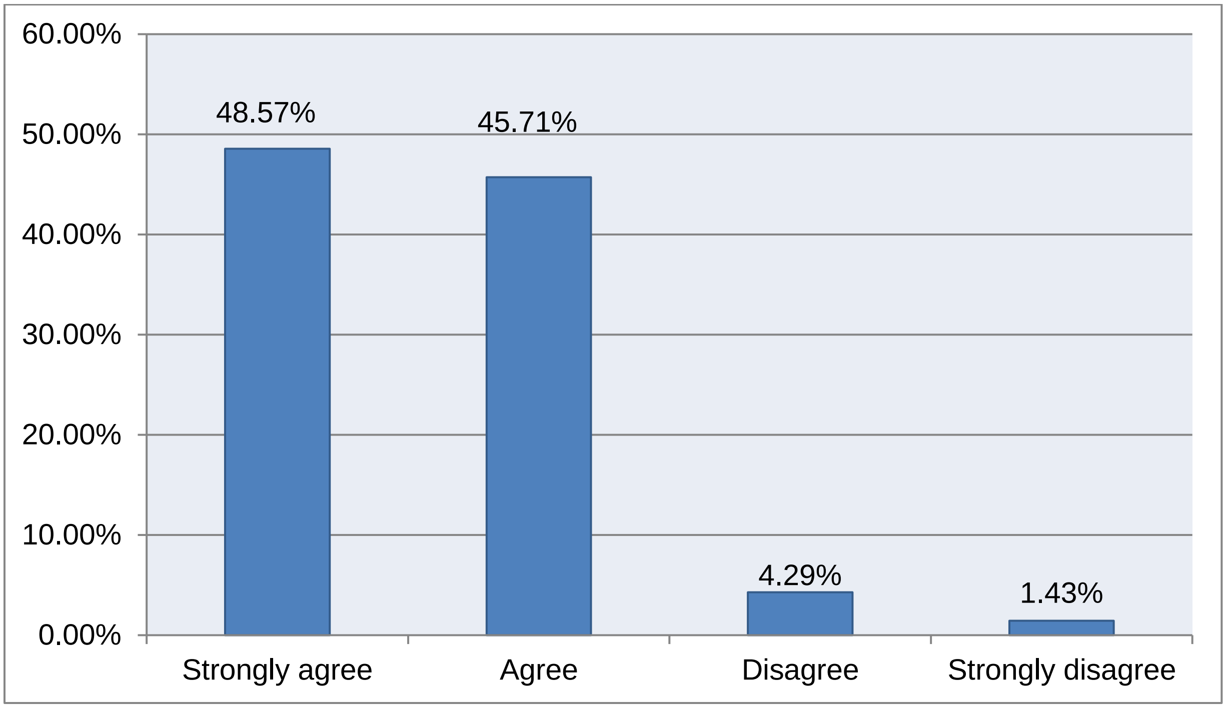
Q16: I consult insights about how the brain learns while developing my teaching philosophy.



Note. Answered = 70, Skipped = 29

Figure B15

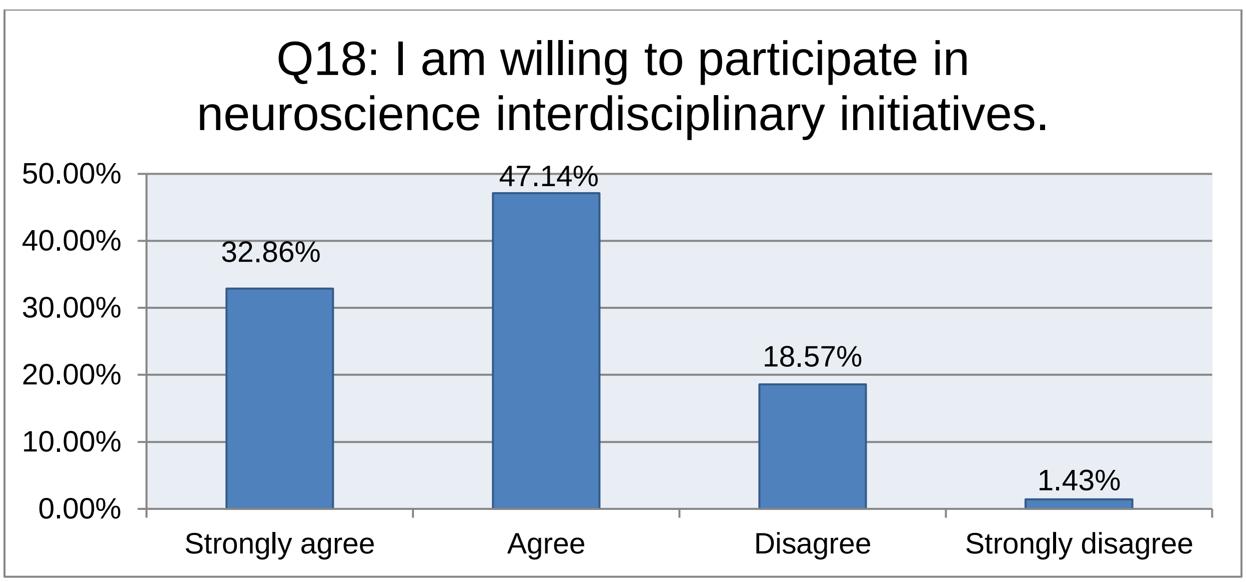
Q17: I believe interdisciplinary initiatives pertinent to brain research are worth the investment.



