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# Uneasiness in interdisciplinary research and the importance of metaphors: A case story on building an interdisciplinary chronic pain research team

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ABSTRACT

Interdisciplinary research is increasingly recognized as a key method to tackle complex societal challenges and stimulate creativity to find innovative solutions. Our key goal when starting our collaboration was to come to innovative ways of treating chronic pain. An ambitious goal that requires out-of-the-box and high-risk-high-gain research. However, interdisciplinary research in practice can be uneasy and will not always be successful. This paper describes a case story focussing on the challenges we faced building an interdisciplinary team. One of the most important lessons is that researchers from different disciplines may think they speak a universal 'language of science', but a thorough understanding of each other's ways of working, research paradigms, methods, and concepts is necessary before they can start working together on solving scientific questions. In fact, if researchers cannot understand each other's language, they cannot expect patients to understand scientific language either. Lastly, for academics to engage with a non-scientific audience and vice-versa, we need to find and create places to meet and find ways to interact effectively. Language is the medium through which all these interactions take place. It is therefore essential that language takes a central place in the process of collaboration across disciplines, interdisciplinary research, patient participation and public engagement. In this case story, we share our experiences in creating a common language, summarized in five steps (1: creating the team; 2: metaphor-forced introduction to disciplines; 3: creating common ground; 4: outreach; 5: integration). Metaphors play an important role in this process. We will demonstrate how we reflectively progressed through these steps while enhancing interdisciplinarity, (scientific) innovation and public engagement. This five-step journey can be used as a process-tool for any other high-risk-high-gain research team seeking to innovate through interdisciplinarity – with the risk of becoming a brilliant failure.

## 1. Introduction case story

In this case story, we describe our journey of becoming an interdisciplinary research group studying the complex societal challenge of chronic pain suffering. Worldwide, an estimated one-fifth of the human population experiences chronic pain, a number which is expected to increase in our aging and changing society [1,6,14,23]. The medical definition of chronic pain as defined by the International Association for the study of Pain currently reads: 'An unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or

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potential tissue damage." This definition is accompanied by six notes, i.e. a note that states that "pain is always a personal experience that is influenced to varying degrees by biological, psychological, and social factors." (for the full definition, see [21]).

Chronic pain not only reduces a patient's quality of life, but also impacts employers, healthcare systems and society at large - creating a large socioeconomic burden [4]. Despite the magnitude of the problem, chronic pain has received surprisingly little formal research attention. In part, this may be due to the fact that pain is by its nature not just a sensory but also an emotional experience, affected by cultural, social, and psychological factors on top of biological mechanisms (see [21] and also see the explanation given by the European Pain Federation https://europeanpainfederation.eu/what-is-the-bio-psycho-social-model-of-pain/). As a subjective, multifaceted experience, chronic pain is inherently difficult to quantify or measure objectively, which in turn limits the search for novel effective treatment strategies. The problem becomes even more complex in non-human subjects (e.g., pets or experimental animals) who cannot verbally indicate their level of pain, or in human patients whose ability to self-report on their pain experiences are limited by problems with speech, memory and/or general mentation [11].

We propose that in order to combat a problem as complex as chronic pain, an interdisciplinary approach is needed for real innovation. Our chronic pain research team consists of a molecular scientist, anesthesiologist-pain specialist / epidemiologist, social psychologist, linguist, veterinary anesthesiologist, behavioral scientist, neurobiologist, immunologist, and material scientist from four different scientific institutes based in the Netherlands. Our ultimate goal is to help defeat chronic pain through innovative thinking, interdisciplinary research and public engagement. As this goal is quite ambitious, we formulated several more comprehensive subgoals (see Table 1).

In order to reach any of our goals, we realized very quickly that although we are all "academics", sharing a research interest in chronic pain, we needed more common ground and understanding to inclusively engage all team members. While writing our first seed grant application, we realized how little we actually knew about each other's scientific fields, let alone the methodologies used, the paradigms taken for granted, or the specific language used within each discipline. In other words, we were not aware of the epistemologies of the 'other' disciplines. Without understanding, we were set out to fail. Therefore, we quickly realized that our primary goals in the first year of collaboration were to foster mutual understanding of each other's disciplines and establish a shared language in line with Repko & Szostak's idea that in order to achieve interdisciplinarity one must have a basic knowledge of the different epistemologies and their defining elements ([22]; also see [16]).

During this process, we found that the use of metaphors was a powerful tool. Not only as a means to talk to each other as academics, but also in a reflexive manner crossing domains: i.e. as an assignment all the academics in this research project were asked to use metaphors to talk to each other and by doing so, we learned how these metaphors influence what and how we think, which can then lead to adapted metaphors and possibly adapted ways of conducting research. *Reflexivity* here means that we as researchers used the construction of metaphors as a practice "through which researchers self-consciously critique, appraise, and evaluate how their subjectivity and context influence the research processes." [18]. Whilst this might be a normal practice for the qualitative researchers in this team, the majority of the researchers had no such experience with reflection or reflexive practices. Furthermore, true reflection is a complex skill that may not be measurable nor does it follow a structured approach (see [28]). By explaining our fields to each other using metaphors, and by reflecting on how we saw each other's fields through conversations with each other, we learned about each other's perspectives. The useful lesson of becoming aware of how your own research context and subjectivity play a role in how you approach scientific questions will be elaborated on below.

