Challenging Minds

Cognitive Scientists' Guide to Interdisciplinary, Research- and Problem-Based Learning

Urban Kordeš, Maruša Sirk, Toma Strle
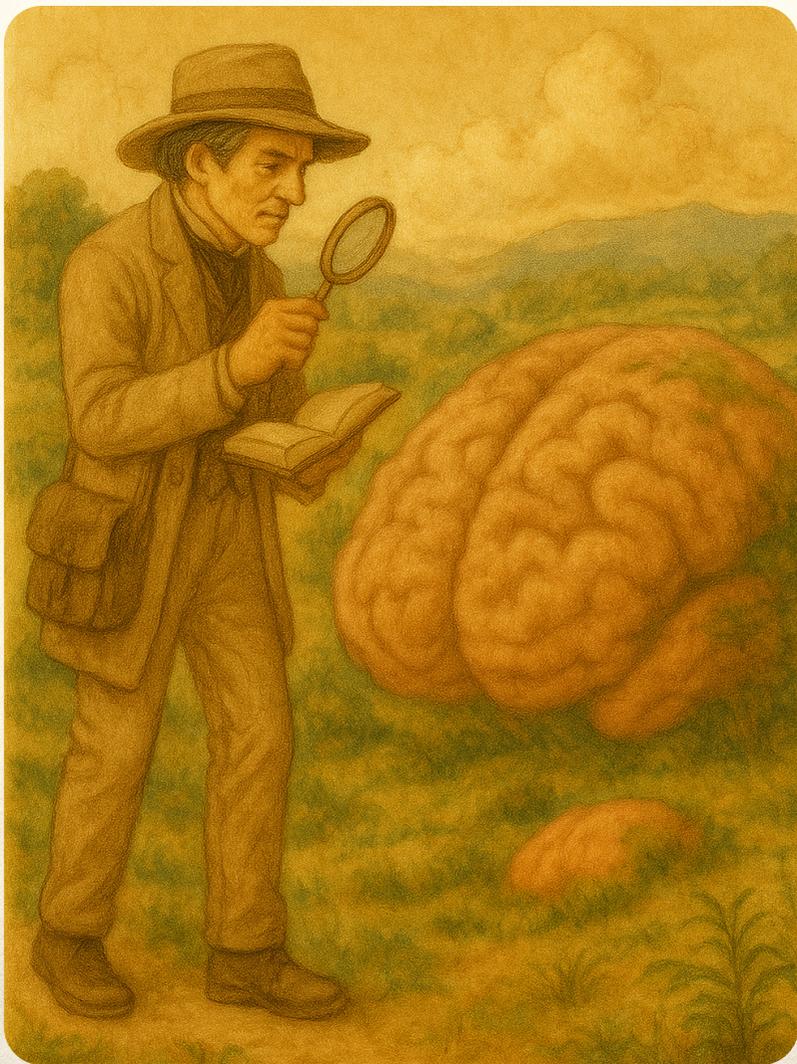
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Foreword

International Joint Interdisciplinary Master's Programme in Cognitive Science

$\mathcal{T}$he interdisciplinary project of the study of the mind known as *cognitive science* is an exciting and relatively new field of research. It seeks to integrate knowledge from all the disciplines that touch upon the human mind and answer fundamental questions about human behaviour, experience, and the physiology that enables both. It would not be an exaggeration to say that cognitive science explores the very essence of who we are. It addresses questions that are potentially even more existentially significant than those posed by the natural sciences – after all, is it not necessary to first understand the characteristics of the observer in order to comprehend what is being observed, be it the self, the surrounding world or the universe?

A fresh field of research demands fresh teaching approaches. The Middle European Interdisciplinary Master's Programme in Cognitive Science, which we co-founded over 15 years ago, offered an opportunity for pedagogical innovation.[1] It was built from the ground up, with a central goal in mind: to transcend old disciplinary constraints. At a time when many study programs were struggling with the mandated transition to the Bologna system of higher education (i.e., trying to keep their programs as close as possible to their pre-Bologna versions), we seized the opportunity to create a fundamentally different educational experience.

Under the sponsorship of the then vice rector of the University of Vienna, a small group of enthusiasts (a.k.a. naïve idealists) from five European universities – Vienna, Bratislava, Budapest, Zagreb, and Ljubljana – came together. Unencumbered by existing teaching practices (simply because there were no established practices in cognitive science at these universities at the time), we asked ourselves: What would an ideal cognitive science program look like? How could we teach an interdisciplinary science of the mind in a way that would preserve the dynamic and emergent nature of this field of research?

I particularly remember debates with professor Markus Peschl, who at the time led the Austrian Society for Cognitive Science (while I simultaneously led its sister organisation in Slovenia). We studied existing programs at major universities worldwide and tried to learn as much as possible from their mistakes. Most of the programs at the time (early 2000s) shared three characteristics that we believed our program needed to surpass:

First: No home for true interdisciplinarity

Although the cognitive science programs address an intrinsically interdisciplinary research field, they are mostly not truly interdisciplinary – nearly all are attached to an existing department at the university, most commonly neuroscience, linguistics, philosophy, or computer science. This means that studying cognitive science often turns out to be studying neuroscience – with potential additions of psychology and fragments of philosophy; or studying linguistics – with an addition of cognitive neuroscience and artificial intelligence; or AI with additions of psychology

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1   Interdisciplinary joint master's in cognitive science, part of the 4-university consortium Middle European interdisciplinary master's programme in Cognitive Science (MEi:CogSci); https://www.meicogsci.eu

and neuroscience, etc. The dependence on the organisational unit, from the outset, prevents an equitable distribution of disciplines within the program.

In our case, the vision of an "ideal" study program involved an equal distribution of the contributing disciplines – independent of the organisational units of the host university and also independent of the currently most prominent or "trendy" discipline (currently AI; at the time, neuroscience). Namely, a brief history of cognitive science reveals that while current brain research may be at the forefront, it has not always been central to understanding the mind – the focus has historically shifted between artificial intelligence, linguistics, and even genetics.

We identified a few universities where cognitive science programs managed to break free from the organisational constraints and create truly interdisciplinary courses (such as those at UC Berkeley or Osnabrück University) – and we sought to follow suit.

Second: Knowledge is fluid, the curriculum is fixed

Most existing cognitive science programs – like other fields of study – teach students the material as if it were set in stone. The curriculum often conveys the impression that we already have a definitive understanding of the brain, experience, and behaviour, leaving students with the primary task of memorising received wisdom. Even the research methods are taught as fixed, well-established algorithms.

In reality, our knowledge of the mind is alive, rapidly changing, and deeply incomplete. Certainly, the past century has brought immense progress, but many new discoveries have opened even deeper questions. Moreover, the recent reproducibility crisis in psychology and biomedicine has shaken the scientific community, revealing that a significant portion of published findings might not be replicable – rendering them scientifically unusable.

Because of this, the backbone of the "ideal" cognitive science program must depart from the traditional *ex-cathedra* teaching culture. Knowledge about the mind should be taught alongside scientific humility. This does not mean that the existing body of knowledge is insignificant or unimportant. Far from it! But when students are shown the winding path that is leading us to this knowledge, it becomes clear that we are at the heart of the process of understanding the mind – not at its conclusion.

It is crucial to present students not only with the knowledge we have gathered but also with its gaps. It is important that students understand science as humanity's (arguably most successful) way of confronting uncertainty and ignorance – not as a dogmatic collection of absolute truths. The fact that there are vast gaps in our understanding of the mind should be reframed: rather than being an unwelcome detail, mentioned briefly at the end of the course, it should be viewed as an exciting opportunity – especially for young researchers, for whom these gaps represent immense potential for ground-breaking discoveries.

In our program, we wanted to reorient students – transforming them from passive photocopiers into active collaborators and co-researchers. For this reason, perhaps the greatest challenge of our program is to frame the confrontation with knowledge gaps as joyful puzzle-solving, rather than as an insurmountable void of uncertainty.

Third: The chasm between the science and lived experience

Almost all researchers and lecturers in the field of investigating the mind[2] overlook a fundamental aspect of the discipline: it is a science about ourselves! We lose a great deal if, as researchers of the mind, we pretend to study something "out there" – something that can be treated as a purely laboratory problem, disconnected from our lives after 5 PM, when we close the lab door behind us.

We envisioned a program that encourages students (and lecturers) to continuously test the taught theories against their own experience of what it means to be human.

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2   In Slovenian: "duševnost", which does not directly translate to mind, but encompasses it.

The Purpose of This Booklet

Contemplating the above-mentioned challenges, it became apparent that we are aiming for a truly interdisciplinary program that fosters a scientific spirit of inquiry, akin to solving puzzles. And a program that continually reminds us that we ourselves are its object of inquiry.

After an idyllic period of theoretical deliberations on the "ideal" structure of a cognitive science program, we faced years of battling university bureaucracies. Despite the Bologna Reform in higher education championing the desirability of programs like ours (interdisciplinary, collaborative, hands-on, and rich in electives), the road to an accredited program was full of – sometimes downright surreal – obstacles. As is often the case, individuals who took the time to understand our ideas, embraced them as their own, and rose above bureaucratic "this cannot be done" came to the rescue.

Fortunately, Ljubljana had enough such individuals – among both faculty and university leadership (thank you, Olga, Zvezdan, Andrej, Julijana, and Polonca). The program came to life, becoming one of the most successful study programs by all conceivable evaluation parameters.

Unfortunately, not all courses in the program reflect the above goals. However, I believe the program as a whole does. This is ensured by a few core courses that aim to weave together narratives about the human mind, as told by neuroscience, psychology, linguistics, philosophy, and artificial intelligence. One such course, with the rather dull title *Introduction to Cognitive Science II*, will serve as an example of (hopefully) good practice and an illustration of fresh approaches to teaching science.

The purpose of this booklet is to show that *interdisciplinarity*, *problem-oriented teaching*, *engaged learning*, and *collaborative work* need not merely be empty buzzwords written to appease bureaucrats allocating funds. These can be vibrant characteristics of dynamic teaching at the academy.

We aim to demonstrate that teaching methods can be completely immune to the negative interference of artificial intelligence – simply because they cultivate skills that (current) AI cannot contribute.

The purpose of this booklet is not to describe the twists and turns of the path to the current form of *Introduction to Cognitive Science II*, but rather to present the end result. The twists and turns were many. Even the current form of the course – fifteen years in the making – is still a work in progress.

This booklet is written with the hope that our insights can be used by anyone tempted to replace ex cathedra teaching with challenging students. Anyone ready to take seriously the worn-out "truth" that it is important to teach how to solve problems and anyone unafraid to take the position of "I don't know". The course in cognitive science is merely a concrete example – our findings, I hope, transcend the field of exploring the mind. Today, I can imagine several scientific disciplines that desperately need interdisciplinarity and engagement with the uncertainty of the unknown; fields that touch us very personally, often existentially, such as ecology, economics, epidemiology, public mental health, etc. These are complex fields, full of unknowns and misunderstandings. Such fields are ideal for unconventional teaching methods like those used in *Introduction to Cognitive Science II*.

The course – from now on referred to as learning unit – *Introduction to Cognitive Science II* was selected by the University of Ljubljana as an example of a modern teaching unit and served as a condensation nucleus for forming a teaching community within the EUTOPIA project – a project aimed at reflecting on what an ideal European university of the future might look like. For the purposes of European collaboration, we selected a segment of the learning unit (researching emotions) and, together with colleagues from the University of Warwick and Gothenburg, adapted it into an online version. Collaboration with colleagues from European universities further convinced us of the importance of the core idea underlying our learning unit – empowering students to confront the uncertainty of the unknown. The EUTOPIA project supported the preparation and publication of this guide.

Our approach to writing this guide is to be brief, concrete, and free of theoretical language acrobatics. Pedagogical literature is saturated with grand terms that, with every use, lose their meaning. We do not wish to repeat this mistake in this text. This is a *how-to guide*, an example of best practices. A description of experiences in designing and delivering a fairly unconventional learning unit. Nothing more.

I hope you find it useful or – even better – thought-provoking. After all, that's the goal, isn't it?

Urban Kordeš

Challenges
In challenging minds

Objectives of the *Challenging Minds* learning unit

*B*efore we proceed, let us find a simpler and more fitting name for our learning unit. We believe that the master's program in cognitive science at the University of Ljubljana is pretty well thought of, it is perhaps even closer to the "ideal" we envisioned during the dreaming-up process than we dared to hope. However, it is not without flaws. One of these is the dull naming of courses – plenty of "introductions to" and numbers (like "1" and "2").

The title *Introduction to Cognitive Science II* is uninspiring, uninspired, and uninformative – it does not give away much about what students can expect. From now on, in this guide, we will call the learning unit *Challenging Minds*.

Perhaps someday, we will successfully navigate the bureaucratic labyrinth and officially rename the learning unit.[3]

Challenging Minds (CM) begins in the second semester of the program. By this point, students have already covered foundational understanding in the core disciplines: cognitive neuroscience, cognitive psychology, philosophy, and linguistics. (In parallel with CM, students also take a foundational course in artificial intelligence.) They are familiar with the key questions in the study of the mind and some of the main theories answering these questions. They understand the history of cognitive science and how different models of the mind have evolved, along with associated shifts in research focus (e.g., emphasis on intelligence, brain function, embodiment, or computational processes).

The foundation is therefore set. This is where CM comes in. It is designed to be a turning point in a student's cognitive science journey. The learning unit is structured to support the transition from being a recipient of information to becoming an independent thinker. While it still includes some traditional lectures, the focus shifts to encouraging students to embark on their own paths of thinking and research. It motivates them to stop acting solely as repositories of information and instead begin to grow into competent and critical peers to their teachers – true partners in solving the mysteries of the mind and consciousness.
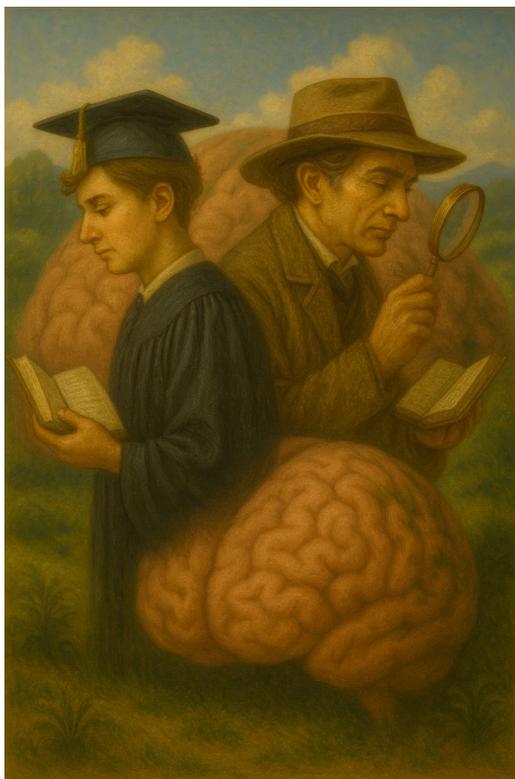
Figure 1.1. The CM learning unit aims to facilitate the transition from being a recipient of information to becoming an independent thinker and researcher.

Main Objectives of the Learning Unit

1. Integrating findings about selected cognitive phenomena from different disciplinary perspectives.
2. Acknowledging gaps in our knowledge and understanding of the mind.
3. Connecting students' everyday experiences with scientific understanding of the discussed phenomena.
4. Gaining the skill of collaborative research.
5. Gaining the skill of solving complex problems.

Some objectives are self-explanatory, while others may require some clarification.

Objective 1: Integrating findings about selected cognitive phenomena from different disciplinary perspectives

Cognitive science is often portrayed as a balanced polygon (as in Figure 1.2), suggesting that the participating disciplines are evenly and harmoniously integrated in the study of the mind. These sorts of depictions are informative in a sense that they enlist relevant areas of knowledge, but the balanced equal lines between them do not entirely reflect the complex and ever-changing relationships between them. Furthermore, it would be incorrect to assume that the state-of-the-art knowledge of mental phenomena is simply the sum of knowledge from all the involved disciplines. Mere addition of the findings from individual core disciplines is not enough to achieve a comprehensive understanding of the mind.[4]

However, it is a necessary starting point. While
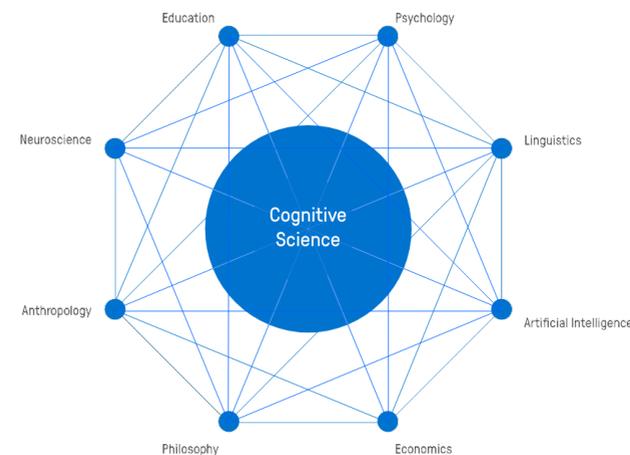
Figure 1.2. Depiction of the participating disciplines evenly distributed and integrated in the study of the same subject – the mind.