Note. Answered = 70, Skipped = 29

Figure B16

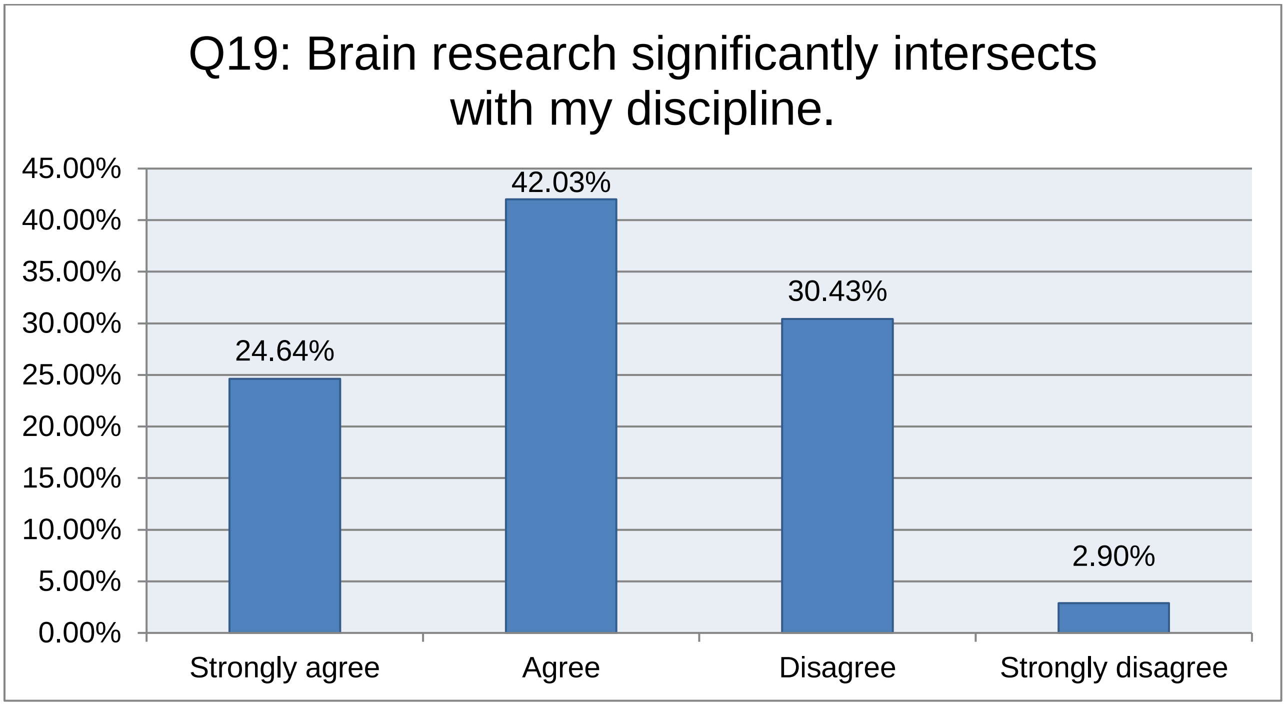
Q18: I am willing to participate in neuroscience interdisciplinary initiatives.