In this paper, we describe our journey of collaboration as a team of academics and our evolving insights based on interaction with patients and the general public. We argue that innovation can be reached through interdisciplinarity, but that interdisciplinarity requires a common language for it to (continue) work(ing). After explaining our five-step journey (a metaphor in itself), we highlight how our steps compare to and differ from Repko & Szostak's 10 steps of the interdisciplinary research process (2021). This paper is likely of interest to other researchers setting up teams representing multiple disciplines and interdisciplinary research, and for researchers who want to more effectively engage with patients and the general public in a reflexive manner. Perhaps our approach can help kickstart brilliant innovations, rather than brilliant failures.

**Table 1**
Subgoals for Chronic Pain research team.

| | |
|---|---|
| Subgoal 1: | construct an easy-to-understand and discipline-overarching definition of chronic pain; |
| Subgoal 2: | perform retrospective analyses on existing patient data to uncover previously unknown subgroups of chronic pain patients; |
| Subgoal 3: | develop "unusual" patient questionnaires to replace previous intake forms used by the Utrecht University Medical Centre pain clinic; |
| Subgoal 4: | perform comparative research on animal and human subjects to better understand common molecular pathways in (chronic) pain; |
| Subgoal 5: | use the output and experience of our interdisciplinary journey to increase our visibility as an interdisciplinary expert team; |
| Subgoal 6: | create a sustainable interdisciplinary pain expertise platform, where patients and professionals find information about our ongoing projects and start conversations leading to further patient-centred research to meet currently unheard and therefore unmet needs. |

## 2. The five steps of our journey

As (long) journeys generally consist of several phases or steps, we will use the term 'step' below. The entire journey is illustrated in Fig. 1, where the steps are drawn as road signposts. Sometimes, however, teams may want to diverge from the signposts and are drawn to side routes. Perhaps they suspect it could be a shortcut, or they just find it more attractive or comfortable. Although side routes diverge from the main journey, our research project taught us that there may be good reasons to take them, as they may provide new and valuable experiences or new opportunities. It is up to the team to decide each time whether taking a side route is worthwhile for them or not.

## 3. STEP 1: Creating a team

In our project, our team was *consciously* multidisciplinary (i.e. each team member came from a specific discipline), but at the same time somewhat *serendipitously* created. The aim of the two initiators of this team was to include various scientific disciplines from three different universities (one general university, one university specialized in healthy food and living environment and one technical university) and one medical center. The initiators were open to all disciplines and this is where serendipity comes in. All individual researchers were already doing research on chronic pain, or interested in the topic and could relate to the overall goal of combining disciplines to tackle unsolved questions in the area of chronic pain. They were also all present at – or at least invited to - an event led by a cross-university funding body, the Centre for Unusual Collaborations (CUCo). This means that all involved researchers were already enthusiastic about unusual group collaborations and interdisciplinarity– all necessary ingredients for a fruitful collaboration. One of the current team members pitched a chronic pain patient case that she needed help with. As a doctor she felt that she needed input from other disciplines to come up with innovative research that could ultimately help this patient and many more patients. Academics who were present at the event and felt like they could contribute from their field joined and together they had a first brainstorm session. For example, our health behavior specialist felt she could contribute a