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3   In the context of an interdisciplinary joint program, "navigating bureaucracy" means approval of changes at the level of four faculties at the University of Ljubljana and four partner universities – a significant investment of time and effort that might be better spent elsewhere.

4   Nearly a third of the CM learning unit is dedicated to tackling this challenge.

various disciplinary courses (e.g., neuroscience, psychology, philosophy) may mention a given cognitive phenomenon from their respective perspectives, this does not guarantee that students have formed appropriate connections in their mental maps. For this reason, the integration of knowledge about selected mental phenomena is the first objective of this learning unit. By presenting insights from various disciplines on a given phenomenon within a single lecture, we aim to encourage students to build a cohesive picture from what they have learned across different courses. Our goal is to inspire students to reorganise their mental maps of the mind: instead of structuring their knowledge by disciplinary boundaries (where the limits are defined by the disciplines), we want their mental geography to be organised around phenomena. This means that the areas on the map are defined by knowledge about a specific cognitive phenomenon, encompassing all relevant insights regardless of their disciplinary origin.

If necessary, we can also add additional information about the selected phenomenon that students may not have encountered during discipline-specific lectures. The goal is not to provide a detailed analysis of every aspect of the chosen phenomena but to establish a solid, interdisciplinary foundation that can support deeper exploration in the future.

Objective 2: Acknowledging gaps in our knowledge and understanding of the mind

As mentioned in the introduction, we believe that our message to students about what science is supposed to do is inadequate. It almost always gives the impression that scientifically acquired knowledge is fixed, thus sweeping under the rug some of the fundamental characteristics of the scientific method: continuous verification and, through that, constant renewal and improvement of knowledge.

It seems as though lecturers are afraid that science will lose credibility if we emphasise the transient and imperfect nature of its knowledge. This fear was, for example, clearly reflected in the public sphere during the COVID-19 pandemic – there was a fear that acknowledging uncertainty would be seen as an admission of scientific impotence. We fear that answers such as "I don't know" or "The current hypothesis is X, but it is very likely to be replaced by a new and different hypothesis soon" will raise doubts about the value of scientific projects.

As if forgetting Richard Feynman's definition of science as doubt about the expertise of experts (he has put it a bit more bluntly: "science is the belief in the ignorance of experts"), we fail to realise that it is precisely the false pretence of omniscience that which ultimately undermines credibility. Such pretence may be appropriate for spiritual teachers and religious leaders, but it certainly does not suit scientists.

In CM, we try to take the opposite approach: unexplained questions and disagreements about which theory is more appropriate are presented as perhaps the most important element of the scientific method. Continuous doubt in the results of colleagues and their ongoing verification is the engine that drives the advancement of knowledge. We want to show students that imperfect knowledge about the mind is good news for them: it means that cognitive science has a long way to go and, consequently, many future job opportunities.

Many students report that CM is the first opportunity in their academic path where the hard problems of science are discussed in detail; while all of them report that it is the first time they are expected to attempt to solve them.

What do we mean by the term "hard problems of science"? For the purposes of this learning unit, we have divided the problems faced by scientists and – more broadly – science into five types. This division is not perfect, as some problems are hard to categorise into just one type; it is, however, clear enough to allow us to present to students the current state of knowledge and – more importantly – ignorance.

Types of problems encountered in science:

1. *Mundane problems related to research professions.*
2. *Problems of choosing and applying "the right" methodology.*
3. *Paradigmatic and epistemic problems.*
4. *Major methodological problems.*
5. *Problems related to interdisciplinarity.*

The first type of problems in acquiring and constructing scientific knowledge is, of course, the mundane everyday tasks of a scientist's work: securing funding, writing reports, dealing with increasingly burdensome bureaucracy... Although we call these challenges "mundane," they are likely the most common and profoundly shape a researcher's life: what would I

like to research vs. what research can I get funding for; how can I – amidst growing bureaucracy – find time for creative thinking and research; how can I open a new research area that does not fit within any existing department of my research organisation? These "mundane" problems can therefore have a significant impact on the development of science. Nevertheless, we believe that the master's level is still a bit too early for students to confront this level of challenges.

The second category includes challenges that could be grouped under the question, "How can we optimally respond to a given research question?" Most good study programs cover these types of challenges within their methodological courses, so we can avoid them in the CM learning unit.

CM addresses types of scientific problems categorised under points 3, 4, and 5 ("hard problems"). Let us define these in more detail:

Type 3 includes questions that we cannot solve because we have incorrect assumptions or models of the field we are studying. Type 4 encompasses blind spots in research that arise due to the limited scope of research techniques – limitations that are often the result of assumptions underlying our understanding of the field. Consequently, type 4 is frequently a consequence of type 3 and there is no clear boundary between the two.

Example: Cognitive science long operated on the behaviourist assumption that cognitive systems could be treated as "devices" whose function is to find (or "compute") the most appropriate response to environmental events (the so-called "stimuli"). As a result, psychology was for a long time blind to "internal" experiential states – it was concerned with reaction times and solutions to behavioural tests but not with subjective experiences.[5]

Even though it may initially seem that measurements allow us to observe the research subject as it truly is, this is not the case. Measurements reveal fragments of the research subject that align with the assumptions underlying our current paradigm. Research approaches enable the testing of hypotheses, but they simultaneously obscure parts of the research field that our assumptions do not encompass.

If we treat the mind as a device for responding to stimuli, we narrow our focus to only the aspects that can be related to outside signals (stimuli,

tasks, problems, etc.). Parts of the mind that are removed from this sort of processing remain unnoticed.

If we assume that the function of the mind is to respond to the environment, it makes sense to conduct research by assigning "tasks" to experimental subjects and then observing their responses (whether neural or behavioural). This is precisely how most experimental cognitive psychology research is conducted: the subject is presented with a task, and we observe what happens – calling this a "response".

We can imagine the surprise of cognitive neuroscientists when, around the year 2000, they came across brain activity that occurs exclusively when a person is *not* exposed to any stimulus or task. This activity, which involves the coordinated functioning of several relatively distant brain regions, was named the *default mode network* (Reichle et al., 2001). An even greater surprise likely followed when they found that mind-wandering – a mental activity associated with functioning without externally imposed tasks – is the most common mental process. Some studies suggest that we might spend up to 70% of our waking time wandering in thought. How is it possible that psychology and the entire field of cognitive science were, until the (accidental) discovery of the default mode network, almost entirely blind to the *most common* mental phenomenon?

The story of the "discovery" of mind-wandering serves as a useful illustration of several of the points mentioned above.

First, it's important to recognise that most major scientific problems are only identified *in hindsight*. For example, when at the end of the 19th century physics couldn't explain why, as the illumination of a photosensitive metal is increased, voltage increased in discrete jumps rather than continuously, most physicists saw it as a minor issue – something that could be resolved through improved measurement techniques or greater technical precision in experimental setups. Only a few imagined that its explanation would upend the entire field of physics – and with it, our understanding of reality.[6]

The same applies to the "discovery" of mind-wandering – psychology and neuroscience were unaware of a massive gap in their knowledge.[7] It was only

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5   One legacy of this era is that the Anglo-Saxon school of psychology still treats phenomena like emotions as "behaviour"!

6   Einstein's explanation of the "quantum" nature of the photoelectric effect – along with a few other discoveries – paved the way for the most unusual and counterintuitive scientific theory to date: quantum physics.

7   This is not entirely true. At the beginning of the 20th century, Hans Berger, the inventor of

recently, as mind-wandering became central to cognitive science research, that we could retrospectively acknowledge this gap as a significant problem.

In general, major problems only reveal their true scale after they have been solved. Before that, the associated open questions tend to appear as "technical" deficiencies that can be resolved with "more of the same" – slightly better measurement techniques, improved instrument precision, or enhanced statistical methods. Interestingly, this is often how students approach potential major scientific problems when confronted with them. They are accustomed to solutions like "it would be good to increase the sample size" always working and often feel lost when we reject such "solutions" (which ChatGPT often advocates as well).

For the CM learning unit, we selected problems that are excellent candidates for being considered as "hard". However, it is always possible that we are mistaken, and future hindsight might show that they were simply resolved at some point. Regardless of whether the chosen examples turn out to be "hard" or not, they help reframe students' thinking – shifting from finding the right procedure to inventing one and thus attempting creative problem-solving.

Such reframing is not easy. Clear, universally accepted problem-solving procedures provide a sense of security – a feeling that the foundation is solid, known, and reliable. Any suggestion to the contrary evokes a similar uncertainty (or disbelief) as would, before the year 2000, an attempt to convince a cognitive neuroscientist that we lack fundamental knowledge about mental phenomena and that this knowledge lies beyond research techniques based on measuring responses to tasks.

The described case of the huge mind-wandering-shaped hole in our knowledge is also revealing from another perspective. It highlights how much cognitive science loses when disconnected from everyday experience. If we were to tell someone today – when mind-wandering is one of the most studied topics – that for much of the history of psychology and later cognitive science, neither field noticed a process that occupies most of our waking lives, we could rightfully expect some ridicule. When we study the mind in ways that disregard everyday experiences, we do so at our own peril.[8]

the EEG technique for measuring brain activity, pointed out the blind spot of this research approach. However, this warning was forgotten for over 80 years.

8   We discuss this challenge in the next objective.

Challenges of interdisciplinary

Let us conclude the enumeration of scientific problems we present to our students with a type of problem that is widely named but rarely understood and almost never acted upon: challenges arising from attempts to integrate multiple, diverse strands of research (type 3 from the above list).

We are convinced that most existentially significant issues of modern society lie in the spaces between disciplines – or require knowledge from more than one discipline to address them effectively. These include ecology, tackling climate change, a comprehensive understanding of the effects of infectious disease spread, etc., and, of course, questions related to the human mind and consciousness. Judging by the vocabulary used by bureaucrats responsible for scientific and educational policies, one might conclude that the importance of interdisciplinarity is widely recognised. The word is almost a mandatory component of "strategies", "guidelines", and "values".

The problem, however, lies in the vast discrepancy between the use of this term in strategic documents and actual attempts at interdisciplinary research. Despite broad consensus that addressing complex scientific issues would benefit from combining knowledge from different disciplines, this rarely happens in practice.

The reasons for this are twofold: 1) Because it is genuinely difficult, and 2) Because it is nobody's business.

Combining knowledge from different specialised disciplines is hard. The challenge lies in the fact that the farther apart two disciplines are in terms of methodology, terminology, and research assumptions, the harder it is to integrate their insights. Interdisciplinary connections between closely related disciplines are important and interesting, but they do not belong to the same category as "strong" interdisciplinary connections. Fields like mathematical physics, biochemistry, neuropsychology, or the intersection between anthropology and ethnology, share the advantage that researchers in both involved disciplines do not need a translator or additional methodological training to understand each other's work. On the other hand, connections between sociology and epidemiology, economics and the physics of climate change, or between neurology and phenomenology, attempt to integrate fields that share neither terminology, nor methodology, nor – often even – epistemic assumptions about the nature of the domain they are studying.

Yet, precisely these "strong" connections are needed to answer most of the pressing questions of contemporary society.

In the CM learning unit, we aim to draw students' attention to the intriguing challenges that arise when attempting to merge disciplines. For example, how different disciplines use the same terms (such as the word "decision-making") to describe very different processes. In such cases, attempts to integrate knowledge are doomed to fail – a frequent occurrence in cognitive science that happens because none of the participating researchers realise they are discussing different phenomena.

Equally fascinating and common is the opposite problem: due to the epistemic bubbles in which individual research fields are typically enclosed, multiple groups of researchers (whether in different disciplines or within the same discipline) may be working on the same problem without knowing about each other. Because of differing vocabularies and the fact that they operate within distinct research communities, they fail to recognise that they are tackling similar issues.
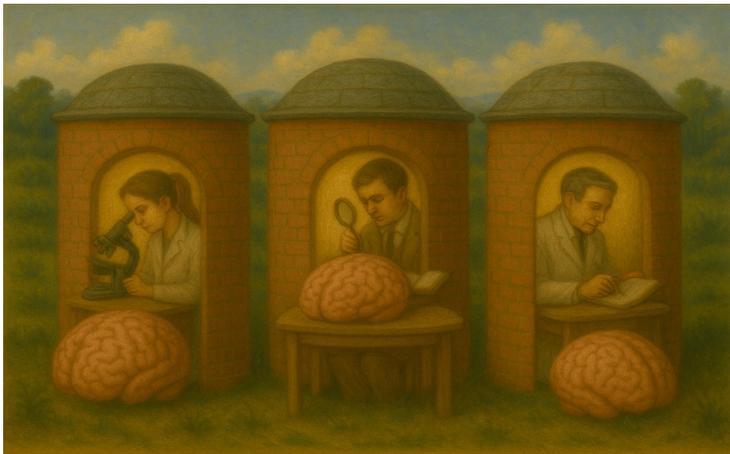

Figure 1.3. Different scientists working on the same problem, without knowing about each other. This poses a great challenge and opportunity for interdisciplinary collaboration.

The challenges of interdisciplinarity only begin here. Once again, it is crucial to emphasise that truly interesting and novel insights are often found in the connections between disciplines that do not share common methodologies or conceptual frameworks. Within cognitive science, some of the most promising connections are those attempting to integrate phenomenology (i.e., the first-person, qualitative study of subjectivity) with neuroscience. Such endeavours aim to bridge the so-called *explanatory gap*.

There are only a few examples where very diverse disciplines have successfully "assembled" their insights into a new, better, or more holistic understanding of the area under investigation. However, this does not mean that attempts at collaboration between vastly different disciplines are futile.

The early period of cognitive science stands as proof of the immense potential of thinking beyond disciplinary boundaries. In 1941, Frank Fremont-Smith, the executive secretary of the Macy Foundation, began developing a problem-solving, multidisciplinary conference format, later known as the *Macy Conferences*. Fremont-Smith believed that the best way to advance knowledge was through interdisciplinary collaboration among diverse fields. Indeed, the Macy Conferences, which brought together physicists, neurologists, anthropologists, philosophers, mathematicians, economists, biologists, and scientists from many other disciplines, sparked a scientific revolution whose benefits we still enjoy today. Participants in these conferences noted that certain abstract models effectively described phenomena across many otherwise unrelated fields. Together, they identified and described structures like the *feedback loop*. They mathematically modelled this structure and discovered that it could explain phenomena in systems that maintain themselves in equilibrium. Such structures were termed *negative feedback loops* or *control systems*. Biologists found such organisation in organisms (e.g., the sensorimotor loop), engineers in devices like thermostats, economists in markets, anthropologists in cultures, and so on. This research occupied the space between disciplines!

This type of research came to be called *cybernetics*. While today the term is often associated with computing or robotics, these are just the two – probably most successful – fields that emerged from cybernetics. Other fields that emerged include systemic and family psychotherapy, communication theory, systems theories in economics, artificial intelligence, and, most notably, the entirety of cognitive science. The entire early period of cognitive science was *transdisciplinary* – many disciplines came together on "no man's land," exploring patterns of functioning (in addition to the already mentioned feedback loops, also information or symbolic processing) that later enriched the development of knowledge about the mind on many levels.

Unfortunately, disciplinary tribalism triumphed over collective research efforts. The question of how to return cognitive science to transdisciplinarity

may well be the most critical issue in contemporary cognitive science. The mission of CM is to encourage students to view the knowledge they acquire during their studies not merely as detailed information about specific research areas but also as patterns of functioning. We believe that fostering an abstract, mathematical, and/or philosophical perspective on individual processes can contribute to a new, more holistic understanding of the mind.

Objective 3: Science of mind vs. lived experience

Connecting scientific insights about the mind with students' everyday lived experiences is another crucial objective of the CM learning unit.