Note. Answered = 70, Skipped = 29

Figure B17

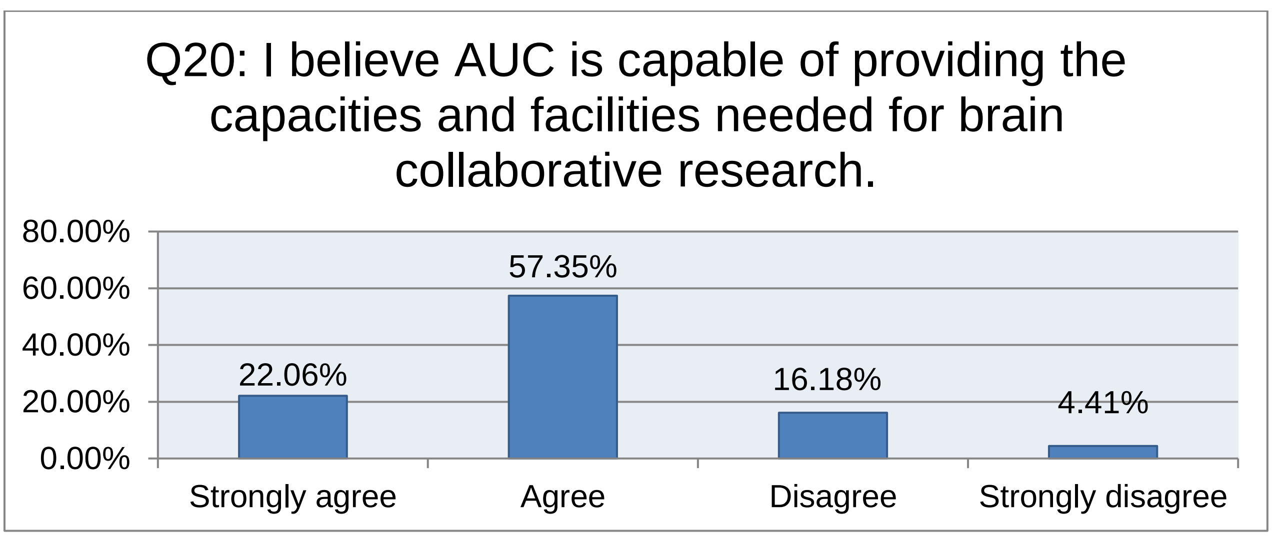
Q19: Brain research significantly intersects with my discipline.



Note. Answered = 69, Skipped = 30

Figure B18

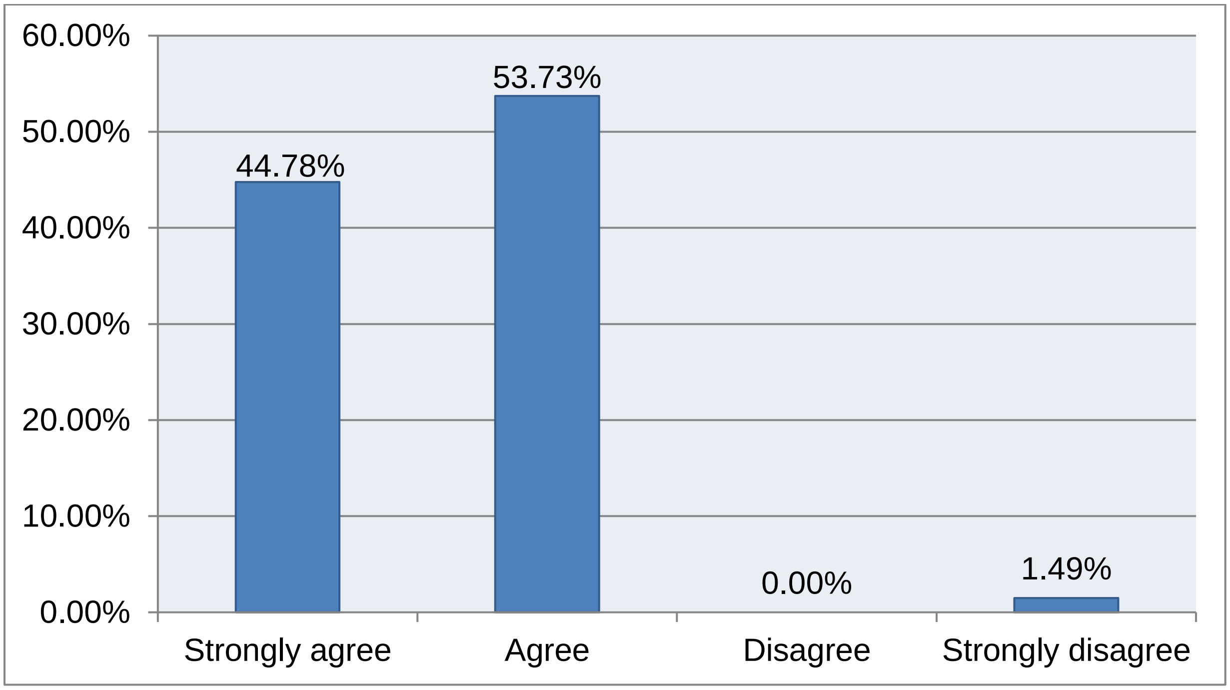
Q20: I believe AUC is capable of providing the capacities and facilities needed for brain collaborative research.