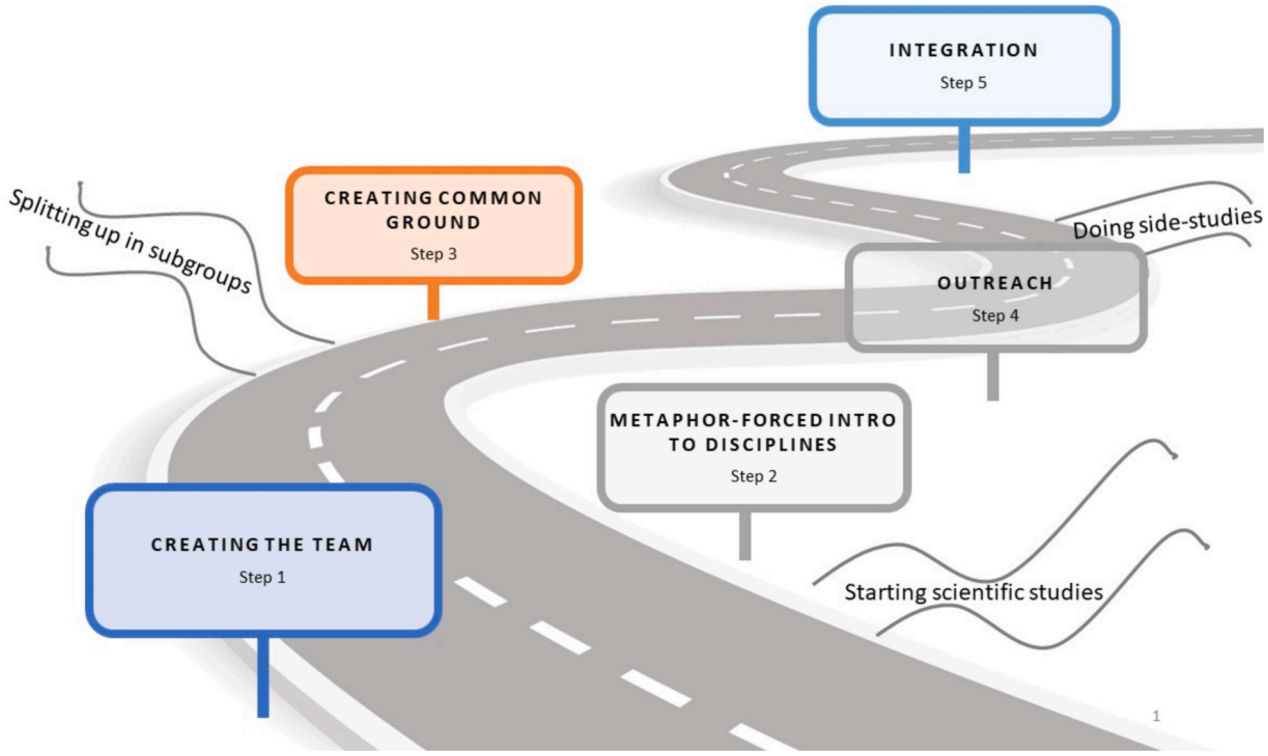


**Fig. 1.** Our five-step journey to interdisciplinary and innovative research.

more holistic approach, our material engineer felt like he could contribute expertise about how new types of materials could help measure pain signals, and our veterinary anesthesiologist was working on very similar issues in animals and felt like a comparative approach could contribute.

At the same time, the team could have also consisted of a random set of other researchers who may have been present had the event been held in a different country or on a different day. When this aspect goes un(*der*)recognized, initial team composition will impose invisible restrictions on input and study outcome. While it is likely impossible for any team to be 100 % inclusive of every discipline that might be of relevance to a multifactorial societal problem, as long as the team utilizes all expertise that is part of the team, recognizes its serendipitous coming together, and remains open to other disciplines to join, this need not be an insurmountable problem.

What is furthermore interesting to note is that this team did not start with a pre-formulated research question, after which input from relevant disciplines was sought (as is common in interdisciplinary research, see [22]:105). Instead, the group started with a group of people and a broad mission (defeating chronic pain), after which we formulated subgoals, research questions and started our interdisciplinary journey. Working with this type of bottom-up approach in defining the research aims, allows for novel research questions and subgoals to be created only after the team is composed. Before meeting the rest of the team none of us would have been able to formulate the subgoals on their own in the way we formulated them together. With this we underscore the importance of 'ignorance' [9], requiring a humble approach from all participants to realize that you don't know what you don't know.

## 4. STEP 2: Full-speed-content-driven talk leads to taking a step back: metaphor-forced introduction of your disciplines

After the team was established, seed funding was received, our team set up a first set of research meetings. The topic of our research being chronic pain, the two initiators (who work at the chronic pain clinic of the University Medical Centre Utrecht and do research on biological markers of chronic pain, respectively), immediately launched into a full-speed discussion on the details of biosensors, molecular pathways and pain phenotyping. This effectively meant that the psychologist, behavioral scientist, materials engineer and linguist could not join the conversation. The linguist's contribution was immediately reduced to noting the linguistic jargon that was used in these first meetings. The psychologist's contribution was reduced to observing the group behavior. The materials engineer answered a question about what materials biosensors can be made of and the behavioral scientist (representing an interdisciplinary field of study by nature) tried to make sense of the various disciplines that comprised the group. And so, we were all doing things we were good at, sticking to our own discipline. However, some of the team members were talking about the content and others were observing the process. We therefore felt it was necessary to take a step back. We had to get to know each other on an academic level first, before launching into studies, experiments, research designs or ethical approval requests.

The linguist and psychologist in the team felt that analogies could be helpful in getting to know each other (see [16]). They created the following assignment for our team: each team member was given a random household object loosely related to finding comfort and dealing with pain, e.g. bath foam, chocolate, a bottle of wine, a yoga mat, socks or a Band-Aid. Loosely related in the sense that in Western culture these items are stereotypically associated with (superficially) relieving pain (i.e. a bandaid for masking pain for children or chocolate for finding comfort for adults). Each team member had to record a 3-min video of themselves explaining their scientific discipline using this object. This led to the neurobiologist explaining neural responses in the brain using bath foam bubbles and a needle moving around water, a linguist explaining how to analyze conversations between two people by having two socks talk to each other, and a veterinarian using a Band-Aid to illustrate what can (or cannot) be done for most animals in pain. Interestingly, most explanations did not associate the household object with pain. This shows that objects can be used metaphorically in so many different ways. For example, the linguist emphasized how important conversational interaction is for pain patients (i.e. [25]) by

using the two 'talking socks', rather than using socks as a comfort item when experiencing pain.

Of course the assignment led to memorable images, but it also forced every researcher to explain their discipline in simple language, reflecting on what sets your discipline apart [2] and what the boundaries of your discipline are [3]. In creating a metaphor to explain a complex phenomenon such as "dorsal root ganglion" or "polymeric materials" we were getting to know each other and learned about the associations others make with certain objects. The use of metaphors is of course not new. Lakoff & Johnson [12] see the essence of metaphors as "experiencing one kind of thing in terms of another" (1980:5) and through the use of metaphors we can understand more abstract things, like scientific fields of study, paradigms or methodologies. In interdisciplinary research, metaphors can be seen as useful tools for communicating ideas and shared understanding [2], and our assignment exemplified this notion.