Science often prides itself on revealing realities that lie beyond our simple ideas about how the world works. The science of the mind is no exception, offering numerous insights that seemingly contradict our intuitions about how we perceive, think, and act.

We believe it is essential to address these contradictions with students. However, we also believe that elevating scientific discoveries to the pedestal of ultimate truth is not the best approach. Dismissing our "naive" ideas about the mind as inadequate and insisting on their swift replacement with scientific ones can sever (or sweep under the rug) our ingrained sense of self, the world, and our place within it.

A better strategy, we think, is to demonstrate to students that these are two distinct domains – despite often using the same terminology. On the one hand, we have scientific theories; on the other, our own meaningful lived experience. These are complementary domains that are interconnected but fundamentally not the same. Meaningful lived experience is the medium in which we exist and navigate our lives. Scientists often forget that our feelings of the *self* exist primarily because they *work* – they help us survive.

Take, for example, the concept of free will. Neuroscientist Benjamin Libet's experiments demonstrated that brain activity initiating finger movement occurs before the conscious decision to move the finger. Such findings seriously challenge the concept of free will. Yet, on the other hand, the sense of being able to make free choices is inherent to (almost) every human being in virtually all moments of life. We believe that the role of scientific education is not to deny this lived experience. Instead, we should encourage students to think in parallel about both truths: it is true that experiments suggest free

will may not exist, and your *sense* of being able to make free choices is real (and incredibly useful). The feeling of free will should be regarded as a user interface that helps us navigate life and not as an indication of what is (or is not) objectively true. As such it should be acknowledged as an essential part of experiential landscape.

We aim to remind students not to forget that, by studying brain activity, behavioural patterns, and theoretical models of consciousness, they are also studying themselves. It is crucial that the next generation of cognitive scientists considers the practical relevance of understanding oneself as one of the benchmarks for evaluating the quality of emerging science.

Objective 4: Gaining the Skill of Collaborative Research

The remarkable success of the Macy Conferences highlights an intriguing characteristic of interdisciplinary research: it is not so much a methodological problem as it is a matter of social organisation. Frank Fremont-Smith is one of the forgotten heroes of science. While he was not the author of any revolutionary scientific insights, he acted as the catalyst for an extraordinary series of discoveries, some of which opened the doors not only to new scientific understandings but to entirely new scientific disciplines. Fremont-Smith was an organiser – he arranged the conditions and convinced the leading scientists of his time to dedicate a week or two each year to meetings not solely focused on their specialised fields of research.

Undoubtedly, interdisciplinary collaboration demands thorough methodological reflection. The question is, who will undertake it? The organisational structures of universities and research institutions are not conducive to the development of new interdisciplinary fields. Typically, those who excel in monodisciplinary environments lack both the motivation and the proper competencies for integrative research. Additionally, it is difficult to be sufficiently literate in more than one scientific discipline.

Although there is a general consensus that interdisciplinary research and teaching are valuable, dedicated collaborative research rarely occurs. Finding funding, space, and – most importantly – mutually available times for all participants – who will take care of that? It's nobody's business.

Interdisciplinary work (whether research or teaching) requires a diverse group of researchers willing to dedicate at least part of their energy to

exploring distant disciplinary "bubbles". It requires individuals willing to invest significant time and personal resources into a project that – even if exceptionally successful – will not bring them much recognition.

It is no exaggeration to say that the foundation of any interdisciplinary project is collaborative work. The goal of the CM learning unit is for students to experience first-hand the dynamics of problem-solving in a diverse group. Fortunately, cognitive science students come from a wide variety of disciplinary backgrounds, making it easy to form groups that include representatives from both sides of the explanatory gap. It is crucial for students to understand the essential role of soft skills in achieving significant research results. These soft skills include:

- Attempting to understand the perspectives and terminologies of colleagues from "distant" disciplinary bubbles.
- The ability to articulate one's own viewpoint in a sufficiently comprehensible way.
- Observing and understanding the group dynamics that emerge in various configurations and reflecting on one's role within them.

In the CM learning unit, the goal of training in collaborative work is treated as equally important as all other, more "scientific-sounding" goals. We address it not as mere lip service to currently fashionable phrases, but as an essential research technique. Perhaps the most challenging task of our learning unit is convincing students of the intrinsic importance of social skills in the research process within the field of interdisciplinary cognitive science.

Objective 5: Gaining the Skill of Solving Complex Problems

It is not enough for students to merely become aware of the major barriers to advancing knowledge about the mind (even though simply confronting the existence of these challenges can sometimes be difficult for students). We also want them to actively engage in solving these issues. All the goals of the CM learning unit described thus far lay the groundwork for achieving this objective.

Students respond to the challenges of contemporary cognitive science in various ways. Some (a rare few) feel relieved. They may have noticed these or similar problems during their undergraduate studies or within our program's

disciplinary lectures and felt isolated because neither professors nor peers addressed these significant gaps in knowledge.

The other (much more common) response is disinterest. Mentions of major open questions fail to resonate with students. This lack of engagement becomes clear the moment we stop merely describing problems and challenge students to solve them. It turns out that, up to this point, students have treated problem descriptions as just another lecture topic – another set of "study material" to be learned. Only when they have skin in the game, when they are expected to provide solutions, do they begin to feel uncertainty, sometimes even anxiety.

The role of the CM learning unit teachers is to try to channel this potential anxiety or confusion into curiosity and demonstrate that the scientific problem-solving attitude is an excellent way to confront uncertainty. As mentioned, this cannot be achieved except through a trial by fire – by inviting students to solve challenges as equal peers; as co-researchers.

This confrontation is conducted as gently as possible: we begin with simple, fun, mini-challenges (which we call "icebreakers"). Then, once students feel a bit more confident in their role as problem-solvers, we present them with the "big" challenges – those that represent the "hard" problems of contemporary cognitive science.

Most students approach solving challenges by trying to find an *appropriate* solution – either online, in the vague and murky waters of AI, or by searching through lecture materials and notes. This approach works for some icebreakers but not for most challenges (recall that many of the grand challenges are drawn from the pool of unsolved scientific problems).

By "appropriate solving", we describe a specific attitude toward problem-solving – what could be called a student mindset. Students assume that an appropriate solution already exists somewhere – their task is merely to recall or find where it is.

Under the label of "appropriate solving" falls another common instinct of students: if they cannot find the solution, they at least attempt to find the *correct or appropriate* way of answering – such that satisfies the evaluator. In this case, the CM learning unit teacher.

The goal of the CM learning unit is to demonstrate that there is another approach or attitude – one that shifts from seeking the *appropriate* solution to seeking the *right* or *good* solution. In other words, instead of looking for answers that will satisfy the professor, students aim to find solutions (or solution processes) that genuinely address the problem.

The step from seeking appropriate solutions to seeking good ones is immense. The entire educational system conditions students to become experts in finding appropriate solutions. Along the way, the distinction is rarely emphasised. A student might occasionally admit, with some honesty, that they wrote something they thought "Kordeš would like". But for the most part, they themselves believe that mastering the skill of providing appropriate solutions to academic tasks equates to expertise in the field. The result of this confusion is that schools produce individuals who excel at gauging the expectations of authority figures (and meeting them) but are quite poor at finding effective or *right* solutions. In other words, instead of fostering curious researchers, schools produce bureaucrats.

So, how can we shift students' mindset from seeking appropriate solutions to pursuing the right ones?

First, we must acknowledge that this goal can never be guaranteed. All we can do is create an optimal learning environment and provide students with maximum encouragement – and then hope for the best. The challenge lies in avoiding, at all costs, the impression that instructors already know the correct way to solve a problem or the "right" solution.[9] If we show students one possible solution path, most will take it as a new "appropriate" procedure, and any hope of reframing the focus from appropriateness to truth-seeking will be lost. Instead, students need to be convinced that the solution is not nearly as important as choosing a meaningful approach to solving the problem. The path – not the destination – is important.

How can we create an environment that fosters curiosity-driven puzzle-solving instead of bureaucratic thinking?

A key step is to clearly shift the emphasis of evaluation from the final answer to the problem-solving process. It is already a significant achievement if a student merely entertains the possibility that alternative approaches to problem-solving exist.

This opens the door to the next crucial step: understanding *that* and *why* something is a problem. We ask students to revisit the problem description. They are encouraged to describe the problem in their own words, summarise them, and extract the essence. We hope that this way, they will place the gist of the problem on their own mental maps and recognise the challenge as important, or – even better – interesting.

If all that is achieved, the students can enter the trial and error process of puzzle-solving. They are encouraged to jot down ideas as they arise – regardless of how unusual or unacceptable they might seem at first glance. This does not mean that anything goes: the next critical step is to establish a feedback loop of validation. First, we encourage all kinds of ideas, no matter how unconventional; then, they are immediately subjected to critical examination and pruning. This is the last, but essential step. Namely, if students feel critique as a threat instead of support, that means that they still haven't internalised the essence of the scientific processes of conjecture and refutation.

We want students to approach problem-solving with a playful attitude – freely exploring ideas without becoming too attached to them. The ideal problem-solving atmosphere would be one where students find satisfaction in identifying flaws in their own arguments.

In summary, we aim to create an environment where students feel safe to play with ideas. In more poetic terms, we can borrow from Oscar Wilde and say that the primary goal of CM is for students to develop the "Oxford temper". This term comes from a letter Wilde wrote from prison to his lover and Oxford colleague, Alfred "Bosie" Douglas. Wilde bitterly notices that Douglas "[...] had not yet been able to acquire the 'Oxford temper' in intellectual matters, never, I mean, been one who could play gracefully with ideas but had arrived at violence of opinion merely" (Oscar Wilde, *De Profundis*).

This is what we want: for students to be able to play gracefully with ideas. If that is too much to expect, then at least for them to be able to suspend the violence of opinions – a violence towards which the current zeitgeist is luring them heavily.

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9   After a few attempts, students often ask, "So how would *you* solve this?"
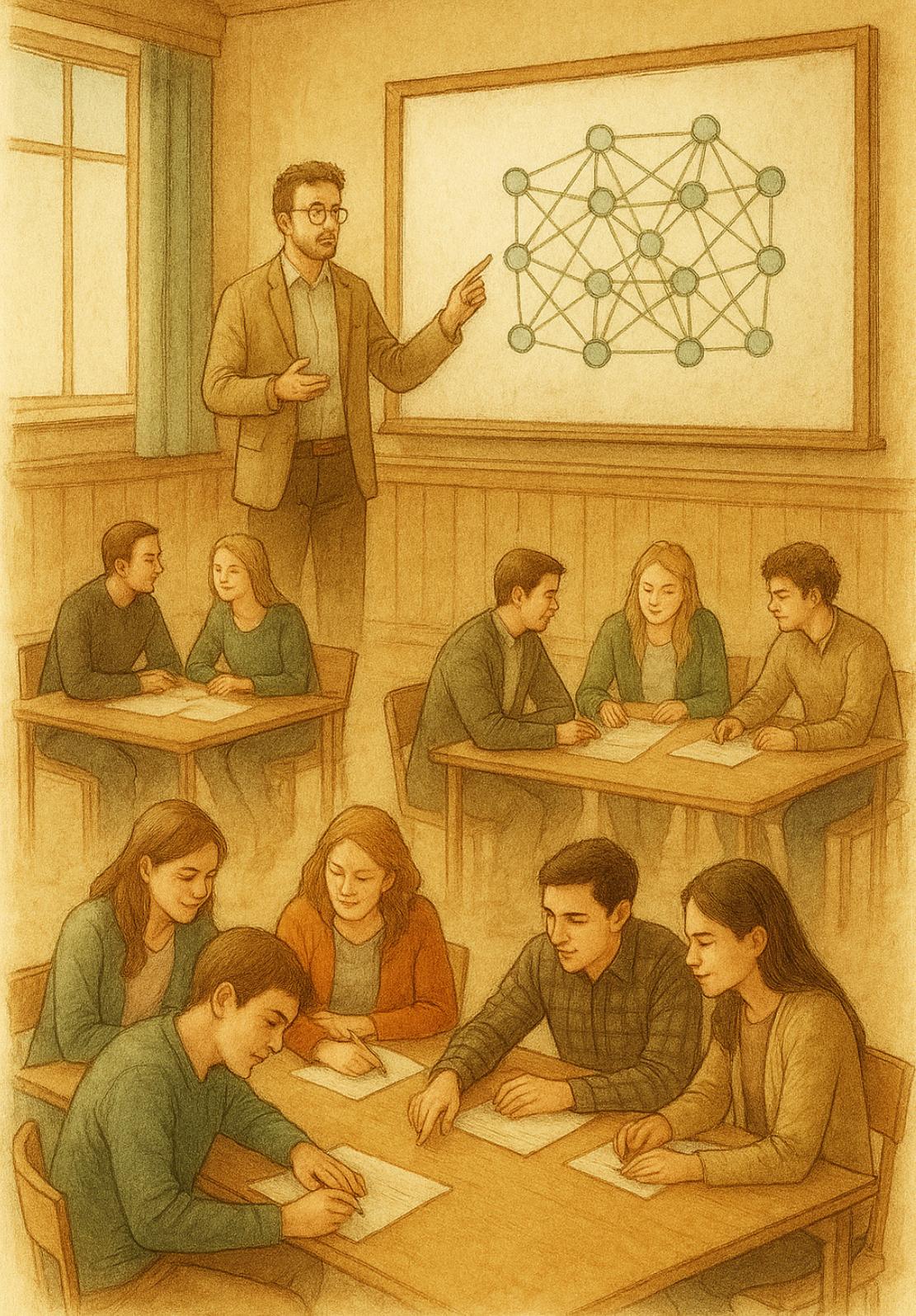
The structure of the
Challenging Minds learning unit

*A*s we have seen, the goals of *Challenging Minds* are ambitious: we aim for students to gain a broad, integrated, and interdisciplinary overview of selected mental phenomena. We want them to understand the relationship between scientific knowledge of these phenomena and their own *lived experience*. Most importantly, we want them to grasp that scientific knowledge is not a carved-in-stone deal but rather unpredictable and ever-changing. And – as a cherry on top of a cake – we hope they experience the joy of forging new paths in solving hard scientific problems.

Introduction to Cognitive Science II (which we termed for the purposes of this guide *Challenging Minds*) is an inherently interdisciplinary learning unit. It forms the backbone of the second semester of the Middle European Interdisciplinary Master Programme in Cognitive Science. Approximately 25 first-year master's students with diverse disciplinary backgrounds – such as psychology, linguistics, life sciences, computer science, and

philosophy – attend the learning unit. Admission to the cognitive science program is competitive (the acceptance rate is about 1:2), meaning most of our students are highly motivated.[10] By the time they begin this learning unit, students have already acquired foundational knowledge in psychology, neuroscience, some research methods, as well as cognitive science more broadly.

In this section of the guide, we will aim to provide a concrete description of the *Challenging Minds* learning unit. Rather than detailing the entire curriculum, we will focus on elements we believe are transferable beyond the disciplinary scope of cognitive science. Specifically, we will emphasise elements that foster interdisciplinarity, collaborative problem-solving, exploration within a diverse team of colleagues, and the comparison of students' personal experiences with scientific findings. At the same time, we will provide enough descriptions of the specific content on mental phenomena discussed in the learning unit to ensure that the context of the challenges is understandable, even to readers without prior knowledge.

Selection of Cognitive Phenomena

It is, of course, impossible to cover the entire body of knowledge about the mind in a semester-long learning unit. It is also clear that the objectives of the learning unit cannot be addressed merely as theoretical knowledge. Hence, we need a handful of the most illustrative examples.

After years of trial and error, we have built the entire learning unit around three cognitive phenomena: decision-making, emotions, and visual perception.

The term "phenomena" may not be the most apt, but it is the broadest. The dictionary defines "phenomenon" as "a fact or situation that is observed to exist or happen, especially one whose cause or explanation is in question." In this sense, we speak of phenomena as overarching terms that cover all elements of the mind whose explanations are in question – elements that are sometimes called events, processes, constructs, etc.

We selected decision-making, emotions, and visual perception for several reasons: they are very different types of phenomena, allowing us to cover

10   Sometimes, they can even be *too* motivated – interested in a very specific aspect of cognitive science to the point where they see unrelated elements of the learning unit as unwelcome distractions.

a substantial part of the vast territory of knowledge about the mind. Additionally, students have already encountered these three phenomena to some extent (mainly in cognitive neuroscience, psychology, and artificial intelligence). A possible exception is decision-making, a large part of which falls under behavioural science, which is poorly covered in our program – addressing decision-making in *Challenging Minds* thus provides an opportunity to cover this gap.