Note. Answered = 68, Skipped = 31

Figure B19

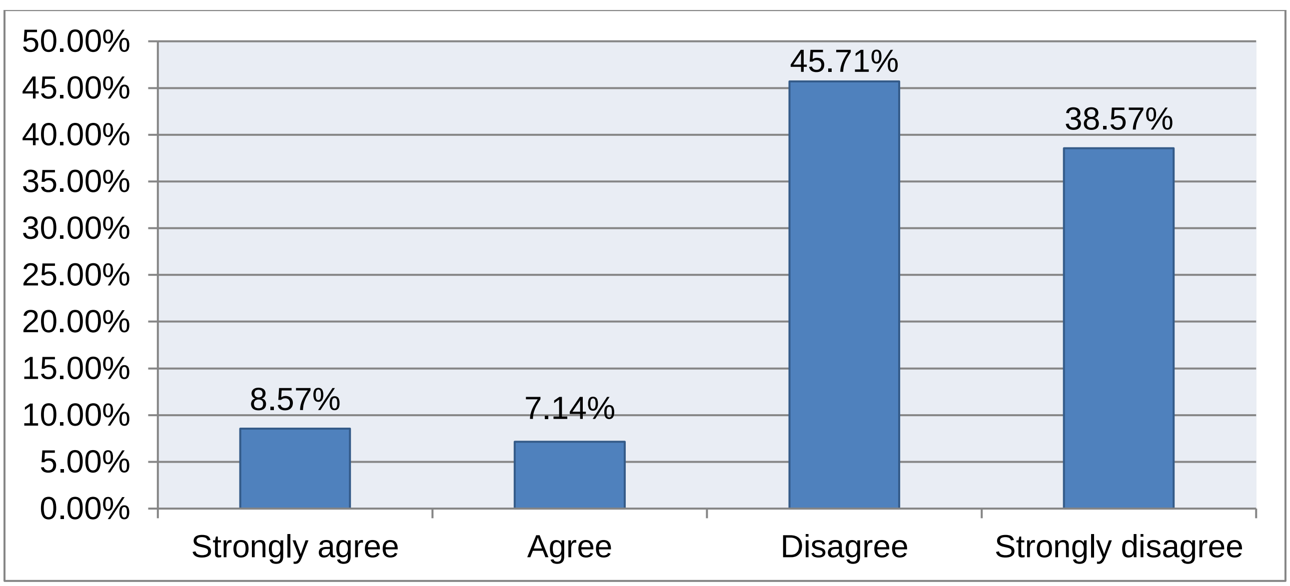
Q21: Neuroscience leads/will lead to more advances in Artificial Intelligence (AI).



Note. Answered = 67, Skipped = 32

Figure B20

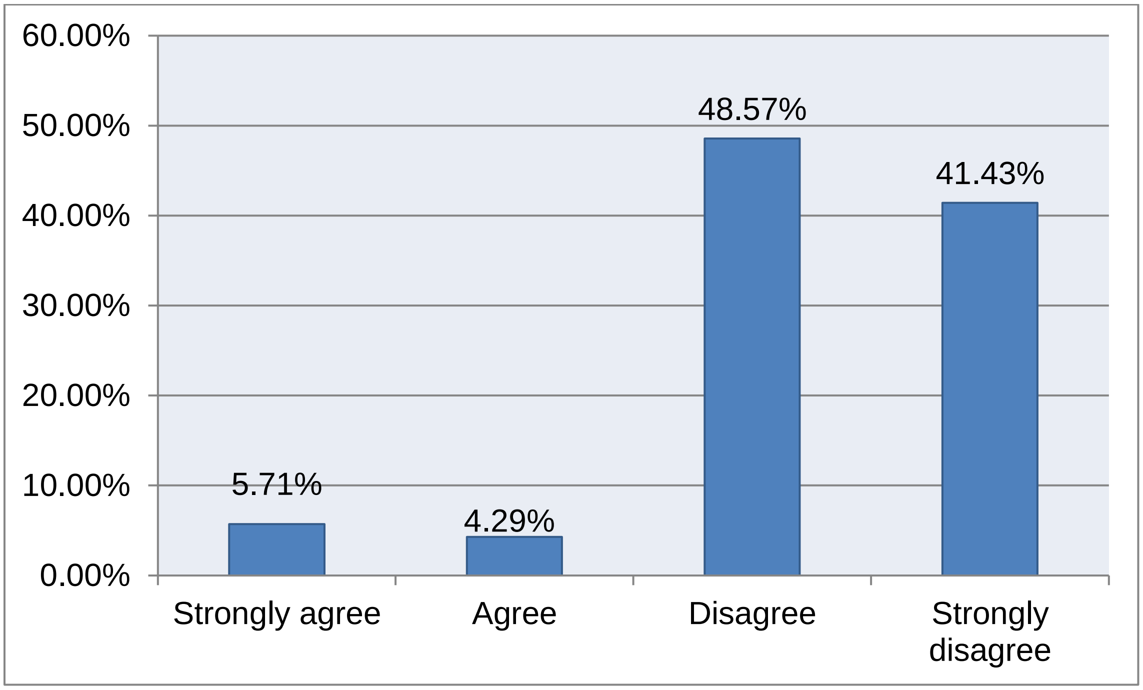
Q22: I have been/ am currently part of neuroscience research.



