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Mental Health of the University Students in India and Switzerland: A Cross-Cultural Investigation of the Interaction Between Physical Pain and Reward-Related Processes

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Table of Contents

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This doctoral thesis is dedicated to my mentor Dr. Daisaku Ikeda.

“Become like the sun. If you do so, all darkness will be dispelled. No matter what happens, live confidently with the conviction that you, yourself are the “sun.” Of course, in life, there are sunny days and cloudy days. But even on cloudy days, the sun is still the sun. Even when you are suffering, it is vital that you strive to keep the sun shining brightly in your heart.”

- SGI President Daisaku Ikeda

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

University students are particularly vulnerable to mental health problems, while physical pain has become a major health issue in this population. Around 54% of university students report physical pain each year worldwide; in India, the proportion ranges from 29−81%. Previous studies evidenced that physical pain leads to lower quality of life, lower academic performance, and reduced general work productivity. It also impairs the reward processes and the motivation to obtain a reward, which weakens academic performance. Studies of people with chronic pain conditions identified mental health markers such as PTSD, depression, anxiety, and stress as additional risk factors, whereas protective factors like self-efficacy and social support diminish the pain experienced. Would these interactions between physical pain and mental health, and more specifically between physical pain and reward processing, be the same in a sub-clinical population of university students? And would they vary according to the cultural context?

To address these questions, this dissertation explores the frequency of physical pain symptoms in sub-clinical populations of university students in both Switzerland and India. Research on this subject has been conducted in European countries and the United States, but rarely in Southeast Asia. We hope to yield new insights to suggest that changes in the reward-pain interaction can be identified in the sub-clinical population and therefore provide information about the effect of pain on the processing of reward, avoiding the limitations induced by medication and treatments. We also hope to evidence the relationship between specific mental health markers (i.e., depression, anxiety, PTSD symptoms, perceived stress), specific protective factors (i.e., social support and self-efficacy), and physical pain among university students in two different cultures, using network analysis.

Our results show a significant correlation between mood responses and monetary wins (amount won) in the Swiss control group (students without physical pain symptoms); this was not observed in the sub-clinical group (students with physical pain symptoms). Interestingly, in India, there was no significant correlation between mood ratings and monetary wins, in either of the two groups. We found no significant difference in the association between mental health markers and protective factors related to physical pain in the two countries. In Switzerland and India PTSD, symptoms are prominent. In summary, our results

suggest that pain-related impairment can also be observed in a sub-clinical population. However, this might not be a universal phenomenon. It can vary across different cultures. Our results indicate that mental health markers are similar in both countries, and these mental health markers and protective factors are related to the high frequency of physical pain symptoms among students in both countries. Therefore, designing an intervention, keeping in mind the mental health markers and protective factors, might lead to the reduction of physical pain symptoms in India and Switzerland.

Keywords: University students, physical pain, reward, mood, mental health markers, protective factors

RÉSUMÉ

Les étudiants universitaires sont particulièrement vulnérables aux problèmes de santé mentale et la douleur physique est devenue un problème de santé majeur dans cette population. Environ 54% des étudiants universitaires font état de douleurs physiques chaque année dans le monde ; en Inde, la proportion varie de 29 à 81%. Des études ont montré que la douleur physique entraîne une baisse de la qualité de vie, des résultats scolaires et de la productivité au travail en général. Elle entrave également les processus de récompense et la motivation à obtenir une récompense ce qui compromet les performances académiques. Des études portant sur des personnes souffrant de douleurs chroniques ont identifié des marqueurs de santé mentale, notamment le TSPT, la dépression, l'anxiété et le stress, comme des facteurs de risque supplémentaire, alors que des facteurs de protection tels que l'auto-efficacité et le soutien social diminuent la douleur ressentie. Ces interactions entre douleur physique et santé mentale, et plus spécifiquement entre la douleur physique et le processus de récompense, seraient-elles les mêmes dans une population subclinique d'étudiants universitaires ? Et varieraient-elles en fonction du contexte culturel ?

Pour répondre à ces questions, cette thèse explore la fréquence des symptômes de douleur physique dans des populations subcliniques d'étudiants universitaires en Suisse et en Inde. Des recherches en la matière ont été menées dans des pays européens et aux États-Unis, mais rarement en Asie du Sud-Est. Nous espérons obtenir de nouvelles informations suggérant que des changements dans l'interaction récompense-douleur peuvent être identifiés dans la population subclinique, ce qui pourraient fournir des indications quant à l'effet de la douleur sur le traitement de la récompense, en évitant les limitations induites par les médicaments et les traitements. Nous espérons également mettre en évidence, à l'aide d'une analyse de réseau, la relation entre des marqueurs spécifiques de la santé mentale (dépression, anxiété, symptômes de stress post-traumatique, stress perçu), des facteurs de protection spécifiques (soutien social et auto-efficacité) et la douleur physique chez des étudiants universitaires des deux cultures.