As mentioned, these three phenomena are the result of a multi-year "natural selection" process. Over the years of running *Challenging Minds*, we have learned that the learning unit's goals are better achieved by working in-depth on a small number of selected phenomena. Throughout the history of the learning unit, we have reduced the number of phenomena without increasing the number of challenges. Instead, now for all challenges, we allow at least one iteration of trial and error problem-solving. In this way, we aim to enact the feedback loop and show students that incorrect solutions are part of the scientific process – every scientific discovery is the result of a trial and error process. In recent years, we have even experimented with focusing on only two phenomena per year – but when we omitted visual perception, students clearly expressed their desire to have it back. We still regret having to let go of many phenomena throughout the history of the learning unit (such as language and consciousness), so we have to constantly remind ourselves that the learning unit's goal is not to be a comprehensive cognitive science course.

Two Main Phases of the Learning Unit: Learning and Problem-Solving

The learning unit consists of two phases:

Phase 1 consists of a series of lectures providing an overview of basic knowledge about the selected phenomena from different disciplinary perspectives. With this, we aim to show students, in one place, the different disciplinary perspectives of the three selected phenomena. In addition to the *ex-cathedra* lectures, this phase also includes reading articles. Students must familiarise themselves with some seminal works from the history of research on the selected phenomena, as well as read several state-of-the-art articles to get a sense of the current research trends. This phase amounts to approximately one-third of the learning unit.

Phase 2 is carried out in an active learning format. Each phenomenon is used to illustrate one or more of the major problems in researching the mind. The teaching process is based on working in groups, where particular problems encountered in researching the selected phenomena are tackled in the form of collaborative challenge/riddle-solving.

The treatment of each phenomenon begins with a so-called icebreaker challenge – an engaging short puzzle that introduces the problem we will be working on in the coming weeks. This is followed by larger, more complex challenges. Through examining these particular problems, students confront fundamental issues in studying the mind. For example, in solving a challenge where students experiment with different approaches to eliciting emotions, students learn not only about emotion research, but also about the more general issue of task-dependent research designs in cognitive science. They also learn about the concept of demand characteristics in psychological research and the problem of relating measurements of behavioural and physiological parameters to participants' lived experience.

We encourage students to critically examine the existing understanding of the selected phenomena, acknowledging gaps in knowledge and identifying areas of research that present a challenge to the collaboration of different research disciplines. Through the described group-based collaborative work, students are challenged to understand the examined cognitive phenomena not only as objects of scientific research, but also as lived and socially embedded phenomena, relevant both for their everyday experiences and for the workings and understanding of society more broadly.

Each group-based challenge is accompanied by a short lecture on the relevant theories and methods. This phase amounts to approximately two-thirds of the learning unit. Students' work in this phase is assessed through the reports on attempts at solving the given challenges.
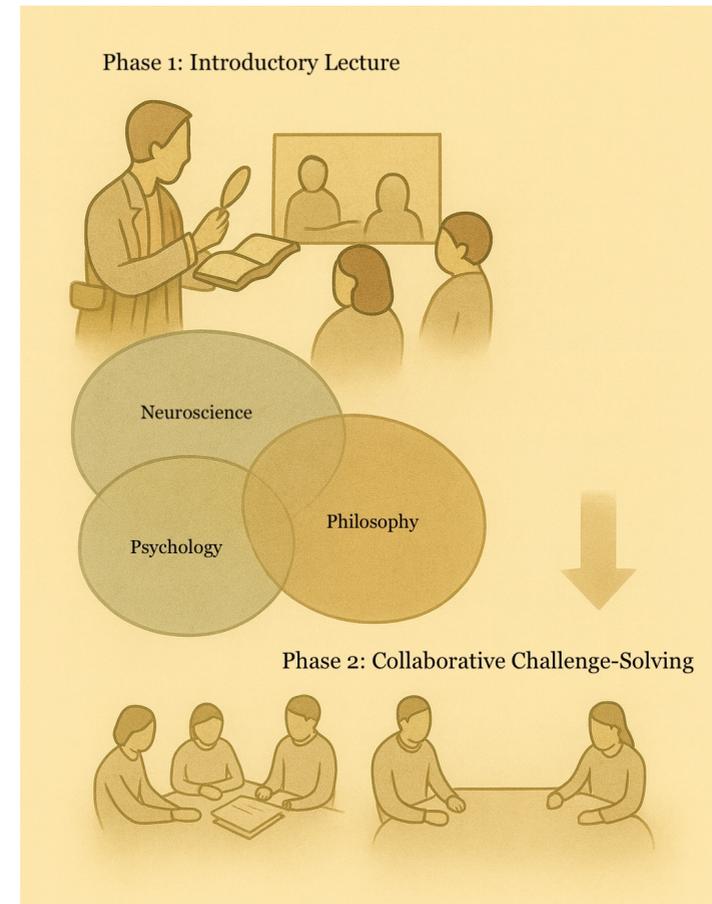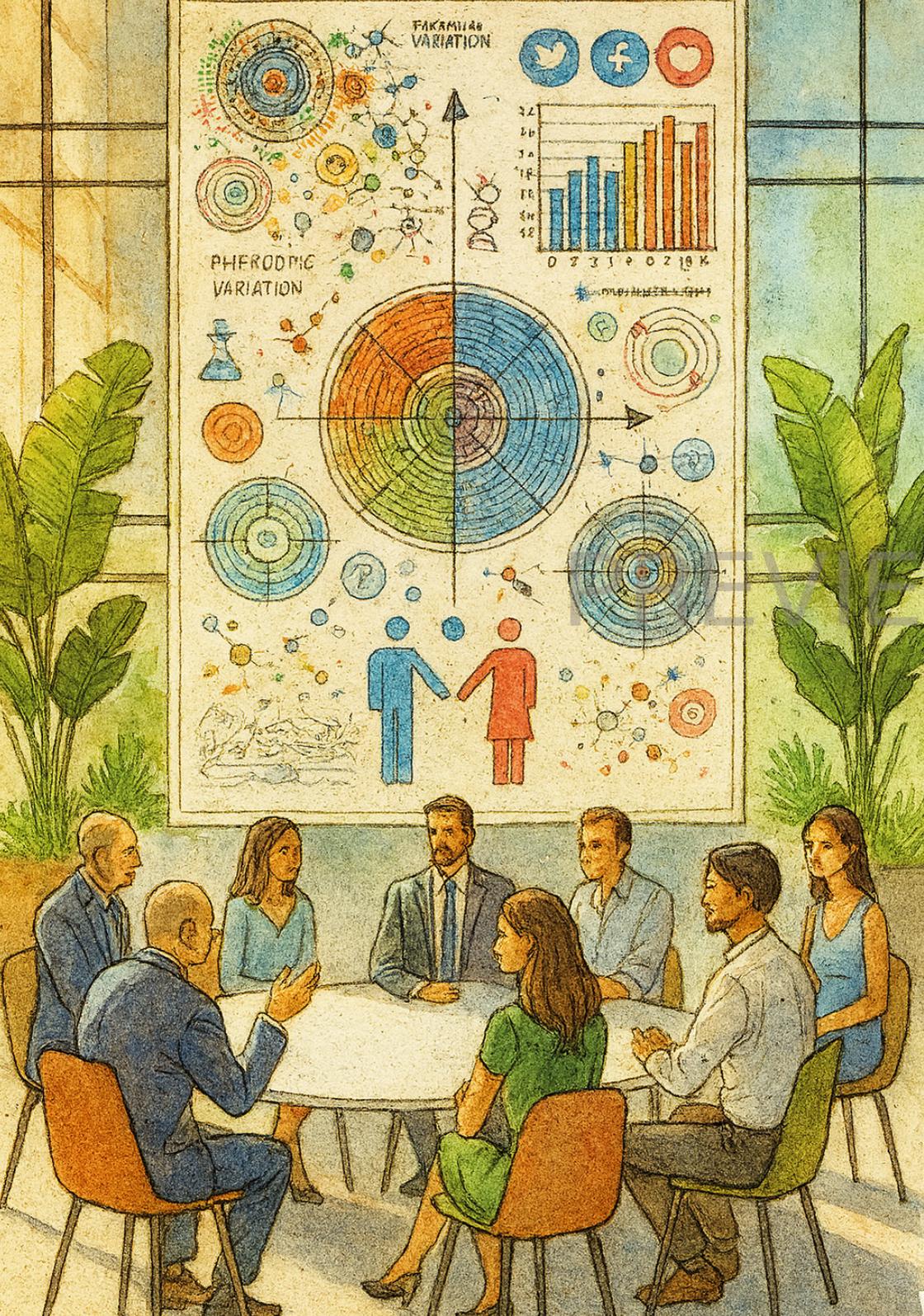

Figure 2.1. Two main phases of the CM learning unit: the ex-cathedra introductory lecture format, followed by collaborative challenge solving. The disciplines shown do not constitute an exhaustive list of all disciplines covered in the learning unit.

Examining emotions
The mystery of the stimulus

*B*efore we start, we invite you to take a deep breath. What emotion are you experiencing right now? Is it tiredness from your everyday turmoil? Or perhaps happiness from starting to read this chapter? Maybe you feel emotional, because someone said something to you? But, what do you think – did this emotion really arise because of an external event? Did perhaps some event just trigger something that was already brewing inside? Or, did the emotion in question arise from the depths of your consciousness unannounced, completely by itself? Whatever the reasons for you feeling as you do right now, let the curiosity about the origin of emotion guide you through the story of emotions in this chapter.

Emotions are phenomena that are richly represented both in scientific research and everyday lived experience. This makes them an ideal subject for investigation in our *Challenging Minds* (CM) learning

unit, in which we want to introduce students to studying complex problems – problems that interact in difficult-to-predict ways and change as a function of time. Both the nature of complex problems and the inclusion of multiple disciplines come with significant methodological challenges. Each discipline approaches the study of emotions using its own methods that emerge from their specific theories and presumptions. In this part of the learning unit, we want to encourage students to critically reflect on what we are actually measuring when we attempt to measure emotions. What do we sacrifice, and what do we gain with each method? And ultimately, are we truly measuring emotions – and emotions only?

To explore this topic, we must start with a fundamental question: *What even are emotions?*

Modern psychology has a long history of studying this phenomenon, with its roots in the work of Charles Darwin and William James. Darwin proposed the idea of universality of emotions among both humans and animals, while James suggested that emotions arise as a consequence of physiological reactions to stimuli, an idea that later became known as the *James-Lange Theory* (after Carl Lange independently reached similar conclusions).

In neuroscience, the study of this phenomenon was facilitated with an "accidental" case study – of *Phineas Gage*. While working on a railroad, a metal rod pierced Gage's head. He suffered a severe brain injury that damaged the frontal part of his brain. This injury altered his personality, making him impulsive, impatient, disrespectful, and unreliable. His case provided key insights into the role of different brain regions in emotional processing. Since then, further discoveries in neuroscience led to various theories on emotional processing and identified multiple brain regions involved in the processing of emotions, one such region being the limbic system.[11]

Additionally, Heidegger's notion on moods [*Stimmung*] and finding oneself in a world through the moods as *Befindlichkeit* marked a milestone in the field of phenomenology of emotions. His body of work emphasises that emotions are not merely internal reactions to external stimuli, but rather that they play an important role in how reality discloses itself to us, orienting us within our lived environment. Other scholars, such as Matthew Ratcliffe and

Russell Hurlburt later additionally contributed to the phenomenological understanding of emotions.

At this point, there are several theories of emotions that converge on certain fundamental aspects. For instance, there is broad agreement that emotions are positive or negative responses to external or internal stimuli, that they involve physiological, behavioural, and phenomenological changes, and that they differ from moods. However, in the CM learning unit, we challenge almost all of these beliefs.

One of the most significant issues, which we address in the CM learning unit, is the problem of eliciting and measuring emotions. Most theories – and, by extension, most measurement methods – assume that emotions are responses to a specific stimulus. While emotions may have indeed evolved as adaptive responses to external circumstances, our everyday experiences suggest that emotions often arise without an obvious stimulus. Moreover, the same stimulus or event can elicit significantly different emotional reactions in different individuals. Even when people are exposed to an identical stimulus, their emotional responses often vary, and the emotion they experience may not even be directly caused by the stimulus itself. Despite this, most experimental techniques designed to measure emotions fail to account for this variability.

At first glance, this challenge may not seem particularly daunting. However, it quickly becomes apparent when we consider a hypothetical conversation between individuals from different disciplinary backgrounds[12] trying to design an experiment to study emotions. This hypothetical conversation vividly illustrates the interdisciplinary challenges in studying emotions. Each field brings its own assumptions and methodologies, yet they all struggle with the fundamental question: *What exactly are we measuring when we measure emotions?*

Student 1 (background in psychology): "It's simple – let's give participants a validated and standardised questionnaire, and then make them watch standardised image sets, for which we already anticipate the emotional response they will evoke. Participants will then report which emotions they experienced on the questionnaire. The only

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thing that we need to agree upon is which questionnaire and which standardised set of images to use."

Student 2 (background in neuroscience): "Showing images might be the right approach, but I disagree with the method of measurement. Let's present the images to participants in an fMRI scanner and measure their brain activity to determine which regions activate in response to a given image. Since previous studies have already standardised these images and identified the emotions they elicit, we don't need to concern ourselves with that now, and thus we don't need a questionnaire to validate the findings of which emotion the participants experienced. The brain region that activates for a particular image is involved in processing the corresponding emotion and with that we know which emotion was experienced."

Student 3 (background in computer science and informatics): "What if we take it a step further? Let's consider the knowledge we already have. We possess standardised images of emotions with known effects, and we also have substantial knowledge about the brain regions activated by these emotions. What if we used this existing data to train a neural network? We could teach it to predict which image a person is viewing based on known brain activity patterns. Then, we could test whether the neural network correctly identifies images it hasn't been trained on. This could mark a breakthrough in mind reading!"

Student 4 (background in anthropology): "Hold on, everyone – it seems to me that these ideas stem from the assumption that there is such a thing as a universal stimulus. But let me remind you that some studies show emotions are deeply shaped by culture, time, and individual experience. A facial expression, a gesture, an animal… pictures in general might evoke completely different emotions in different people. We can't just blindly rely on standardised tools and pretend as if context does not matter."

Student 5 (background in phenomenology): "These ideas are fascinating and exciting for scientific progress, but I urge you, dear colleagues, to return to the things themselves.[13] Do we truly know that a specific image evokes a targeted emotion? And does brain activity genuinely tell us how a person feels while viewing an image? Let me remind you of one of the most fundamental statistical principles: correlation does not imply causation. Does brain activity associated with viewing an image – an image that is assumed to trigger a particular emotion – actually tell us that the person experienced that emotion? In our research process, are we not losing sight of the very thing we set out to study: the emotion itself?"

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13   "Back to the things themselves!" Is a call to go back to the way things are actually experienced and not merely theorised. The call was made by the famous phenomenologist Edmund Husserl.

The CM learning unit aims to encourage students from different disciplines to engage in precisely the kinds of conversations described above, without putting a preference on one discipline over another. The combination of students' diverse disciplinary backgrounds and their prior knowledge of the phenomenon forms a solid foundation for embarking on the quest to solve the mysteries of the phenomenon of emotions.

Figure 3.1. A depiction of the interdisciplinary debate between students from different backgrounds, trying to come up with an experiment to study emotions.

Main objectives of the phenomenon of emotions learning unit

As we have seen above, one of the core methodological (if not conceptual) assumptions of experimental cognitive psychology is that stimulus always precedes an emotion. We need only consult the first paragraph of any number of introductory textbooks on psychology or neuroscience. Thus Kandel et al. (2012):

> *Emotions are transient responses to specific stimuli in the environment (e.g., danger), the body (e.g., pain) or, for humans, the mind (e.g., train of thought).*

And Gazzaniga et al. (2019):

> *[Emotions] are triggered by emotionally salient stimuli, which are highly relevant for the well-being and survival of the observer.*

This assumption is also implied in Banich and Compton (2023):

> *Emotional experiences often include bodily changes, such as an increased heart rate or sweaty palms, that are considered to be part of the body's fight-or-flight response.*

If these scientists are correct, then measuring emotions should not be particularly difficult: we simply identify a suitable stimulus, present it to participants in a lab, and the corresponding emotional reaction should reliably occur. But, as already discussed above, things are not necessarily that straightforward. While many people might feel fear when shown a picture of a snake, some do not. Others may even respond with curiosity or excitement. And, perhaps most strikingly: many feel nothing at all. Therefore, it is interesting to present and investigate the methodological problems of eliciting and measuring emotions that follow from the standard postulate of a stimulus always preceding an emotion, which is the main goal of this part of the learning unit. In doing so, all five learning objectives as described in the introduction chapter are addressed. However, the emphasis is placed on the second objective, which is to *acknowledge the gaps in our knowledge and understanding of the mind*. It also importantly addresses the objective of *connecting students' everyday experiences with the scientific understanding of the discussed phenomena*.