In a second round of recorded presentations, we collaboratively decided to explain how our disciplines can contribute to research on defeating chronic pain. Although the explicit instruction was to keep the presentations short, and in simple language, we soon realized that the content of the presentations became too complex, too quickly. We therefore decided to allow everyone to view each other's presentations beforehand and gather questions for an interactive session. The psychologist in the team also created a quiz to enhance (digital) interaction in an informal atmosphere. In these interactive, fun sessions several fundamental questions arose, such as: Do you think pain is measurable, can pain be scored with a number, what is the definition of chronic pain for doctors and patients?

These fundamental questions became an exercise in boundary-crossing [2,29]. By boundary-crossing we mean that we needed to move beyond the comfort of our own disciplines and understand what types of knowledge, methods and assumptions belong to other disciplines. Boundaries are brought to the foreground when interacting with disciplines other than your own. Wherever there is tension, or challenges, and these are made explicit, new ideas arise and interaction becomes possible [2]. The questions that were raised and discussed made us realize that our research topic was much more complex than we imagined – and that our group harnessed unique potential to uncover new facets of this problem. This became the real start of our interdisciplinary journey. We had grounded the problem of chronic pain in various disciplines and as researchers we were (only) beginning to learn about these different, other perspectives. (See the term 'disciplinary grounding' in [22], explained as maintaining a strong foundation in one's own discipline).

## 5. STEP 3: Creating common ground through a visual metaphor

As we were beginning to understand where team members came from, we were ready to talk to each other about our shared topic: chronic pain. We came together, with a facilitator, to discuss our common ground – a term often used by Repko & Szostak [22]. We each wrote down our personal definitions of chronic pain and responded to each other's definitions. The facilitator also asked us to explain this definition to an imaginary alien, who had just landed on earth for the first time. This typical exercise in perspective taking helps one to become aware of one's own assumptions and language use. When talking to the imaginary alien, most of us started to define chronic pain – again – with the aid of metaphors, such as noise, electric shocks, needles, a hammer, fire, music and a dj table. The language of pain has often been tied to metaphorical usage, often researched to find relationships between pain type or pain intensity and metaphor use (e.g., [17]) or using metaphors to be able to communicate pain experience to others (e.g., [5]). Some scholars, in the fields of literature studies, medical humanities, or specifically metaphor studies, have also suggested that "sensitivity to metaphor can deepen our understanding of healthcare and, arguably, improve its quality." ([15]: 213).

Although metaphors are used everywhere within science to communicate research findings and results to colleagues and a general public, little is written about how creating a visual metaphor can aid the common ground search process. We do know that metaphors can help make conceptual connections but they can also be the source of miscommunications [10]. Taking a chance in possibly failing to turn our ideas into a visual metaphor – we decided to give it a try. By combining everyone's input, we set out to create a visual that encompassed every team member's definitions and thoughts on chronic pain. The DJ table, or mixing console, best suited our combined ideas. A professional drawing agency (Flatland Agency) helped us design an image, which we updated in a continuing process (see the visual in Fig. 2, and also see STEP 4). This visual metaphor - a mixing table used in music and stage performances - became an integrated product of our interdisciplinary team. In hind-sight, we used this metaphor as a pivotal point in changing from a multidisciplinary approach (placing insights from two or more disciplines side by side, [22]: 24) to an interdisciplinary approach (drawing on disciplines "with the goal of integrating their insights to construct a more comprehensive understanding", [22]: 9).

In our visual mixing console metaphor, we distinguish three key components, described below:

*Microphone:* This is the input in our visual, on the top left corner. Just like a real microphone can pick up sound and convert it into another (electrical) signal, the nervous system detects a painful trigger caused by an injury (e.g., a damaged knee) and converts it into an (electrical) signal. That signal travels via nerve fibers through the spinal cord and onto the brain. Normally the pain signal is informative and tells us something about the state of the body and about possible dangers to consider avoiding next time. However, in the case of chronic pain, the pain signal may be disproportionately large and/or prolonged, while the intital cause has been resolved, thus making it no longer informative or protective (i.e. [13,27]).

*Hall sound:* This is the output in our visual, in the top right corner. The electrical signal in a microphone eventually leads to sound that is heard and experienced. Similarly, the injury signal emitted from tissue damage/inflammation arrives in the brain where the painful experience occurs, with possible associated emotions such as fear, anxiety or depression. Also, this pain experience draws attention toward the painful site. In the case of chronic pain, a strong negative emotional experience arises over a long period of time, taking a large emotional and cognitive toll on the patient (i.e. see [7]). Strong emotions of despair may also arise, also in part due to the various (physical) obstacles that the chronic pain experience often entails, such as not being able to work or play sports, or even walk up the stairs or cook food for your family. These different layers in the pain experience can be heard in the complexity in the music or noise as the hall sound.