Note. Answered = 70, Skipped = 29

Figure B21

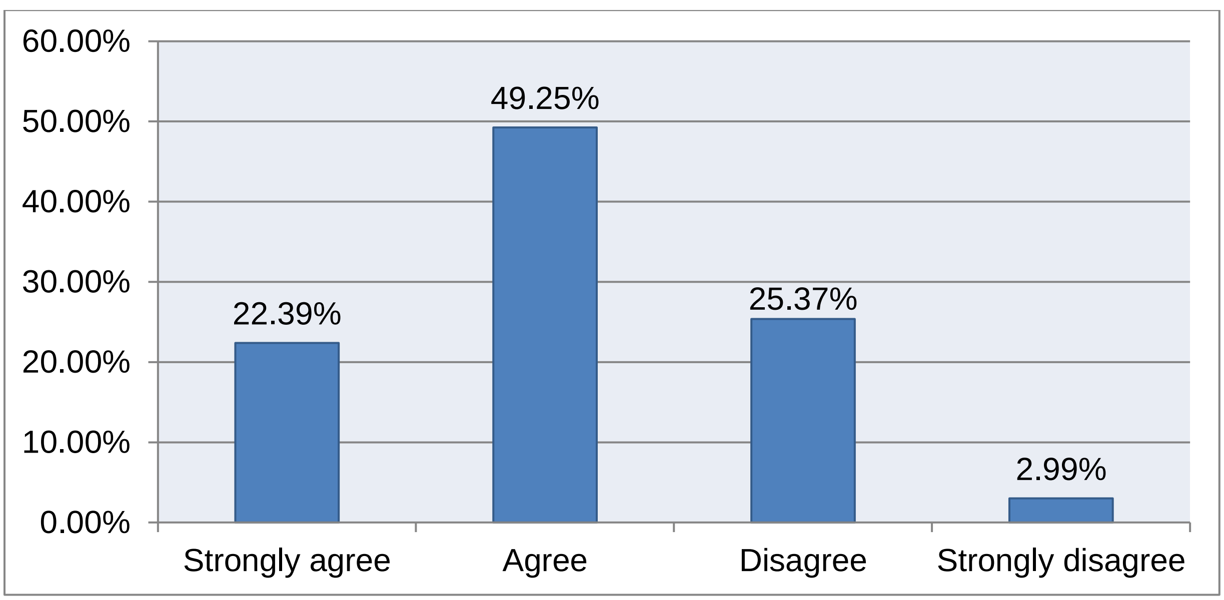
Q23: I have been/ am currently part of neuroscience collaborative research.



Note. Answered = 70, Skipped = 29

Figure B22

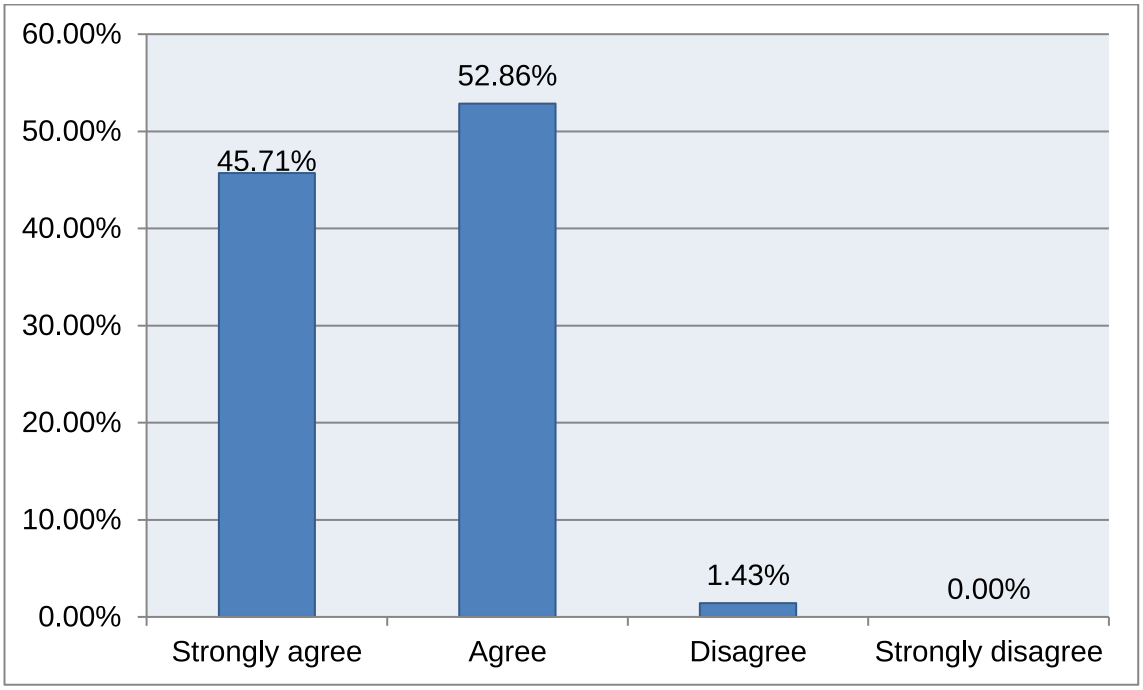
Q24: I believe AUC can lead the region in neuroscience interdisciplinary integration.