In the chapter on decision-making, we will be introduced to the problem of epistemic bubbles, which describes the situation when an individual approaches scientific research (and also everyday problems) from a particular disciplinary perspective thereby becoming unaware of different ways of understanding this phenomenon from a different methodological and epistemological point of view. It is important to recall this issue when addressing the problem of eliciting and measuring emotions. Each discipline has its established methods for investigating phenomena, so we can imagine disciplines as enclosed in their own bubbles. Nevertheless, all these disciplines investigate the same phenomenon, and they arrive at different insights about it. The bubbles of disciplines intersect in the sense that they investigate the same phenomenon, but they remain confined within their own paradigmatic and methodological frameworks, hence closed in their own bubbles.
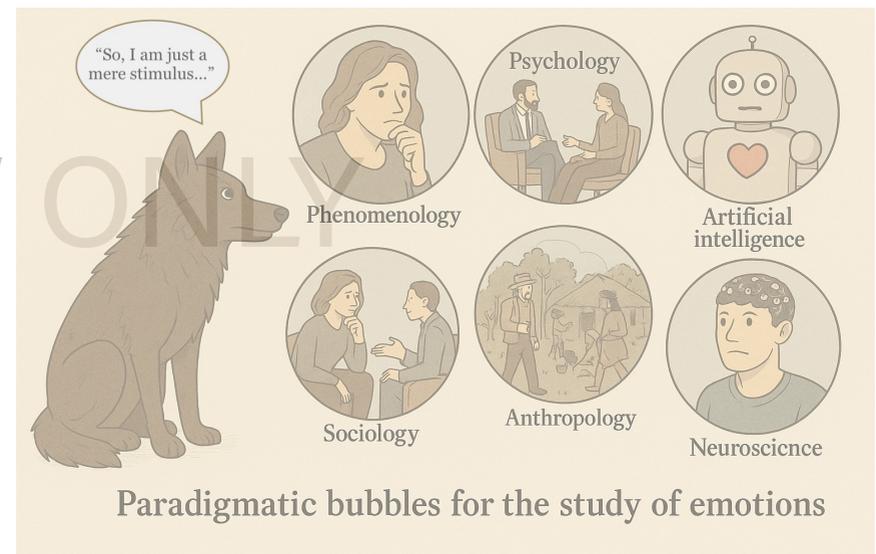

Figure 3.2. A stimulus (the wolf), waiting for each discipline to figure out its method of measuring the emotion it elicited. The picture depicts the closedness of each discipline in its own bubble.

When researching emotions, most disciplines try to quantify them and make measurements as replicable and reliable as possible, which means that if the test were repeated in the future, we would get the same results. However, in real life, it seems that emotions are not experienced as numbers, and most experiments are conducted in the laboratory, which means they (most probably) have low ecological validity – we do not know whether a person would experience the same emotion in a real-world situation. When we look deeper and explore individual descriptions of emotions and their phenomenology, we see that their quantification is insufficient, as we lose

the essence of the emotional experience when we reduce them to numbers. Nevertheless, descriptions of emotions are not always suitable for scientific research because they are highly subjective and non-replicable, but they tend to be closer to the described phenomena or at least of how they feel like to an individual The problem, therefore, lies in whether we choose to prioritise more reliable or more valid data.

In this part of the learning unit, we will tackle the challenge of eliciting and measuring emotions, while trying to connect the scientific knowledge and methods to the implications that the findings have on the lived experience of the phenomenon of emotions in everyday lives of people.

Learning unit overview for the phenomenon of emotions

Introductory lecture – The diversity of disciplinary perspectives on emotions

Collaborative challenge-solving

1. First part: Elicitation and measurement techniques
   •   Mini challenge: How emotions arise
   •   Challenge: An experiment on paradigms of studying emotions
2. Second part: The problem of emotion elicitation
   •   Challenge: The quality of emotion elicitation
   •   Mini challenge: Ecological validity in emotion research – The case of curious emotions
3. Third part: Problems in measuring and reporting emotions
   •   Challenge: Reflecting on the challenges in measuring and reporting emotions
   •   Mini challenge: Demand characteristics – What do we measure when we report emotions
   •   Conclusion: Ethical reassessment of the stimulus-to-emotion model from a lived experience perspective

Introductory lecture: The diversity of disciplinary perspectives on emotions

We begin the quest of "finding" emotions, with an introductory lecture on the disciplinary perspectives of emotion research. The goal is to provide a comprehensive overview of what different disciplines already know about the phenomenon at hand. This helps us establish a foundation for "solving" the challenges that students will face in the next part of the learning unit. Students are given some basic textbooks to read, as well as more recent articles that present contemporary findings in the field. A comprehensive list of the literature is provided in the literature section.

The first problem we encounter when presenting the state-of-the-art research in the field of emotions is the definition of what emotions actually are. When searching for a unified definition of emotions, one quickly discovers that, while there are some dimensions that mostly overlap, there is differing evidence regarding the basic claims of what emotions are (see e.g., Izard, 2011). The main dimensions that usually overlap include the idea that emotions are a response to a stimulus, involving several different dimensions, such as behavioural and experiential changes, etc. However, theories are generally not unified regarding which components constitute emotions, how they are connected, related, and manifested (see e.g., Gazzaniga et al., 2019).

Universality of emotions. One key debate in emotion research concerns whether basic emotions are universal or socially constructed. The idea that emotions are universal – not only across individuals but also across other species – was first proposed by Darwin (1872). His claims were later expanded and deepened, particularly through the work of Paul Ekman, who provided substantial evidence for emotional universality. Through extensive research, including studies on communities from isolated cultures, Ekman found cross-cultural consistency in facial expressions associated with basic emotions (Ekman & Friesen, 1971). On the other hand, researchers such as Lisa Feldman Barrett have challenged this perspective, providing substantial evidence that the way emotion experiments are structured greatly influences their outcomes. By employing different techniques to study emotions in secluded cultures, Barrett found results that support the idea that emotions are shaped by culture and context rather than being biologically hardwired (Barrett, 2017).
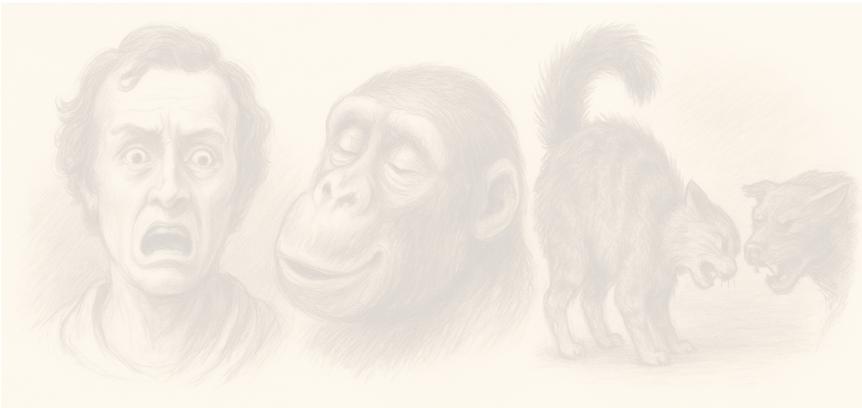
Figure 3.3. Darwin-inspired illustration of universal emotional expressions (fear, happiness and anger, respectively), across humans and animals. The image represents some of the basic human emotions, in line with Darwin's ideas, which were later adopted and expanded by researchers such as Ekman.

Structure of emotions. The debate over what emotions are is also reflected in differing views on their structure. Emotions are generally understood through either a categorical or dimensional framework. The categorical approach treats emotions as distinct categories, classifying them into basic and complex emotions. Fear, anger, sadness, happiness, disgust, and surprise are normally conveyed as basic emotions, while complex emotions such as jealousy and love are a composition of specific basic emotions (Gazzaniga et al., 2019). In contrast, the dimensional approach views emotions as existing along a continuum rather than as discrete categories. A prominent example is Russell's circumplex model of emotions, which organises emotions along two dimensions: valence (ranging from pleasant to unpleasant) and arousal (ranging from low to high). Based on numerous studies using this model, emotions have been mapped onto these two dimensions according to how individuals subjectively rate them (Posner et al., 2005).

Emotion generation theories. Another key topic in the introductory lecture is the exploration of theories on the origin of emotions. These theories provide different layers of explanation, primarily focusing on the sequence in which emotions arise after a stimulus is perceived. While they all agree that a stimulus is necessary for an emotion to emerge, they differ in their proposed mechanisms and components of emotion generation. James-Lange Theory for example suggests that emotions result from physiological reactions to events. According to this theory, we first experience bodily changes (e.g., increased heart rate) in response to a stimulus, and then we interpret

these changes as emotions (James, 1884; Lange, 1922). Cannon-Bard Theory challenges this view, arguing that emotions and physiological responses occur simultaneously and independently, rather than one causing the other (Cannon, 1927). Schachter-Singer Two-Factor Theory introduces a cognitive component, proposing that when we experience physiological arousal, we interpret it using environmental cues to determine what emotion we are feeling (Schachter & Singer, 1962). LeDoux's Dual-Pathway Model adds brain circuits in this equation, identifying two pathways for emotional processing: a fast, subconscious pathway from the thalamus to the amygdala, triggering a rapid response to danger, and a slower, more deliberate pathway involving the cortex, which allows for a more detailed evaluation of the situation (LeDoux, 1996). For a broader overview of different emotion theories, see, e.g., Dalgleish (2004).
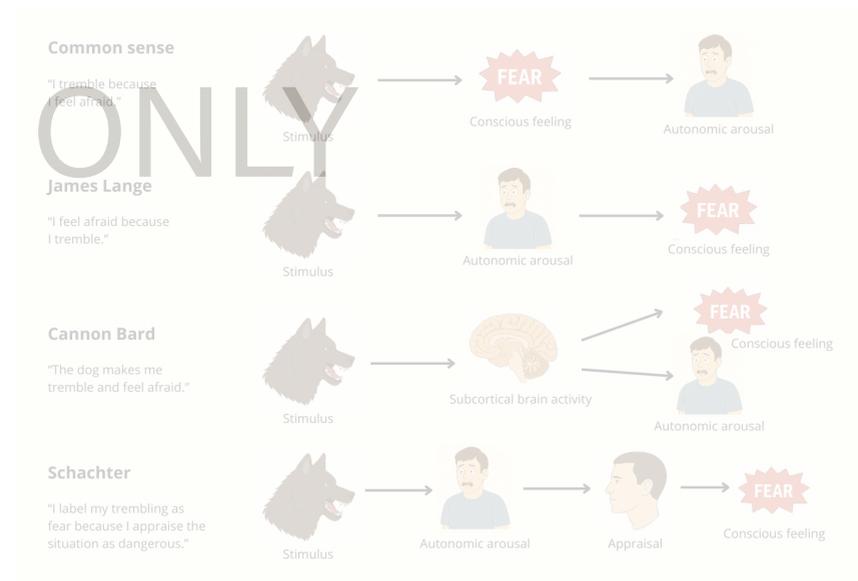

Figure 3.4. An overview of some emotion generation theories.

Neuroscience of emotions. The process of generating emotions involves multiple brain structures and neural pathways. However, identifying which specific brain areas activate in response to particular emotions is a complex challenge. A foundational theory in the neuroscience of emotions is the Papez Circuit theory, which proposed that a network involving the hippocampus, hypothalamus, and cingulate cortex is responsible for emotional experiences

Many meanings of
Decision-making

What is decision-making? Typically, decision-making is defined as the process of choosing between alternative options or courses of action by a wide range of scientific disciplines – psychology, economics, philosophy, neuroscience, artificial intelligence, ethology, etc. However, although all explicitly define decision-making in a very similar manner, they study the phenomenon from quite different perspectives and use a diverse range of research approaches and methodologies to study the phenomenon. This implies however, as we shall see, that different research approaches often reveal rather different aspects of decision-making and, consequently, form quite a diverse range of theories and models of the phenomenon.

Classical normative economic models of decision-making mostly focus on creating formal (mathematical) descriptions of the phenomenon that delineate conditions for optimal choices or choices that best

satisfy one's preferences. The philosophical take on decision-making similarly concerns itself with theoretical understanding of decision-making: it explores, for instance, what it means for an agent to make rational choices, analyses concepts, relevant for understanding decision-making (e.g., beliefs, desires, volition, free will), theoretically explores what kind of reasonings could underlie agents' choices, compares different theories of decision-making and the presuppositions on which they are based. Psychology and behavioural economics, on the other hand, take an empirical approach to studying (mostly) behavioural aspects of judgment and decision-making (judgment is generally conceived as an integral part of the process of decision-making, where people evaluate, estimate and infer what uncertain events (e.g., outcomes) will occur and what consequences they will have). Contrary to classical normative models, psychology and behavioural economics aim at understanding how people actually decide and whether their decisions align with the "rules" of formal, normative models of rational choice. One of the most influential approaches to empirical study of judgment and decision-making, established by Daniel Kahneman and Amos Tversky (in their seminal and quite famous 1974 and 1979 papers), demonstrates, for instance, that people mostly do not make decisions rationally. Instead, they rely on mental shortcuts (heuristics) which, under certain circumstances, lead to systematic errors (biases) in judgment and poor choices. Neuroscience, moreover, focuses on identifying neural processes and mechanisms involved in decision-making. It explores, for instance, how the brain represents values of options or outcomes, how it assesses the probabilities of outcomes or subjective consequences of
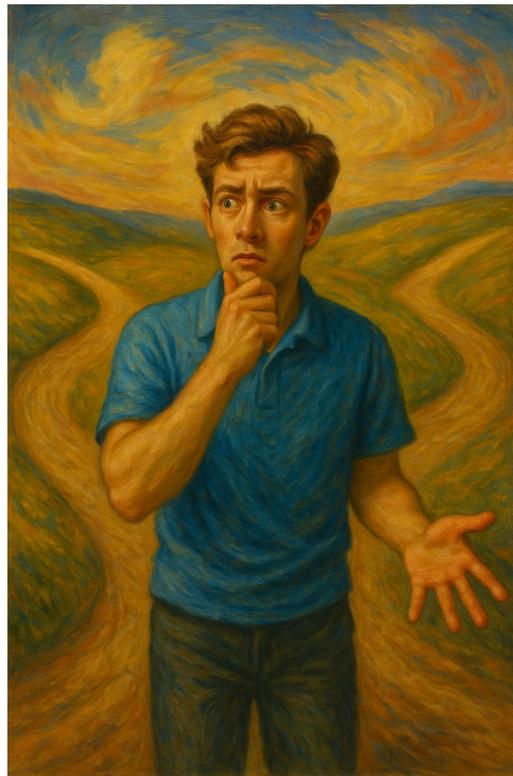
Figure 4.1. A person wondering which path to take – it's a tough decision!

choices, tries to understand what role the brain's reward system plays in decision-making, how sensory information is integrated within the decision-making processes, etc. It must be pointed out that neuroscience, which started exploring decision-making on a larger scale much later than psychology or behavioural economics, relies heavily on using behavioural study designs. As such, it focuses mostly on identifying neural correlates of behaviours people exhibit when solving laboratory decision tasks. Contemporary artificial intelligence is, on the other hand, less concerned with how humans make decisions. Its interest rather lies in developing systems that aid human decision-making (e.g., assisting airline pilots in navigating stormy weather conditions) or systems that themselves make choices instead of humans (such as self-driving cars).

Most empirical research on decision-making is conducted in laboratory settings. However, some approaches do focus on studying decision-making "in the wild" – i.e., in natural environments. For instance, naturalistic decision-making framework in psychology emphasises researching decision-making in demanding real-world situations (e.g., how expert firefighters arrive at their decisions in critical situations; how doctors and patients make decisions about treatment, etc.). Empirical phenomenology also investigates decision-making as it unfolds in natural environments and everyday lives of people – however, it focuses on exploring lived experience of decision-making (for instance, how parents experience the process of deciding about their sick infant's medical treatment). Ethology (the study of animal behaviour), moreover, explores how various types of organisms make choices – from small worms like C. elegans to primates such as chimpanzees (its interest lies, for instance, in investigating how primates' choices are embedded in their wider social environment or in studying group decision-making of bees – e.g., how bees collaboratively decide for a new hive or choose profitable food sources.[25] (The reader will, towards the end of the chapter on decision-making, discover that understanding bees' behaviour can be quite useful for tackling one of the challenges.)