*Mixer:* In the middle of our visual is the large mixing console. A real mixing console can determine the relationship between microphone "input" and ultimately the hall sound "output". That relationship depends on how the various knobs and sliders on the mixer are set. Also, the relationship between the transmitted pain signal and the lived pain experience is ambiguous, and can be influenced by certain sliders and knobs. These may be biologic/genetic contribution, such as subtle changes in DNA that directly influence the strength of pain signals generated and/or the intensity of the pain experience, or societal factors that influence how one thinks and feels about pain (expression) (i.e. [8]). Our behavior and lifestyle are also strongly related to chronic pain, and important factors on the mixing panel. How we can express ourselves verbally and nonverbally affects both our pain experience and our ability to communicate about it effectively; in turn, and complicating the story further, the way we express ourselves can itself be affected by the pain experience. Linked to this, our emotional state (i.e., elated or dejected) also directly affects how strong a pain experience is. It is known in both humans and animals that anxiety can amplify pain responses, while extreme stress / excitement can suppress the pain experience [26]. All these factors are also at play in the context of chronic

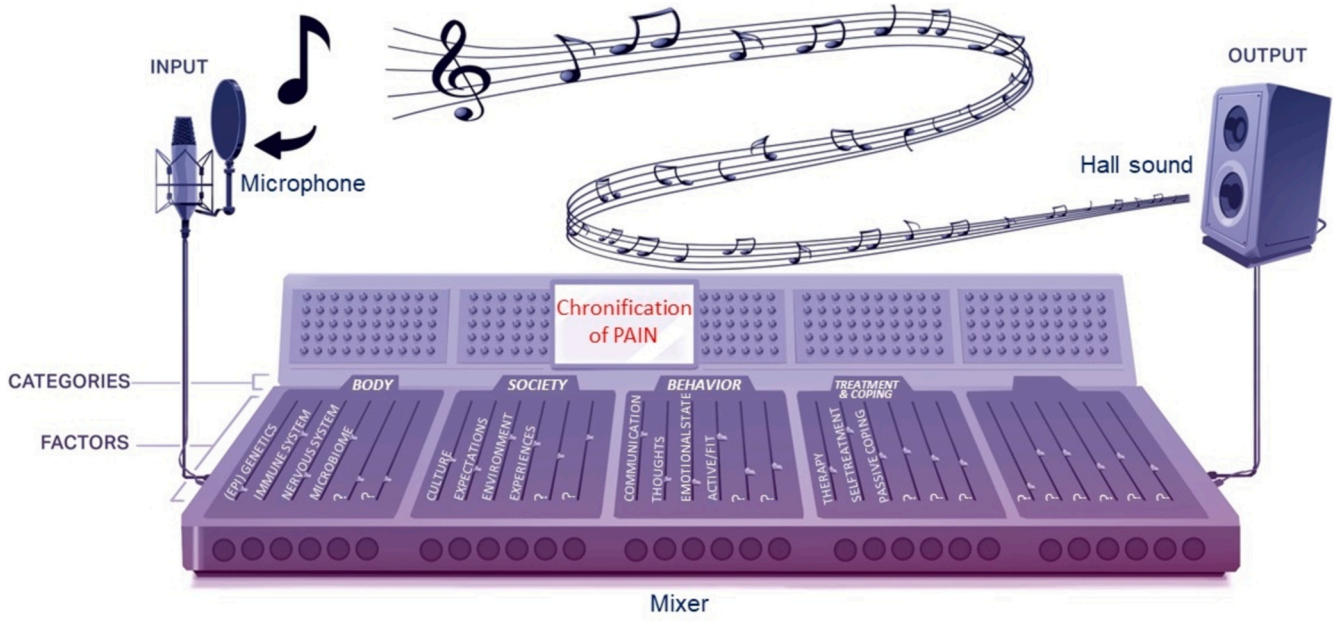


**Fig. 2.** Our visual metaphor of chronic pain: a mixing console.

pain, with behavior taking a central role in an individual's response and coping mechanism. Does one seek medical treatment for the pain? Does one seek forms of self-medication (e.g., over the counter painkillers, prescription drugs)? Does one engage in mindfulness exercises, meditation, or does one revert to (over)consumption of comfort food? To what extent do those treatments then turn the problem of chronic pain for the better? Or do the side effects of the (self)medication choices outweigh the therapeutic effects (e.g., when the consumption of comfort food leads to obesity)? The (behavioral) mixing factors and the pain experience are very closely intertwined and interact strongly.

It is exactly this complex interplay of the different knobs and sliders -with each being the realm of different scientific fields- that causes chronic pain to arise and persist, but which may also hold the complex solution to treat chronic pain. The mixing table shows the variety of causes, effects and possible treatments of chronic pain in such a clear way. It also illustrates how we as a team of researchers representing different disciplines see and aim to deal with this complexity and that we need each other to be aware of this and find out what the interaction between causes and effects is. We realize that there is an interaction at play between the sliders. If one of us moves a slider up, another slider might move down. If the intensity of the physical pain rises, a person may not be able to go to work, causing stress levels to possibly reduce or rise – depending on the individual situation. Pain outcome is directly related to this interplay of factors. We also purposely left one of the slider categories blank, as individual patients can have other (yet unknown) factors that influence their pain levels. This complex metaphor showed us as researchers that we need to know more about the interaction between the sliders and possibly we need to fill in the empty category for every patient individually. Since this visual metaphor was meant to create an interdisciplinary visualization of our team members' ideas and inputs concerning chronic pain, we did not invite patients into this process yet. Our primary goal until now was to understand each other and each other's scientific fields, before reaching out. At a later stage we did ask patient feedback and adapted the visual according to this feedback (i.e. adding the musical notes above the mixing console).