Note. Answered = 67, Skipped = 32

Figure B23

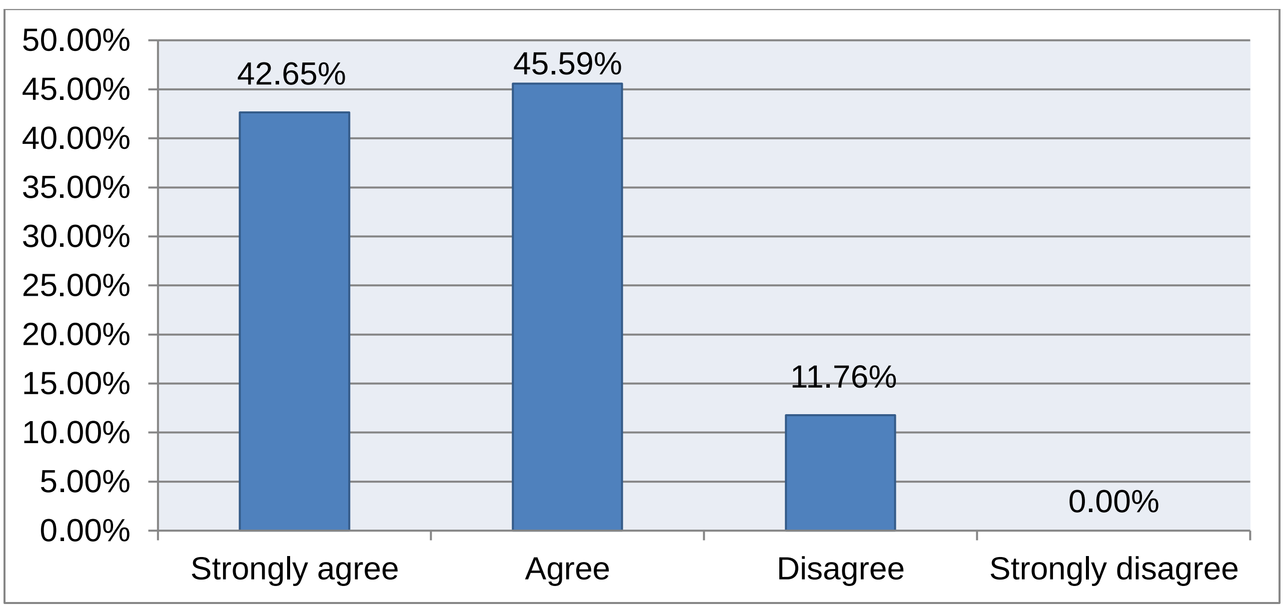
Q25: I believe collaboration is integral to brain research.