A brief examination of the diverse field of decision-making research reveals that decision-making is, in fact, a multifaceted, complex, and a highly diverse phenomenon, which can be studied from very different perspectives. To

25   Here, we mostly consider core disciplines and research approaches to studying decision-making that generally focus on decision-making of individuals, omitting, for instance, political, management, and organisational sciences, which are mostly concerned with group or institutional aspects of decision-making.

illustrate this claim, let us examine a few quite different decision-making study designs.

First illustration: Behavioural and neural correlates of decision-making under risk – a financial decision-making task

We are looking at a screen displaying an initial sum of money ("You receive 50 euro."; pounds are stated in the study). Researchers inform us that we will not be able to keep the entire amount. We must then choose one of the two presented options – one carries risk (it's called a gamble), the other carries no risk (it's a sure option bringing gain with certainty). In the first scenario, if we choose option A *we keep 20* euro with certainty but if we choose the risky option B we keep all 50 euro with a probability of 0.4 and lose all 50 euro with a probability of 0.6. In the second scenario, if we choose option A *we lose 30* euro with certainty but if we choose option B we again keep all 50 euro with a probability of 0.4 and lose all 50 euro with a probability of 0.6. We repeat the task multiple times. Up to this point, the study is purely behavioural, measuring reaction times, and responses (choices) of participants; if we are interested in the neural correlates of participants' behavioural responses, functional magnetic resonance imaging (fMRI), for instance, can be added to the study design. This allows us to identify, among other things, which brain regions are involved in making such choices under different conditions. The task described here is taken from De Martino et al. (2006) who studied the neural basis of the framing effect – how framing or presenting options in terms of gains (*keep 20* euro with certainty) or losses (*lose 30* euro with certainty) influences our choices – individual differences in susceptibility to framing effect, and the role of emotions in mediating biases stemming from framing choice problems in terms of gains or losses. Framing effects were first discovered and systematically described by Kahneman and Tversky (1979) and Tversky and Kahneman (1981).

Second illustration: Behavioural and neural correlates of perceptual decision-making

We are lying in an fMRI scanner and looking at a screen displaying what appears to be a chaotic movement of many small dots. Some dots are moving to the left, others to the right. The "sum" of the movement of the dots (the collective motion of the dots) is left or right but the dots are moving in such a way that we cannot clearly determine the direction. Even though we cannot see (consciously determine) in which direction the cluster of dots is moving, we must repeatedly choose the overall direction of movement. We

indicate our decision by pressing the left or right button. In a variation of the task, we are looking at a screen and must repeatedly decide whether the presented ambiguous and noisy image depicts a house or a face (which we cannot clearly consciously determine). This type of decision-making task is primarily used in the context of studying perceptual decision-making – the area of investigating the neural basis of how organisms gather and integrate sensory information and how this informs their choices (Heekeren, Marrett & Ungerleider, 2008).

Third illustration: Lived experience of decision-making in a natural setting

In the empirical phenomenological study, van Manen (2014) examined the lived experience of parents of premature infants who required intensive hospital care (life-support therapy such as mechanical ventilation or cardiovascular support) due to extreme prematurity, complex congenital defects, neurological injuries, etc. The parents were faced with an "impossible choice" (posed by the doctors), unimaginable to those of us who are lucky enough never to have been faced with such a predicament. The parents had the option to discontinue their infant's life-support (which almost certainly meant the infant would not survive) or to undertake a high-risk treatment (e.g., heart surgery, organ transplantation, or tracheostomy). While the latter offered the possibility of the infant's survival, it carried a high risk that the prematurely born child would be severely disabled in later life. As the parents worked through their existential choices (which in some cases lasted for days), they documented their lived experience and reported it to the researcher. The study showed that different parents navigated the decision-making process in very different ways. Some oscillated between alternatives, imagining different possible consequences; others remained trapped in indecision; still others could not help but constantly return to a decision they had already made. Some parents, however, reported that they never experienced anything like a decision-making process or choice at all, for the answer to the question of how to proceed in this extremely difficult situation had always been clear to them – they immediately felt they must give their infant a chance to survive, regardless of how small that chance was or what consequences it might have brought.

Although many disciplines and research approaches explicitly define decision-making in a very similar manner, the three examples of research clearly reveal quite different aspects of what researchers call decision-making. In the above illustrations, the first two studies investigate decision-

making from the third-person perspective, studying behavioural and neural aspects of the phenomenon, whereas the third explores the lived experience of decision-making from the first-person perspective. Moreover, the first study is concerned with risky choices involving monetary gains and losses, representing a typical type of a laboratory decision problem where alternatives, outcomes, and probabilities are all known. The second study examines how the brain integrates sensory information to make simple choices that resemble pattern recognition rather than what we might call decision-making in everyday lives. While the first two studies exemplify the predominant study of decision-making in laboratory settings, the third study, on the other hand, serves as an illustration of how decision-making can be investigated in natural environments where the decision situation is full of uncertainty.[26] As such, decision-making seems to be quite a diverse and broadly understood phenomenon. When we consider more examples and approaches later in the first challenge, the diversity and broadness only become more apparent – to the degree that we will perhaps have to start doubting the claim that these different research approaches investigate the same phenomenon.

Main objectives of the decision-making part of the learning unit

This part of the booklet highlights two core objectives of the *Challenging Minds* (CM) learning unit. Firstly, it addresses the challenge of integrating findings about cognitive phenomena from different disciplinary perspectives. We tackle this challenge from two different sides. The first can be briefly described in the following way. In the early days of cognitive science, we somewhat naively imagined that we could integrate knowledge from different disciplinary perspectives by simply adding all knowledge together. However, decision-making serves as a good example that quickly teaches us that this is not so simple. The diversity of disciplinary perspectives and approaches to studying and understanding decision-making clearly demonstrates that the integration cannot simply be a matter of summing up existing knowledge of individual disciplines. We address this aspect of the first objective in the *What is decision-making?* section. The second side tells a similar story but from an "inverted" perspective. It often happens that different disciplines and research approaches do study the same or closely related phenomena but are unaware of each other's ideas – they often "live" in their own epistemic bubbles, relatively stable and closed cognitive "worlds", through which they

practice research and gain knowledge about the phenomenon of interest. And, as we shall see, it is not as simple as it might seem to look beyond our ever-present epistemic perspective that co-determines our perception, knowledge and behaviour. We address this aspect of the first objective in the *Epistemic bubbles* section.

Secondly, this part of the booklet also tries to relate everyday lived experience aspects of the decision-making with its scientific understanding. How do we experience decision-making in our daily lives and does this differ from what science has to say about it? Moreover, how does our own epistemic perspective as ordinary human beings shape the way we see the world, others, and ourselves – bearing in mind that scientists, after all, are human too? Posing such questions is essential, for cognitive science is, after all, a science of living, experiencing beings.

Despite the many perspectives and approaches to studying and understanding decision-making – and the challenges they pose – we have to start the learning unit somewhere. In the introductory lecture, we first look at what individual disciplines know about decision-making, how they study it, and how (un) connected this knowledge is across disciplinary approaches and perspectives. This serves as a starting point for playful reflection on the challenges of interdisciplinary research and the (dis)connection between lived experience and scientific understanding of the human mind in the second phase of the learning unit.

Learning unit overview for the phenomenon of decision-making

Introductory lecture – A diversity of approaches to studying and understanding decision-making

Collaborative challenge-solving

1. First part: What is decision-making?
    • Mini challenge: Finding a definition of decision-making
    • Challenge: Comparing different conceptualisations of decision-making through the lens of study design
2. Second part: Epistemic bubbles
    • Mini challenge: Cognitive scientists' disciplinary bubbles
    • Challenge: How to change one's epistemic bubble?

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26   Descriptions of the three illustrations are adapted after Strle and Markič (2021).

Introductory lecture: A diversity of approaches to studying and understanding decision-making

In the introductory lecture, students are introduced to basic disciplinary perspectives and methodological approaches to studying decision-making, get acquainted with main theories of the phenomenon, and learn about interesting and important studies. Moreover, cases of (dis)connectedness of methodologies, findings, and theories of individual disciplinary approaches are presented. For example, we consider how insights into experiential aspects of decision-making remain largely ignored within third-person sciences of decision-making. Moreover, in a journal club setting, students engage with certain seminal and contemporary studies on decision-making. As part of this activity, they write summaries of selected research, comment on their peers' work, and present the studies to each other. Through this process, they gain a deeper understanding of some of the key studies in the field, learn to identify and express the core ideas of research reported in scientific papers, and develop insight into how our knowledge and theories about a given phenomenon evolved over time.

The introductory lecture first provides a basic definition of decision-making, presents the components of the decision-making process, different types of decision problems (e.g., decision-making under risk and uncertainty), and various (disciplinary) perspectives from which decision-making can be examined. The lecture continues with a short introduction to the prehistory of decision-making – students get to know, for instance, the basic ideas of Blaise Pascal, Daniel Bernoulli and Jeremy Bentham. Early classical economic theories and views on decision-making are then presented – students get acquainted with classical normative theories of rational choice, such as the *subjective expected utility theory*, and authors such as John von Neumann, Oskar Morgenstern, and Maurice Allais.

The notion of *bounded rationality*, proposed by Herbert Simon, is then introduced to serve as a bridge between normative theories of rational choice and empirical research that tries to understand, mostly through laboratory experimentation, how we really decide (and how human choice deviates from postulates of normative models). Seminal theories and empirical approaches from the areas of psychology and behavioural economics are discussed in more detail. Most notably, the heuristics and biases approach of Daniel Kahneman and Amos Tversky, and their *prospect theory* are presented – the

most influential work on decision-making to this day. Other theories are addressed as well: *the fast and frugal heuristics*, *decision-field theory*, *dual-process theories*, *naturalistic decision-making*, etc. Then, we delve into the differences between intuitive and deliberate decision-making. We spend some time on answering the question of whether, and under which conditions, intuition leads to correct judgments and advantageous choices, and in which it does not. Some ways of how to aid and/or improve decision-making are moreover presented (with a focus on decision nudges). Here, we also touch upon artificial intelligence approach to modelling decision-making. From discussing intuitive judgment and decision-making, we turn to considering the role of emotions in decision-making. From there, we slowly move into the realm of neuroscience of decision-making – where research on the role of emotions is quite richly represented, notably by the seminal work of Antonio Damasio, Antoine Bechara and others. Students get insight into some of the main neuroscientific approaches and findings on decision-making. For instance, we look into neuroscience's understanding of how the brain represents and evaluates probabilities, uncertainty and values, how it evaluates and deals with gains and losses, what role emotions play in this process, and what role the brain's reward systems plays in decision-making. Here, we introduce the basic ideas of the predictive processing account of how the brain processes rewards. It turns out the brain is not much concerned with rewards *per se* (as was theorised in the past), but with what it expects and the errors it makes in its expectations or prediction – this is also one of the findings that will turn out to be important for solving the second main challenge of the decision-making part of the learning unit. We moreover look into the area of perceptual decision-making where the interest lies in how organisms gather and combine sensory information to inform their choices.

The last part of the lecture is dedicated to discussing some important aspects of studying decision-making that have traditionally been neglected. First, we discuss differences between studying decision-making in the laboratory and in natural environments – some evidence from the area of psychology and neuroscience is presented to show that findings from laboratory studies cannot always be generalised to the natural environment. Secondly, we introduce students to the phenomenology of decision-making. Some key on lived experience of decision-making reveal that behavioural and neuroscientific third-person approaches to studying the phenomenon have much to learn from phenomenological approaches. Since the area of decision-making research is very broad, we end the introductory lecture by making

Conclusion

The bumpy path from student to researcher

*I*n the introduction of this booklet, we described the goal of the CM learning unit: to allow students to at least get a taste of what it is like to be a researcher – free from the prison of the professor's expectations, free to discover something new. We aim to spark students' interest in solving a problem (rather than seeking the correct answer that will satisfy the evaluator). As CM instructors, we want to draw attention to the mistaken equation of the ability to perform well at exams with mastery in research. We do not wish to contribute to the inflation of professionals trained merely to reproduce broadly accepted "solutions". Instead, we would much prefer that at least a certain percentage of our graduates be capable of identifying important gaps in existing knowledge and filling them creatively.

The goal of CM is to shift the mindset of the student – from one focused on finding the correct response to the professor's questions,

to one where an intriguing challenge (i.e., a gap in knowledge) becomes the centre of attention, and the aim of the work is to solve or at least address this challenge. We have labelled these two mindsets *the student* and *the researcher* (or *"explorer"*) *attitudes*.

By calling it "student", we are not suggesting that this attitude is inferior or wrong. In fact, such an attitude is quite necessary in order to become acquainted with the existing body of knowledge in a given field. One characteristic of this attitude is that – when it encounters a question without an immediate answer – it automatically assumes the problem lies in not having yet learned the material: surely the answer is out there – in a textbook, on the internet, or in the neural networks of ChatGPT; it just needs locating. This attitude often proves to be accurate and successful. But it does not hold in cases where new, non-existing solutions are needed – the cases that science and cutting-edge industrial innovation aim to address.

Figure 5.1. A student, eager to learn how to become an equal to his teacher/researcher.

The student attitude, then, sees problem-solving as the problem of locating the appropriate answer. The criteria for "appropriateness" may be defined by the demands of the academic context (e.g., the professor's expectations), but the mindset can also be viewed more broadly – as an attempt to meet the expectations of an authoritative recipient (reader, evaluator, superior...).

The attitude we want to encourage – the researcher attitude – is characterised by the desire to discover the true (real, meaningful...) answer. Not in order to satisfy an evaluator, but because we have noticed a grey area in our personal model of the world – a gap in knowledge we want to fill. The researcher seeks to find out what is *true*, rather than what is *appropriate*. It is not unusual for researchers to discover that the gap in knowledge cannot be filled with existing understanding (i.e. that the given problem will not be solved by merely locating the pre-existing answer) and that they will have to construct the answer themselves. For this, they are prepared to engage creativity, originality – and even bold speculation.

In the following pages, we will try to summarise some insights, working principles, and open questions that we have encountered in over a decade of searching for a formula for the magical transformation of students into researchers.

The shape of the challenge: from the everyday and tangible to theory – and back again

The final challenge example in the chapter on decision-making – the question of how a young researcher might discover alternative models of decision-making – can serve to illustrate the structure of a typical challenge, and, in a way, also exemplifies the general approach to content presentation throughout the CM learning unit.

At first glance, the task appears simple and straightforward. One is asked to describe a possible narrative involving a researcher in the field of computational modelling of decision systems, who realises that her own internal, personal decision-making process (choosing the breed of a new pet) did not unfold in the way the models she studies in her lab would predict.

Despite the friendly, everyday nature of the story, it is important for students to recognise that behind this tale of an AI scientist lies a broader issue of contemporary science – the problem of the inflation of scientific efforts, which makes it impossible to maintain a comprehensive overview of the body of research, even within relatively narrow domains. In other words: the problem of *epistemic bubbles*. And closely related to it, the question of how one might escape the confines of their own bubble – how to extend knowledge beyond the boundaries of the currently used paradigm.

Students must therefore identify the deeper problem embedded within the seemingly charming story about choosing a dog breed. They need to distinguish *signal* from *noise*. In this case, students must realise that the problem will not be solved simply by inventing a story that leads the scientist to phenomenological inquiries into decision-making. They must understand that they will get lost in irrelevant details if they start by searching for specific steps. What is the signal? What is the real general problem, and what is just noise arising from the particularities of the case?

The challenge's protagonist begins in the field of AI, with the anticipated end of her journey in empirical phenomenology or behavioural science. Yet for understanding the broader narrative, all of this constitutes the noise – unimportant, secondary details. Even the issues of the dispersion of the scientist's knowledge, although still an important issue, is not the backbone – the "signal" – of the task. Behind all these distracting "details" lies the true challenge: how can we model an epistemic bubble in a way that could indicate practical strategies for its expansion or transformation?

The presented problem must thus be abstracted from its specific context: What is an epistemic bubble? Can we model it abstractly? The second step is to describe the possibilities such a model offers. The final step – pleasant and preferably humorous – is to "dress" the solution in the details of the given story and to add even more playful, intriguing, and creative noise.