## 6. STEP 4: Outreach

Once we understood each other better, had created a metaphor to be able to visualize the complexity of chronic pain, and had come to appreciate the intricate interplay of our various disciplinary fields, we felt we were ready to reach out to a scientific and general public, with the aim to engage professional and public audiences while working on our scientific studies. The mixing table metaphor became a tool that we could show to patients in order to start a conversation, exploring what aspect(s) of the metaphor resonate(s) most with them, realizing that a metaphor can never be perfect and should be open to future changes. Furthermore, the visual image allowed us to share the complexity of the topic of chronic pain with the general public and truly exemplifies the interdisciplinary approach that is required to reach innovative solutions.

It is important to note that while we were working on various studies together aimed at innovation, we were simultaneously reaching out to a general audience. An advantage of doing this parallel to each other is that you are constantly reflecting on your research activity choices (e.g., adapting your questionnaire questions to the language you hear back from patients, or adding variables to your experiments because you receive input about alcohol usage or sports activities from a general audience at a science festival). Below we will highlight two ways in which we reached out and how these outreach events led to innovative ideas and end products, which in turn led to further engagement with the public. In other words, the outreach events themselves became an integral and reflexive part of our interdisciplinary research journey.

### 6.1. 4a: Outreach through teaching

For three consecutive years we coordinated a course for graduate honours students at Utrecht University, The Netherlands. Per year, 10–12 international master students, from all possible fields of study, chose to take part in our interdisciplinary course on chronic pain. One of their first assignments was to search for a paper on chronic pain within their own discipline. This led, for example, to a computer scientist finding a paper on the application of artificial intelligence (AI) in chronic pain patient narratives and an architecture student finding a scientific study on how to create public spaces in order to help chronic pain patients alleviate their symptoms. This exercise immediately showed everyone, including ourselves as researchers and teachers, how many fields of study are involved in chronic pain research and in fact may form part of the solution in combatting chronic pain. Students were given lectures by the different researchers on our team and chose two fields to zoom in on. By making a podcast, in which they also had to

interview a chronic pain patient, students learned that definitions of chronic pain differ amongst disciplines as well as between patients, cultures and languages. They also discovered that chronic pain patients are everwhere. One of our team members reflects:

"*The outreach activities make me again realize how many people suffer from chronic pain. For example, in the Graduate Honours Seminars, students interviewed people with chronic pain. Unfortunately, it was not difficult for them to find those patients, they even interviewed young peer-students/ friends*."

Another team member added:

"*When preparing for the [graduate honors seminar], I feared that our students in their 20s would have little affinity for the subject, but they were actually very interested, precisely because many were already directly or indirectly affected by it. It made me realize how much hidden suffering there is from chronic pain in my direct environment*."

Reflecting on this teaching experience, we as researchers realized that although definitions are important in science, embracing the diversity of definitions across different communities allows us to learn from the perspectives of other disciplines, countries, and cultures (also see [20]). One of our group members said:

"*I have learned that chronic pain is something very difficult to grasp, almost mythical. Everyone has a different view or definition on this topic and patients also certainly do not always agree on how to define this. The term is almost too broad to be defined. However, we learned that by learning each other's language it is possible to be able to define it and with that hopefully how to help these people with chronic pain*."

Our teaching exercise also demonstrates that the definition of chronic pain that a discipline works with, defines how research is done on it. Students showed that, for example, AI studies are generally based on data primarily collected in the medical world (e.g., [19]). Their definition is therefore tied to the medical definition of chronic pain (see the definition given by the International Association for the Study of Pain in [24]) in which the time factor (pain that persists for more than 3 months or beyond the expected time of healing) is crucial in categorizing who is a chronic pain patient and who is not. In contrast, a linguistic or literary approach focuses much more on the verbalized pain experience and pain expressions, taking language and how patients themselves describe their pain, to be the most informative aspect of the definition of chronic pain (i.e. [25]). Lastly, teaching about chronic pain to students motivated us to continue our research – that seemed to move so slow at times.

### 6.2. 4b: Outreach through public engagement events

One of our biggest outreach events was our presence at the annual Betweter ('Know-it-all') Festival in Utrecht, The Netherlands in 2021. This is a festival featuring science, music, live experiments, film, personal stories and art. The Betweter festival aims to provide visitors the opportunity to experience science: to take part in it, learn from it and question it. As chronic pain team we proposed to do four 'studies' at the festival, in order to inform the public about chronic pain, gather input for two scientific studies and to have conversations with a non-expert audience about chronic pain. These choices were made with the research team and the Betweter festival organizers, based on finding a balance between informing the general public and wanting to collect relevant data for research. Our experiments and interaction with the public at the festival yielded important data for four studies: 1) how a standardized pain stimulus was perceived both biologically, experientially, and linguistically; 2) how the body's own pain suppression mechanisms are influenced by factors such as gender, age, sports, and alcohol use; 3) how people define chronic pain; and 4) what body parts are mainly affected by chronic pain amongst the Betweter Festival audience. Furthermore, we had countless conversations with people experiencing pain. Two life-size naked mannequins on which people could put red stickers to indicate where they most often experienced pain, proved to be an excellent conversation starter, for chronic pain patients, their close friends and relatives and also people who never experienced chronic pain.