Note. Answered = 70, Skipped = 29

Figure B24

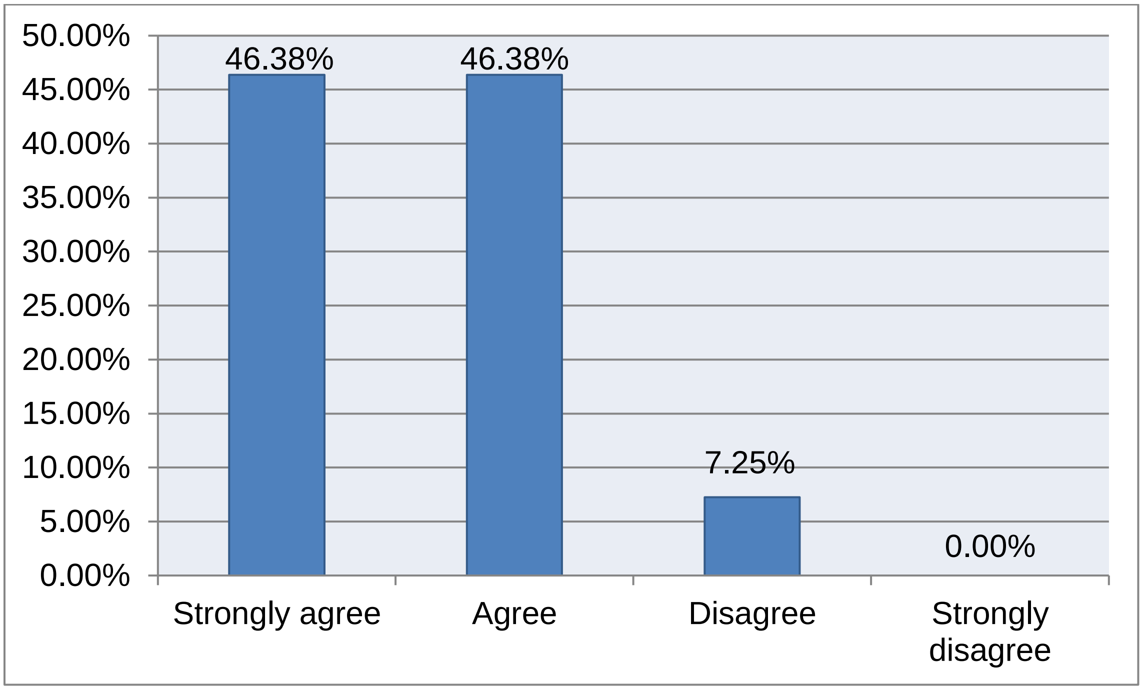
Q26: I believe collaborative brain research initiatives are timely.



Note. Answered = 68, Skipped = 31

Figure B25

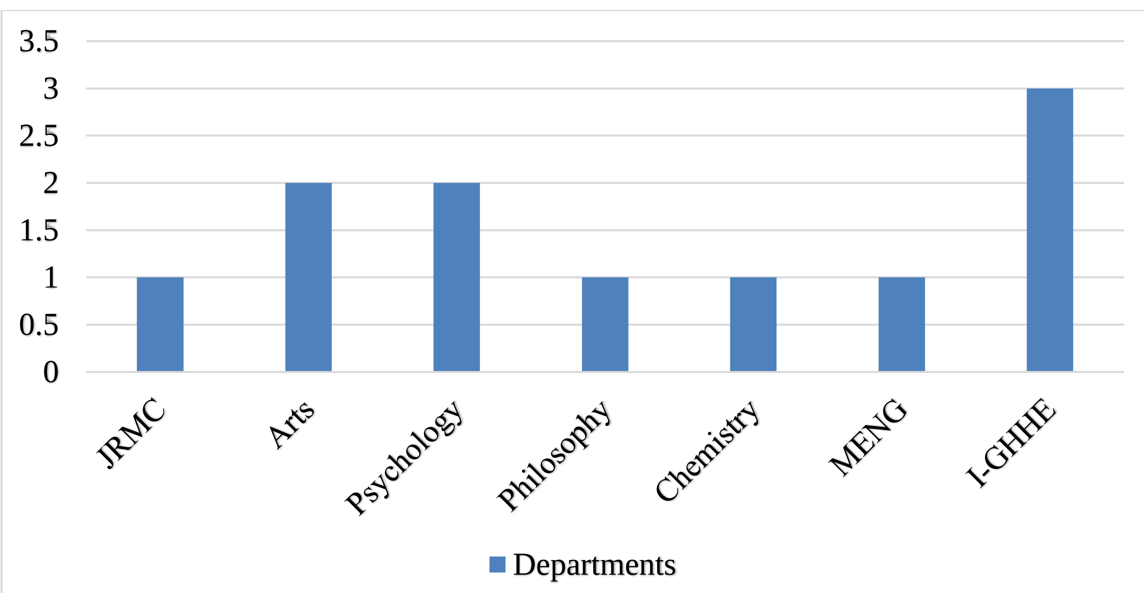
Q27: I believe collaborative brain research initiatives are significant.