Let us now take a closer look at the first two steps.

First step in problem-solving: understanding the core (of the) problem

As previously stated, it is crucial that students sense the presence of an important, "big" problem behind a challenge. We want them to recognise *the* general within the particular.

In the early stages of preparing this learning unit, we assumed that the playfulness of the challenges would enhance students' enjoyment and contribute to their engagement with the material in a curious and exploratory way.

We were surprised to find that this playfulness often appeared to increase the difficulty for some students – particularly those accustomed to clear, exam-like questions with learnable, well-defined answers. They perceived the playful framing of a challenge as a source of ambiguity ("why not simply straightforwardly ask 'how to model epistemic bubbles'?").

At the same time, the often humorous and everyday character of the challenge narratives led other students to dismiss them as mere entertaining riddles – amusing, but not worthy of deeper intellectual engagement and thus not worthy to dig into the core of the problem.

Despite misunderstandings like that, we insist on maintaining the playful character of the challenges and on wrapping profound problems of understanding the mind in everyday clothing. Partly because we want to keep the general playful tone of the learning unit, but more importantly, because it reflects the reality of scientific inquiry. Real-life problems (i.e., those encountered in research) rarely present themselves as neatly formulated theoretical questions (e.g., *How can Bayesian statistics be used to model epistemic bubbles?*). Rather, they tend to be masked and cluttered with the noise of concreteness – without any subtitle labelling them as "big problems".

Framing "big" questions in the form of playful stories only appears to make things harder for students. The true advantage of this method is that it implicitly (yet clearly) signals that a different set of rules is in play. Questions that directly articulate theoretical problems are easier to treat as "schoolwork" and to approach with the student attitude. Problems wrapped in stories, on the other hand, hint that CM is not about finding correct answers or memorising established solutions – but rather about playfully constructing and testing ideas. We wish to present playfulness as a basic method for confronting deep uncertainties in science – as well as, perhaps, in everyday life.

When students manage to identify the general within the specific – when they succeed in distinguishing signal from noise – this is a very promising sign. But the road to that point is often long.

No matter how colourful or unconventional a challenge may appear, students will often attempt to respond to it in the way they have been conditioned – by searching for the "correct" or established answer. Instead of trying to understand the problem, they focus on divining the expectations of the instructor. Because playfully formulated tasks do not resemble standard academic questions, this guesswork becomes more difficult – but usually not difficult enough that they would abandon the attempt. An example of the student way of contemplating the solution (to a decision-making challenge):

"Since we know the professor is interested in studying human experience, he probably expects us to highlight the importance of experiential approaches in decision-making research."

The task of the CM instructor is to somehow convince students that they need not worry about his or her expectations. That they are free to engage with the problem itself, without concern for whether the result will be deemed "appropriate". Not all students manage to make this leap. Overcoming this requires at least a certain level of motivation and inherent curiosity – something no curriculum can guarantee. The challenge text must be approached with as fresh a perspective as possible. One must try to set aside the lens that frames it as just another assignment on the path to graduation.

One way to support students is by emphasising the importance of the first step in problem-solving: rereading and reflecting on the purpose of the challenge. We encourage students to express the challenge in their own words – to paraphrase it. This step often reveals the core of the difficulty that the students encounter in the attempt to solve the challenge. If a student cannot clearly articulate the challenge in their own words, it's usually a sign that they haven't fully understood it. It often happens that a student's paraphrase actually conveys something entirely different – and only when they hear themselves (or when their peers or instructor reflect it back to them) do they realise how much their expectations have reshaped the original challenge.

For example, in an assignment exploring the concept of a stimulus in emotion research, the task was: *"Compare the standard definition of a stimulus with the way the term is used in cognitive neuroscience."* One group paraphrased the task as: *"Our assignment is to criticise the concept of a stimulus."* Only after the instructor asked why they believed their task was to criticise, did the students realise they had fundamentally misunderstood the challenge. (They explained that the task was not entirely clear to them, but they knew the learning unit encourages critical evaluation of foundational assumptions in cognitive science. So – almost unconsciously – they concluded that the instructor must be expecting a critical take on the concept of stimulus in experimental design.)

Often, students recognise that a CM challenge is different from standard exam-style assessments, but they struggle to situate this difference within any familiar mode. Their prior study experience offers little to help them approach CM-style challenges. As instructors, we sense that in these moments of groundlessness, students stand on the threshold of a shift toward a researcher mindset, or at least that they are open to such a shift. This is why it's crucial to be sensitive to these opportunities. They present the best portals into a deeper engagement with the problem.

The engagement with the problem usually develops in a form of a circular, trial-and-error process. It's essential to maintain student motivation even when the feedback is simply: *"You don't quite understand the question yet – try again."* As we will see in the next section, the trial-and-error loop becomes even more vital and strategic in the second stage of problem-solving, but even here, it is crucial that we allow the time and space that the circular process of discovery requires – from both student and instructor.

Of course, not every CM student requires this kind of guidance when encountering a challenge. Some are natural researchers who light up when they realise they are finally allowed to play with ideas. For this group, all they need is reassurance: *"Yes, really, you can solve this your own way!"* and *"Yes, you really can experiment with ideas!"* The only task of the CM learning unit instructor in such cases is to keep these students (more accurately: these researchers) on track – their curious nature can easily lead them off into exploring tangential challenges.

Second step: establishing the loop of self-correction – creative and iterative construction of a solution

If a student reaches the point where they grasp the "message" of the challenge (i.e., successfully completes the first step of problem-solving), we already consider this a success (and evaluate it accordingly). Fortunately, this is rarely where students stop. If the student internalises the understanding that the challenge presents an engaging and meaningful problem – and if they realise that the goal is not a final, correct, or desired solution, but rather the testing of ideas along the path toward a solution – it is unlikely they will be content with understanding of the problem alone.

The task of the learning unit instructors regarding the second step is twofold:

1. To prevent students from rushing into solution-mode too early – that is, before they fully understand the challenge;

2. And once the deeper question hidden within the challenge is clear, to help the student establish and sustain a loop of self-checking.

Just like understanding the challenge, this loop of creatively constructing a solution can occur at three different levels:

- within the student's internal dialogue with themselves,
- among peers,
- and between the student and the instructor.

CM instructors do everything possible to support all three levels of this loop – encouraging solution-building and critical reflection on the usefulness of the ideas being tested. As already mentioned, it is crucial that the course module allocates time and space for this kind of feedback process.[44] What we must guarantee is iterativeness. Nothing can replace the process of gradual mapping of the space of possible solutions.

One of the key difficulties we face as instructors (aside from the formal challenges of justifying repeated iterations and involving more than one instructor per session) is the loss of motivation that students often feel due to the feeling of failure at the end of each "unsuccessful" solution attempt. From a student's perspective, repeatedly working on the same problem is often seen as a failure. A student's quality is typically measured by how quickly they can find a correct answer (and move on to new material). Slow meandering of ideas is not what the system expects from students. But from a research perspective, that is the job description. Science is a process of trial and error – or, in philosopher Karl Popper's words, a string of conjectures and refutations.

So how do we convince students that discovering a "failed" solution – along with the insight that it doesn't work, and the decision to continue testing – is an important and highly desirable component of the research process? And how do we keep them motivated to remain in that loop of experimentation for as long as possible?

Bonus points for every failure

There is a way to preserve the teaching environment while also encouraging a research-oriented approach. We wish we could claim authorship of this method, but we cannot. The idea was proposed by a student – Nina. Once she understood the core intention of the course, she simply asked: *"Why not reward failure?"* She realised that it is the fear of failure that paralyses students

(and not only students) when it comes to exploring something new, original, and untested.[45]

As instructors, we're still scratching our heads, wondering how we didn't come up with the idea ourselves. Now that we have it, it seems so obvious and self-evident. Following Nina's suggestion, we added a new element to the assessment criteria: every iteration that does not produce a viable solution to the challenge raises the final grade – regardless of how strange, unconventional, or even silly the proposed solution might be.

We opened a dedicated space in the online classroom for additions to the main challenge reports. This optional supplementary report includes:

- a description of the attempted solution,
- a description of the feedback process that led to the realisation that the proposed idea does not solve the problem,
- a reflection on the insights gained from this "failed" attempt.

In this way, students are rewarded for trying. They now know that "unsuccessful" solutions will not harm their performance in the course – in fact, they will improve it. The supplementary report requires enough effort that we've effectively protected against the risk of students documenting every minor attempt just to boost their grade. But even if that risk weren't fully prevented – wouldn't it actually be interesting if a student started inventing new and novel types of solutions, regardless of their motivation? After all, creativity is valuable – no matter what drives it.

Individual tutorship

The "bonus points for failure" scheme described above can significantly aid in establishing a self-correction loop during group challenges. In such settings, the instructor has no direct insight into group dynamics, so any mechanism that fosters the spontaneous emergence of reflective practices is welcome. For individual challenges, however, the main responsibility for guiding the student toward a research-oriented attitude naturally falls to the instructor or mentor.

These days, it is not uncommon to hear that students feel threatened when told that they've solved a task incorrectly or when weaknesses in their arguments are pointed out. This prevailing mindset is not particularly helpful

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44   In CM, creating space for such processes was the main reason we opted to reduce the number of topics covered and instead focus on a more in-depth exploration of just two phenomena.

45   Thank you, Nina!

A note on the creation process of the booklet

We would like to once again thank the European EUTOPIA program and the EUTOPIA office at the University of Ljubljana for their financial support in the creation of this book, as well as for enabling us to build an international EUTOPIA learning community around the *Challenging Minds* learning unit.

The authors of this book were the instructors of the learning unit in the academic year 2023/2024, namely Urban Kordeš, Maruša Sirk and Toma Strle. We divided the writing as follows: the introduction and conclusion (*Foreword*, *Challenges in Challenging minds* and *Conclusion: The bumpy path from student to researcher*) were prepared by Urban Kordeš, the section on emotions (*Examining emotions: The mystery of the stimulus*) by Maruša Sirk, and the section on decision-making (*Many meanings of decision-making*) by Toma Strle.

Although each author prepared the initial draft of their respective section, the final version of all chapters is the result of collaborative work. Some chapters were originally written in Slovene, the initial English translation was done with the help of ChatGPT, while the final version of the text was edited and rewritten by the authors.

Illustrations in the book were created using a combination of AI-generated imagery, which were generated via ChatGPT's image tools, and manually produced visualisations developed in RStudio and Canva. If not stated otherwise under the picture, the pictures were created using ChatGPT.

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The booklet's design wouldn't have been the same without Barbi Seme's initial ideas and suggestions. For that, we are truly thankful.

No good book is created alone, and this one is no exception. It is the product of collaborative, interdisciplinary work – many times messy, but driven by dedication, curiosity and a spirit of playful inquiry.

Literature

Literature from section Challenges in challenging minds

Raichle, M. E., MacLeod, A. M., Snyder, A. Z., Powers, W. J., Gusnard, D. A., & Shulman, G. L. (2001). A default mode of brain function. *Proceedings of the National Academy of Sciences, 98*(2), 676–682. https://doi.org/10.1073/pnas.98.2.676

Literature from section Examining emotions: The mystery of the stimulus

Introductory lecture: Key readings

Bear, M. F., Connors, B. W., & Paradiso, M. A. (2016). *Neuroscience: Exploring the Brain* (4th ed.). Wolters Kluwer.

Gazzaniga, M., Ivry, R. B., & Mangun, G. R. (2019). *Cognitive Neuroscience: The Biology of the Mind* (5th ed.). W. W. Norton & Company

Schacter, D. L., Gilbert, D. T., Nock, M. K., & Wegner, D. M. (2020). *Psychology* (5th ed.). Worth Publishers.

Introductory lecture: Cited references

Banich, M. T., & Compton, R. J. (2023). *Cognitive Neuroscience* (5th ed.). Cambridge University Press. https://doi.org/10.1017/9781108923361

Barrett, L. F. (2017). *How emotions are made: The secret life of the brain*. Houghton Mifflin Harcourt.

Bear, M. F., Connors, B. W., & Paradiso, M. A. (2016). *Neuroscience: Exploring the brain* (4th ed.). Wolters Kluwer.

Cannon, W. B. (1927). The James–Lange theory of emotions: A critical examination and an alternative theory. *The American Journal of Psychology, 39*, 106–124. https://doi.org/10.2307/1415404

Dalgleish, T. (2004). The emotional brain. *Nature Reviews Neuroscience, 5*(7), 583–589. https://doi.org/10.1038/nrn1432

Darwin, C. (1872). *The expression of the emotions in man and animals*. John Murray.

Ekman, P., & Friesen, W. V. (1971). Constants across cultures in the face and emotion. *Journal of Personality and Social Psychology, 17*(2), 124–129.

Gazzaniga, M., Ivry, R. B., & Mangun, G. R. (2019). *Cognitive Neuroscience: The Biology of the Mind* (5th ed.). W. W. Norton & Company

Izard, C. E. (2010). The many meanings/aspects of emotion: Definitions, functions, activation, and regulation. *Emotion Review, 2*(4), 363–370. https://doi.org/10.1177/1754073910374661

James, W. (1884). *What is an Emotion?* Mind, 9(34), 188–205.

Kandel, E. R., Schwartz, J. H., Jessell, T. M., Siegelbaum, S. A., & Hudspeth, A. J. (2012). *Principles of Neural Science* (5th ed.). McGraw-Hill Education / Medical.

Lange, C. G. (1922). The emotions. In K. Dunlap (Ed.), *The emotions* (pp. 33–90). Williams & Wilkins.

LeDoux, J. E. (1996). *The emotional brain: The mysterious underpinnings of emotional life*. Simon & Schuster.

OpenAI. (2025). *ChatGPT and DALL·E* [Large language model and image generation tools]. https://openai.com

Papez, J. W. (1937). A proposed mechanism of emotion. *Archives of Neurology and Psychiatry, 38*(4), 725–743. https://doi.org/10.1001/archneurpsyc.1937.02260220069003.

Posner, J., Russell, J. A., & Peterson, B. S. (2005). The circumplex model of affect: An integrative approach to affective neuroscience, cognitive development, and psychopathology. *Development and Psychopathology, 17*(3), 715–734. https://doi.org/10.1017/S0954579405050340

Schachter, S., & Singer, J. (1962). Cognitive, social, and physiological determinants of emotional state. *Psychological Review, 69*(5), 379–399. https://doi.org/10.1037/h0046234

Further reading

Adolphs, R., Tranel, D., Damasio, H., & Damasio, A. (1994). Impaired recognition of emotion in facial expressions following bilateral damage to the human amygdala. *Nature, 372*(6507), 669–672.

Aragona, B. J., Liu, Y., Curtis, J. T., Stephan, F. K., & Wang, Z. (2003). A critical role for nucleus accumbens dopamine in partner-preference formation in male prairie voles. *The Journal of Neuroscience, 23*(8), 3483–3490.

Arroyo, S., Lesser, R. P., Gordon, B., Uematsu, S., Hart, J., Schwerdt, P., et al. (1993). Mirth, laughter, and gelastic seizures. *Brain, 116*(4), 757–780.

De Boer, A., Van Buel, E. M., & Ter Horst, G. J. (2012). Love is more than just a kiss: a neurobiological perspective on love and affection. *Neuroscience, 201*, 114–124.

Ekman, P., O'Sullivan, M., Friesen, W. V., & Scherer, K. R. (1991). Invited article: Face, voice, and body in detecting deceit. *Journal of Nonverbal Behavior, 15*(2), 125–135.

Ekman, P. (1999). Basic Emotions. In Dalgleish, T. & Power, M. J. (Eds.). *Handbook of Cognition and Emotion* (pp. 45–60). John Wiley & Sons Ltd.

Feinstein, J. S., Buzza, C., Hurlemann, R., Follmer, R. L., Dahdaleh, N. S., Coryell, W. H., et al. (2013). Fear and panic in humans with bilateral amygdala damage. *Nature Neuroscience, 16*(3), 270–272.

Gendron, M., Roberson, D., van der Vyver, J. M., & Barrett, L. F. (2014). Perceptions of emotion from facial expressions are not culturally universal - evidence from a remote culture. *Emotion, 14*(2), 251–262.

Krack, P., Kumar, R., Ardouin, C., Dowsey, P. L., McVicker, J. M., Benabid, A. L., & Pollak, P. (2001). Mirthful laughter induced by subthalamic nucleus stimulation. *Movement Disorders, 16*(5), 867–875.