The studies we conducted and the data obtained were a direct result of the multiple disciplines that were part of our team. We, for example, not only looked at physical reactions and numerical pain scores for our experiment (1) with a pain stimulus, but also asked people to use words to describe the pain. This then led to both statistical analyses of physical reactions as well as pain scores and a linguistic analysis of pain descriptions. This taught us that people's vocabulary when describing pain sensations is endless, and often metaphorical and cannot be correlated with numerical pain scores. (for more information, see our results at the CUCO website.)

Without the results for the above studies, we would never have reached STEP 5 (below). It is through setting up studies, engaging with a general audience, stepping out of our comfort zones during the event itself (e.g. a linguist putting on a doctor's coat and assisting in a pain experiment as if she were a doctor, or a biologist engaging in conversation with members of the audience when putting red stickers on the abdomen of a mannequin), analyzing and discussing the data, and collaboratively writing up the results, that we have grown as individual researchers and as a team. One of our team members reflects:

"*The outreach activities brought me into contact with patients suffering from chronic pain. Their stories further increased my awareness of the burden this condition directly places on people, but also of the indirect problems it causes.*"

Our Betweter Festival experiments and tasks show that pain is a complex construct that is influenced by many variables and brings about creative language use and associations amongst participants. We also realized that pain is a concept that we all own. We all have different words for it, and these words often do not match the medical definition of chronic pain. By incorporating this input, and integrating the various scientific explanations from different fields on the mechanisms underlying chronic pain, we refined our mixing console metaphor (see Figure 3 above, as part of STEP 3).

## 7. STEP 5: Integration of disciplines

Creating the metaphor of the mixing console, adjusting it and taking it to chronic pain patients is one example of our integrated product. The mixing console also made us realize that questionnaires for chronic pain patients lead to certain classifications – each approach (biological, social, psychological) leads to separate questionnaires. Therefore in one of our research projects we aimed to identify if different chronic pain subgroups exists, incorporating aspects from all three dimensions of the biopsychosocial model, using validated questionnaires We discovered that there are three subgroups of chronic pain patients based on psychosocial questionnaires and computational cluster analysis (this was previously unknown; see our preprint publication here). Amongst 5466 patients with chronic pain, the first subgroup ($n = 750$) was characterized by high psychological burden, low health-related quality of life (HRQoL), lower educational levels and employment rates, and more smoking. The second group ($n = 1795$) showed low psychological burden, intermediate HRQoL, higher educational levels and employment rates, and more alcohol consumption. The third group ($n = 2909$) showed intermediate features. Most strikingly, we found that pain treatment is less effective in the group of patients with high psychosocial burden, suggesting that this group of patients will benefit from an additional treatment strategy. As we incorporated aspects from all three dimensions of the biopsychosocial model, comparing groups in terms of sociodemographic characteristics, lifestyle factors, perceived HRQoL, pain diagnosis, and treatment response, we needed to integrate our knowledge amongst all team members to make sense of the observed findings.

These results are an important first step toward more patient-subgroup targeted therapy (e.g. lifestyle change, psychological treatment, drug treatment; paper submitted).

After our year-long journey of building understanding of each other, creating a common language while learning about each other's disciplines and insights, we have now reached the pivotal stage where we can redirect our focus from the process itself to the content of our research project. At the time of writing, we have completed our first empirical studies where we combined insights and instruments from several disciplines in a novel manner.

Integration also occured outside the direct scope of our project. One team member reflects:

"*Being part of this chronic pain team and discussing pain from different viewpoints with different people, made me realize that sometimes you use methods without questioning the practices. It is standard practice. For example, to investigate whether our zebrafish have a specific mutation in their DNA, we used to clip part of the fin under anesthesia. When members of the team raised their eyebrows and asked the question whether that did not lead to long term pain in the fish, I started to delve into the recent literature and found that new studies showed that indeed hours after this finclip, fish still behave differently (as seen by their altered swimming behavior). I searched for alternatives to this fin clipping method and adopted a method to gently swab the skin of my fish to obtain the DNA. This works perfectly, I do not have to clip part of their fin, and the fish are not experiencing pain!*"

It is important to realize that for integration of disciplines to be successful, it is key to focus on the collaborative process as well as the output. This also means having discussions on the integration and the collaborative process should be part of every meeting. We have seen there is a tendency to split up into small groups, with people from closely related disciplines doing 'subprojects' or writing disciplinary grants as spin-offs. In other words, we tend to take side steps (see Fig. 1). While this is not to be discouraged, there is a risk that the team splits up, members seek those who they feel most closely related to from a disciplinary point of view and therefore the entire team does not integrate as much anymore. What could also happen is that the team members revert to being a multidisciplinary research team, creating disciplinary output under the same thematic umbrella.

### *7.1. Our five-step model compared to the 10 steps of the Interdisciplinary Research Process (IRP)*

Above we have described our journey of doing interdisciplinary research on chronic pain. We identified five steps that were crucial for us as team to come to our integrated output and to continue our interdisciplinary research in the future. Our steps illustrate a practical application of Repko and Szotaks' often used model of doing interdisciplinary research. However, we did not depart from this model. In this section we will reflect on our five-step journey compared to Repko and Szotaks' IRP [22].