Note. Answered = 69, Skipped = 30

Figure B26

Number of Faculty Members Participating in Brain Research by Department



Note. Number of respondents = 70

Appendix C

Table C1

Mean Scores of the Six Variables according to Experience

Years of experience category	Mean familiarity score	Mean relevance score	Mean collaboration score	Mean integration in practice score	Mean willingness score	Mean AUC trust score
1= (0-5)	1.95 (SD= 0.509)	1.75 (SD= 0.636)	1.41 (SD= 0.326)	2.19 (SD= 0.547)	1.63 (SD= 0.582)	1.71 (SD= 0.393)
2= (6-10)	2.15 (SD= 0.496)	1.93 (SD= 0.644)	1.63 (SD= 0.626)	2.3 (SD= 0.483)	1.75 (SD= 0.486)	2.1 (SD= 0.658)
3= (11-15)	2.06 (SD= 0.653)	1.87 (SD= 0.668)	1.67 (SD= 0.582)	2.2 (SD= 0.720)	2 (SD= 0.764)	1.97 (SD= 0.831)
4= (> 15)	2.27 (SD= 0.548)	2.09 (SD= 0.588)	1.66 (SD= 0.491)	2.4 (SD= 0.573)	2.02 (SD= 0.767)	2.17 (SD= 0.679)

Table C2

Mean Scores of the Six Variables according to Gender

Gender	Mean familiarity score	Mean relevance score	Mean collaboration score	Mean integration in practice score	Mean willingness score	Mean AUC trust score
1 = Male	2.2 (SD= 0.536)	2.04 (SD= 0.563)	1.72 (SD= 0.557)	2.33 (SD= 0.584)	1.96 (SD= 0.664)	2 (SD= 0.639)
2 = Female	2.13 (SD= 0.610)	1.9 (SD= 0.684)	1.52 (SD= 0.438)	2.29 (SD= 0.627)	1.91 (SD= 0.782)	2.17 (SD= 0.784)

Table C3

Mean Scores of the Six Variables according to School/Center

School	Mean familiarity score	Mean relevance score	Mean collaboration score	Mean integration in practice score	Mean willingness score	Mean AUC trust score
1= Business	2.43 (SD= 0.523)	2.11 (SD= 0.745)	1.69 (SD= 0.610)	2.56 (SD= 0.556)	2.22 (SD= 0.833)	1.78 (SD= 0.565)
2= GAPP	2.07 (SD= 0.452)	2.06 (SD= 0.554)	1.56 (SD= 0.371)	2.15 (SD= 0.494)	2.04 (SD= 0.498)	1.91 (SD= 0.437)
3= HUSS	2.14 (SD= 0.622)	1.9 (SD= 0.653)	1.66 (SD= 0.569)	2.34 (SD= 0.652)	1.95 (SD= 0.762)	2.37 (SD= 0.827)
4= SSE	2.14 (SD= 0.591)	1.98 (SD= 0.610)	1.59 (SD= 0.523)	2.25 (SD= 0.624)	1.72 (SD= 0.691)	1.89 (SD= 0.530)
5= CLT	1.94 (SD= 0.0884)	1.67 (SD= 0.00)	1.5 (SD= 0.354)	2.25 (SD= 0.00)	1.5 (SD= 0.707)	1.5 (SD= 0.707)

Appendix D

CASE #2020-2021-060

THE AMERICAN UNIVERSITY IN CAIRO
INSTITUTIONAL REVIEW BOARD

To: Sondos Moshtohry

Cc: Dena Riad

From**:** Atta Gebril, Chair of the IRB

Date**:** Jan. 21, 2021

Re**:** IRB approval

This is to inform you that I reviewed your revised research proposal entitled "**Faculty Perspectives on Neuroscience Interdisciplinary Integration: A Descriptive Study in the American University in Cairo**" and determined that it required consultation with the IRB under the "expedited" category. As you are aware, the members of the IRB suggested certain revisions to the original proposal, but your new version addresses these concerns successfully. The revised proposal used appropriate procedures to minimize risks to human subjects and that adequate provision was made for confidentiality and data anonymity of participants in any published record. I believe you will also make adequate provision for obtaining informed consent of the participants.

This approval letter was issued under the assumption that you have not started data collection for your research project. Any data collected before receiving this letter could not be used since this is a violation of the IRB policy.

Please note that IRB approval does not automatically ensure approval by CAPMAS, an Egyptian government agency responsible for approving some types of off-campus research.
CAPMAS issues are handled at AUC by the office of the University Counsellor, Dr. Ashraf Hatem. The IRB is not in a position to offer any opinion on CAPMAS issues, and takes no responsibility for obtaining CAPMAS approval.

This approval is valid for only one year. In case you have not finished data collection within a year, you need to apply for an extension.

Thank you and good luck.

Atta Gebril

Dr. Atta Gebril
IRB chair, The American University in Cairo
2046 HUSS Building
T: 02-26151919
Email: agebril@aucegypt.edu

Institutional Review Board

The American University in
Cairo AUC Avenue, P.O. Box
74 New Cairo 11835, Egypt.
tel 20.2.2615.1000
fax 20.2.27957565
Email: aucirb@aucegypt.edu