Kurdi, B., Lozano, S., & Banaji, M. R. (2017). Introducing the Open Affective Standardized Image Set (OASIS). *Behavior Research Methods, 49*(2), 457–470. https://doi.org/10.3758/s13428-016-0715-3

Orne, M. T. (1962). On the social psychology of the psychological experiment: With particular reference to demand characteristics and their implications. *American Psychologist, 17*(11), 776–783.

Schacter, D. L., Gilbert, D. T., Nock, M. K., & Wegner, D. M. (2020). *Psychology* (5th ed.). Worth Publishers.

Scherer, K. R. (2005). What are emotions? And how they can be measured? *Trends and developments: research on emotions, 44*(4), 695–729. https://doi.org/10.1177/0539018405058216

Tice, M. D., Bratislavsky, E., & Baumeister, R. F. (2001). Emotional Distress Regulation Takes Precedence Over Impulse Control: If You Feel Bad, Do It!. *Journal of Personality and Social Psychology, 80*(1), 53–67.

Weiskrantz, L. (1956). Behavioral changes associated with ablation of the amygdaloid complex in monkeys. *Journal of Comparative and Physiological Psychology, 49*(4), 381–391.

First part: Elicitation and measurement techniques

Blood, A. J., & Zatorre, R. J. (2001). Intensely pleasurable responses to music correlate with activity in brain regions implicated in reward and emotion. *Proceedings of the National Academy of Sciences of the United States of America, 98*(20), 11818–11823. https://doi.org/10.1073/pnas.191355898

Bradley, M. M., & Lang, P. J. (1994). Measuring emotion: The self-assessment manikin and the semantic differential. *Journal of Behavior Therapy and Experimental Psychiatry, 25*(1), 49–59. https://doi.org/10.1016/0005-7916(94)90063-9

Gabert-Quillen, C. A., Bartolini, E. E., Abravanel, B. T., & Sanislow, C. A. (2015). Ratings for emotion film clips. *Behavior research methods, 47*(3), 773–787. https://doi.org/10.3758/s13428-014-0500-0

Gross, J. J., & Levenson, R. W. (1995). Emotion Elicitation Using Films. *Cognition and Emotion, 9*(1), 87–108. https://doi.org/10.1080/02699939508408966

Hertenstein, M. J., Keltner, D., App, B., Bulleit, B. A., & Jaskolka, A. R. (2006). Touch communicates distinct emotions. *Emotion, 6*(3), 528–533. https://doi.org/10.1037/1528-3542.6.3.528

Hurlburt, R. T. (2011). *Investigating Pristine Inner Experience: Moments of Truth*. Cambridge University Press. https://doi.org/10.1017/CBO9780511842627

Husserl, E. (2012). *Ideas: General introduction to pure phenomenology* (W. R. B. Gibson, Trans.). Routledge. (Original work published 1913)

Kim, H., Lu, X., Costa, M., Kandemir, B., Adams, R. B., Jr, Li, J., Wang, J. Z., & Newman, M. G. (2018). Development and validation of Image Stimuli for Emotion Elicitation (ISEE): A novel affective pictorial system with test-retest repeatability. *Psychiatry research, 261*, 414–420. https://doi.org/10.1016/j.psychres.2017.12.068

Kurdi, B., Lozano, S., & Banaji, M. R. (2017). Introducing the Open Affective Standardized Image Set (OASIS). *Behavior Research Methods, 49*(2), 457–470. https://doi.org/10.3758/s13428-016-0715-3

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (2008). *International Affective Picture System (IAPS): Instruction manual and affective ratings, Technical Report A-8*. The Center for Research in Psychophysiology, University of Florida.

Nummenmaa, L., Glerean, E., Hari, R., & Hietanen, J. K. (2014). Bodily maps of emotions. *Proceedings of the National Academy of Sciences of the United States of America, 111*(2), 646–651. https://doi.org/10.1073/pnas.1321664111

Porcherot, C., Delplanque, S., Raviot-Derrien, S., Le Calvé, B., Chrea, C., Gaudreau, N., & Cayeux, I. (2010). How do you feel when you smell this? Optimisation of a verbal measurement of odor-elicited emotions. *Food Quality and Preference, 21*(8), 938–947. https://doi.org/10.1016/j.foodqual.2010.03.012

Ratcliffe, M. (2008). *Feelings of Being: Phenomenology, Psychiatry and the Sense of Reality, International Perspectives in Philosophy & Psychiatry*. Oxford University Press. https://doi.org/10.1093/med/9780199206469.001.0001

Röggla, T. (2019). *Self-assessment manikins SVG* [Illustration set]. https://github.com/cwi-dis/self-assessment-manikins-svg

Rottenberg, R., Ray, R. D., & Gross, J. J. (2007). Emotion elicitation using films. In: James A. Coan & John J.B. Allen (ed.) *Handbook of emotion elicitation and assessment* (pp. 9–28). Oxford University Press.

Russell, J. A. (1980). A Circumplex Model of Affect. *Journal of Personality and Social Psychology, 39*(6), 1161–1178. https://doi.org/10.1037/h0077714

Susindar, S., Sadeghi, M., Huntington, L., & Singer, A. (2019). The Feeling is Real: Emotion Elicitation in Virtual Reality. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 63*(1), 252–256. https://doi.org/10.1177/1071181319631509

Second part: The problem of emotion elicitation

Aanstoos, C. M. (1991). Experimental psychology and the challenge of real life. *American Psychologist, 46*(1), 77–78. https://doi.org/10.1037/0003-066X.46.1.77

Downing, S. M., & Haladyna, T. M. (2006). *Handbook of test development*. Lawrence Erlbaum Associates Publishers.

Kline, P. (2000). *Handbook of psychological testing*. Routledge.

Lomas, T. (2018). *Translating Happiness: A Cross-Cultural Lexicon of Well-Being*. The MIT Press.

Oxford English Dictionary. (2024). *Awe* (n., sense 1.b). Retrieved October 24, 2025, from https://www.oed.com

OpenAI. (2025). *ChatGPT and DALL·E* [Large language model and image generation tools]. https://openai.com

Third part: The problem of emotion measurement

Bradley, M. M., & Lang, P. J. (1994). Measuring emotion: The self-assessment manikin and the semantic differential. *Journal of Behavior Therapy and Experimental Psychiatry, 25*(1), 49–59. https://doi.org/10.1016/0005-7916(94)90063-9

Creswell, J. W., & Plano Clark, V. L. (2011). *Designing and Conducting Mixed Methods Research*. SAGE Publications.

Hurlburt, R. T. (2009). Iteratively apprehending pristine experience. *Journal of Consciousness Studies, 16*(10-12), 156–188.

Hurlburt, R. T., & Heavey, C. L. (2006). *Exploring Inner Experience: The Descriptive Experience Sampling Method*. John Benjamins.

Kurdi, B., Lozano, S., & Banaji, M. R. (2017). Introducing the Open Affective Standardized Image Set (OASIS). *Behavior research methods, 49*(2), 457–470. https://doi.org/10.3758/s13428-016-0715-3

Lush, P., Scott, R. B., Seth, A. K., & Dienes, Z. (2021). The phenomenological control scale: Measuring the capacity for creating illusory nonvolition, hallucination and delusion. *Collabra: Psychology, 7*(1), 1–16. https://doi.org/10.1525/collabra.29542

Orne, M. T. (1962). On the social psychology of the psychological experiment: With particular reference to demand characteristics and their implications. *American Psychologist, 17*(11), 776–783. https://doi.org/10.1037/h0043424

Weber, S. J., & Cook, T. D. (1972). Subject effects in laboratory research: An examination of subject roles, demand characteristics, and valid inference. *Psychological Bulletin, 77*(4), 273–295. https://doi.org/10.1037/h0032351

Literature from Section Many Meanings of Decision-Making

Introductory Lecture

Key Readings

Eysenck, M. W., & Keane, M. T. (2020). *Cognitive psychology: A student's handbook* (8th ed.). Psychology Press.

Gazzaniga, M. S., Ivry, R. B., & Mangun, G. R. (2018). *Cognitive Neuroscience: The Biology of the Mind* (5th ed.). New York: W. W. Norton & Company.

Hardman, D. (2009). *Judgment and decision making: Psychological perspectives*. BPS Blackwell.

Kordeš, U. (2009). *The phenomenology of decision making*. Interdisciplinary Description of Complex Systems, 7(2), 65–77.

Strle, T., & Markič, O. (2021). *O odločanju in osebni avtonomiji* [On decision-making and personal autonomy]. Aristej.

Cited References

Eysenck, M. W., & Keane, M. T. (2020). *Cognitive psychology: A student's handbook* (8th ed.). Psychology Press.

Gazzaniga, M. S., Ivry, R. B., & Mangun, G. R. (2018). *Cognitive neuroscience: The biology of the mind* (5th ed.). W. W. Norton & Company.

Hardman, D. (2009). *Judgment and decision making: Psychological perspectives*. BPS Blackwell.

Heekeren, H. R., Marrett, S., & Ungerleider, L. G. (2008). The neural systems that mediate human perceptual decision making. *Nature Reviews Neuroscience, 9*(6), 467–479. https://doi.org/10.1038/nrn2374

Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica, 47*(2), 263–291. https://doi.org/10.2307/1914185

Kordeš, U. (2009). The phenomenology of decision making. *Interdisciplinary Description of Complex Systems, 7*(2), 65–77.

Van Manen, M. A. (2014). On ethical (in)decisions experienced by parents of infants in neonatal intensive care. *Qualitative Health Research, 24*(2), 279–287. https://doi.org/10.1177/1049732313514132

De Martino, B., Kumaran, D., Seymour, B., & Dolan, R. J. (2006). Frames, biases, and rational decision-making in the human brain. *Science, 313*(5787), 684–687. https://doi.org/10.1126/science.1128356

Strle, T., & Markič, O. (2021). *O odločanju in osebni avtonomiji* [On decision-making and personal autonomy]. Aristej.

Tversky, A., & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. *Science, 185*(4157), 1124–1131. https://doi.org/10.1126/science.185.4157.1124

Tversky, A., & Kahneman, D. (1981). The framing of decisions and the psychology of choice. *Science, 211*(4481), 453–458. https://doi.org/10.1126/science.7455683

First part: What is decision-making?

Bechara, A., Damasio, H., Tranel, D., & Damasio, A. R. (1997). Deciding advantageously before knowing the advantageous strategy. *Science, 275*(5304), 1293–1295. https://doi.org/10.1126/science.275.5304.1293

De Martino, B., Kumaran, D., Seymour, B., & Dolan, R. J. (2006). Frames, biases, and rational decision-making in the human brain. *Science, 313*(5787), 684–687. https://doi.org/10.1126/science.1128356

Dijksterhuis, A., Bos, M. W., Nordgren, L. F., & van Baaren, R. B. (2006). On making the right choice: The deliberation-without-attention effect. *Science, 311*(5763), 1005–1007. https://doi.org/10.1126/science.1121629

Heekeren, H. R., Marrett, S., Bandettini, P. A., & Ungerleider, L. G. (2004). A general mechanism for perceptual decision-making in the human brain. *Nature, 431*(7010), 859–862. https://doi.org/10.1038/nature02966

Kordeš, U. (2009). The phenomenology of decision making. *Interdisciplinary Description of Complex Systems, 7*(2), 65–77.

Klein, G., Calderwood, R., & Clinton-Cirocco, A. (2010). Rapid decision making on the fire ground: The original study plus a postscript. *Journal of Cognitive Engineering and Decision Making, 4*(3), 186–209. https://doi.org/10.1518/155534310X12844000801203

Kim, J., Justin, C., Mavris, D., & Briceno, S. (2022). Data-driven approach using machine learning for real-time flight path optimisation. *Journal of Aerospace Information Systems, 19*(1), 1–16. https://doi.org/10.2514/1.I010963

Vakili, E., Amirkhani, A., & Mashadi, B. (2024). DQN-based ethical decision-making for self-driving cars in unavoidable crashes: An applied ethical knob. *Expert Systems with Applications, 255*(Part A), e124567. https://doi.org/10.1016/j.eswa.2024.124567

Liu, G., Luo, Y., & Sheng, J. (2024). Applying AVWEWM to ethical decision-making during autonomous vehicle crashes. *Scientific Reports, 14*, 3924. https://doi.org/10.1038/s41598-024-30924-3

Liu, P., Chen, B., & Wang, Z. W. (2020). GABAergic motor neurons bias locomotor decision-making in C. elegans. *Nature Communications, 11*, 5076. https://doi.org/10.1038/s41467-020-18894-3

Libet, B., Gleason, C. A., Wright, E. W., & Pearl, D. K. (1983). Time of conscious intention to act in relation to onset of cerebral activity (readiness potential): The unconscious initiation of a freely voluntary act. *Brain, 106*(3), 623–642. https://doi.org/10.1093/brain/106.3.623

Seeley, T. D., & Buhrman, S. C. (1999). Group decision making in swarms of honey bees. *Behavioral Ecology and Sociobiology, 45*(1), 19–31. https://doi.org/10.1007/s002650050536

Second part: Epistemic bubbles

Blackmore, S. (2006). *Conversations on consciousness: What the best minds think about the brain, free will, and what it means to be human*. Oxford University Press.

Clark, A. (2023). *The experience machine: How our minds predict and shape reality*. Pantheon.

Friston, K. J. (2010). The free-energy principle: A unified brain theory? *Nature Reviews Neuroscience, 11*, 127–138. https://doi.org/10.1038/nrn2787

Grüter, C., & Farina, W. M. (2009). The honeybee waggle dance: Can we follow the steps? *Trends in Ecology & Evolution, 24*(5), 242–247. https://doi.org/10.1016/j.tree.2008.12.007

Kirchhoff, M. D. (2017). Predictive brains and embodied enactive cognition: An introduction to the special issue. *Synthese, 195*(6), 2355–2366. https://doi.org/10.1007/s11229-017-1470-8

Magnani, L., & Bertolotti, T. (2011). Cognitive bubbles and firewalls: Epistemic immunisations in human reasoning. *Proceedings of the Annual Meeting of the Cognitive Science Society, 33*, 3370–3375.

Nguyen, C. T. (2020). Echo chambers and epistemic bubbles. *Episteme, 17*(2), 141–161. https://doi.org/10.1017/epi.2018.32

Operational definition. (n.d.). In *Wikipedia*. Retrieved October 24, 2025, from https://en.wikipedia.org/wiki/Operational_definition

Reynolds, A. M., Smith, A. D., Reynolds, D. R., Carreck, N. L., & Osborne, J. L. (2007). Honeybees perform optimal scale-free searching flights when attempting to locate a food source. *Journal of Experimental Biology, 210*(21), 3763–3770. https://doi.org/10.1242/jeb.009563

Seth, A. K. (2021). *Being you: A new science of consciousness*. Dutton.

Varela, F. J., Thompson, E., & Rosch, E. (1991). *The embodied mind: Cognitive science and human experience*. MIT Press.

Weidenmüller, A., & Seeley, T. D. (1999). Imprecision in waggle dances of the honeybee (Apis mellifera) for nearby food sources: Error or adaptation? *Behavioral Ecology and Sociobiology, 46*(3), 190–199. https://doi.org/10.1007/s002650050608

Unraveling the mystery of decision-making?

Luria, A. R. (1979). *The making of mind: A personal account of Soviet psychology* (M. Cole & S. Cole, Eds.). Harvard University Press. https://www.marxists.org/archive/luria/works/1979/mind/ch01.htm

List of figures

"In a world full of ambiguities and profound technological transformation, we as cognitive systems face the extremely challenging task of making sense of such an uncertain (VUCA-)environment. Nowhere is this challenge more acute than in cognitive science, an emerging field that is so closely related to our own lives. In their outstanding book, the authors present a truly transformative educational guide and roadmap in which a genuinely interdisciplinary approach is key to navigating this complexity.

In addition to its interdisciplinary nature, what makes this work special is its radically enactivist and phenomenological perspective. This perspective effectively bridges the critical gap between objective science and our everyday lived experience. Moving beyond abstract and conceptual discussion, the authors translate these profound insights into concrete, problem-based teaching/learning settings, empowering students to become independent, autonomously thinking, and creative researchers."

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"How can we address the challenges facing education in the era of generative artificial intelligence?"

This book presents an innovative approach to guiding students as explorers in the interdisciplinary field of cognitive science. Through playful stories that pose challenging questions, it encourages critical thinking, invites exploration of scientific methods across disciplines, and helps students connect these ideas to their own lived experiences.

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