Firstly, we did not start with a pre-formulated research question (step 1 'define the research question' of the IRP). The broad mission of helping to defeat chronic pain served as a foundation where our journey started. The complex nature of chronic pain justified the need for an interdisciplinary approach (step 2 'justify using an interdisciplinary approach'). We included researchers from multiple disciplines that we thought were needed to tackle the issue (step 3 'identify relevant disciplines').

Our metaphor-based presentations and discussions functioned as a form of preliminary literature review (step 4 'Conduct a literature review and analyze insights'), where team members shared insights from their disciplines and analyzed how these could contribute to the research on chronic pain. Following intense content-driven discussions, stepping back allowed us to reflect and ensure holistic consideration of all perspectives (step 5, 6, and 7, 'develop adequacy in each relevant discipline, analyze the problem and evaluate each insight or theory, identify conflicts between insights and their sources'). Developing a visual metaphor facilitated shared conceptualization, aligning with the IRP emphasis on creating common ground (step 8).

Engaging with broader audiences through teaching and public events enriched our research with diverse perspectives, and aligns with step 7 ('…and communicate your research to the appropriate audience'). However, we not only communicated *to* others, we also gathered important input *from* others. By engaging with students, the public and patients, we broadened perspectives and enriched our research outcomes.

Finally, the integration of the diverse findings into cohesive outcomes reflects the IRP ultimate goal of synthesizing disciplinary insights for innovative solutions (step 9 and 10, 'construct a more comprehensive understanding and reflect on, test and communicate the understanding'). During the creation of a visual metaphor and our interactive team sessions fundamental questions were raised. This represents the integration of insights. These activities helped our team to develop a more comprehensive understanding of chronic pain, showcasing the core of interdisciplinary research.

It is also important to note that 'our' step 4 is not generally part of an interdisciplinary research process – or at least not before the integration phase (i.e., [22]). However, we would like to argue that engaging a general audience and collecting feedback from previously uninvolved participants, adds another layer to the interdisciplinary collaboration and can be very informative for your research.

In the IRP, integration is the goal of the last four steps (2021: 77). Other models of interdisciplinary research also strive for integration of disciplines. It is this "magic" ([2]: 28) or breakthrough (p. 30) that takes place when the team is open, creative, sensitive and allows for improvisation, intuition, daring and serendipitous moments (p. 28) Our creative, open process facilitated this "magic."

## 8. Conclusion

### *8.1. Innovation*

When starting our collaboration we sought innovation within the overall goal of helping to defeat chronic pain. But innovation requires ignorance, serendipity, curiousity, trust, and a lot of team effort on getting the process right. Our journey taught us that it is important for interdisciplinary research teams to prioritize and devote considerable attention to getting to know each other, finding common ground and setting the stage for the research collaboration at the start of the project. While team members may assume they have the same interests and speak the same scientific language from the start, it turns out that researchers from different fields implicitly or explicitly diverge in terms of definitions, assumptions, insights, and working methods. Exploring similarities and differences between fields gives rise to valuable discussions and even new research ideas, while also improving communication and building trust between team members. One team member reflects: *"…I have changed my perspective on communication itself, learning it is essential to be able to understand each other to be able to work in a team representing different disciplines.*" As we have shown in this paper, metaphors are valuable in different ways throughout this process, as they help people communicate ideas in a natural, personal and relatable way. Metaphors can aid reflexivity, be an analogy to be able to explain your own field, be a tool to facilitate creating common ground and integration and be used as a communication device to – in our case – chronic pain patients.

At certain points we felt like we were failing along the way, not yet reaching true innovation, or groundbreaking scientific results. But, in the end, our journey turned out to be an inspiring adventure. We hope the 5-step framework outlined in this paper will be helpful for other teams to set up their collaboration, after which they can start discovering new and exciting findings that they could not have identified in a monodisciplinary team.

We realize that within all publics we engage with, whether these are fellow academics, students or the lay public, 1 out of 5 of these people suffer from chronic pain. Even amongst us as a group of researchers, we have patients amidst us. The doctor on our team reflected:

"*I have realized that chronic pain is not just a medical problem with*

*psychological effects and interactions. Our view on chronic pain is also influenced by historical perspectives, the words we use, societal receptiveness, cultural habits and more, making interdisciplinary research on this topic the only way forward.*"

W now continue our research by sharing our findings on a web-based platform, so that we can collect even more points of view, stories and metaphors. And so the chronic pain journey continues.

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## CRediT authorship contribution statement

**T.C. Van Charldorp:** Writing – review & editing, Writing – original draft, Formal analysis, Conceptualization. **M.A. Strick:** Writing – review & editing, Methodology, Formal analysis, Conceptualization. **J.C. de Grauw:** Writing – review & editing, Methodology, Formal analysis, Conceptualization. **S. Brugman:** Writing – review & editing, Conceptualization. **Y. Van de Burgt:** Writing – review & editing, Conceptualization. **L.H.H. Winkens:** Writing – review & editing, Conceptualization. **F.J. Meye:** Writing – review & editing, Conceptualization. **M. Rijsdijk:** Writing – review & editing, Supervision, Conceptualization. **H.L.D.M. Willemen:** Writing – review & editing, Supervision, Conceptualization.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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