Nos résultats montrent une corrélation significative entre réponses d'humeur et gains monétaires (montant gagné) dans le groupe de contrôle suisse (étudiants sans symptômes de douleur physique) ; cette

corrélation n'a pas été observée dans le groupe subclinique (étudiants présentant des symptômes de douleur physique). Il est intéressant de noter qu'en Inde, dans les deux groupes, il n'y avait pas de corrélation significative entre les réponses d'humeur et les gains monétaires. Nous n'avons pas trouvé de différence significative dans l'association entre les marqueurs de santé mentale et les facteurs de protection liés à la douleur physique, dans les deux pays. En Suisse et en Inde, les symptômes de stress post-traumatique sont prédominants. En résumé, nos résultats suggèrent que des difficultés liées à la douleur peuvent également être observés dans une population subclinique. Toutefois, il ne s'agit peut-être pas d'un phénomène universel, puisqu'il peut varier d'une culture à l'autre. Nos résultats indiquent que les marqueurs de santé mentale sont similaires dans les deux pays, et que ces marqueurs et les facteurs de protection sont liés à la forte fréquence des symptômes de douleur physique chez les étudiants des deux pays. Par conséquent, une intervention qui tiendrait compte des marqueurs de santé mentale et des facteurs de protection pourrait permettre de réduire des symptômes de douleur physique, et ce aussi bien en Inde et qu'en Suisse.

Mots-clés : Étudiants universitaires, douleur physique, récompense, humeur, marqueurs de santé mentale, facteurs de protection

CHAPTER 1: INTRODUCTION

Mental health-related problems account for a large proportion of young people's disease burden worldwide (Patel et al., 2007). Most mental health-related problems start in the youth (Zautra et al., 2010) accounting for 13% of the global burden of disease in this age group (18-24 years) (WHO, 2021). University students are particularly vulnerable to mental health problems commonly associated with the transition to university life and the new academic environment, heavier workload, and frequent financial difficulties (Auerbach et al., 2018; Rubley, 2017). Students are faced with multiple stressors, including academic overload, competition with peers, pressure to succeed, and concerns about the future, often amplified by homesickness to the extent that it is perceived as unsustainable (Thurber & Walton, 2012). Moreover, they are at increased risk for the development of psychopathological problems such as post-traumatic stress disorder (PTSD), anxiety, depression, and stress, resulting in both mental and physical suffering (Kessler et al., 2007). Around 12 to 46% of university students worldwide are affected by mental health disorders and about half of the burden of the disease is reported in high-income countries (Auerbach et al., 2016; WHO, 2008). This leads to long-lasting negative consequences for an individual, for instance, lowered academic achievements, dropouts, and problems in the future life (Harrer et al., 2019).

In addition to mental health issues, physical pain has become a major health problem among university students, with around 54% of them reporting physical pain each year worldwide (Ando et al., 2013). Common physical pain symptoms experienced by the students are headaches (8-83%) and abdominal pain (4-53%), followed by musculoskeletal pain (4-40%) and back pain (12-24%) (Kirtley et al., 2016). Most of the studies have shown the prevalence of physical pain among students from Western, educated, industrialized, rich, and democratic (WEIRD) countries. For instance, in Switzerland over 80% of students reported lower back pain and neck pain yearly according to the Swiss Health Survey data (Angst et al., 2017; Crawford et al., 2018). In the USA a majority of the students showed a high prevalence of musculoskeletal discomfort during/after computer use (Hamilton et al., 2005), and in the UK, the prevalence of self-reported physical pain was 66.9% (Mallen et al., 2005). To our knowledge, not many studies have been conducted on the non-WEIRD population even though physical pain is quite common

among students in non-Western countries. For instance, in India, 29-81% of students report physical pain symptoms each year (Madaan & Chaudhari, 2012). In China too, a community-based study reported that the prevalence of physical pain among the local adult population was found to be 42.2 % (Chen et al., 2016). Due to the high prevalence of physical pain, many university students have reported suffering from physical disability, lower quality of life, lower academic performance, and reduced general work productivity (MacDonald et al., 1997). Due to these challenges, university students often encounter mental health issues for instance anxiety, depression, and high level of stress (Sokratous et al., 2013). A study conducted in Portugal showed that 43% of college students (N = 1493) reported suffering from symptoms of physical pain and, out of these, 30% showed an association between physical pain symptoms and signs of anxiety or depression (Minghelli et al., 2014).

Previous studies evidenced that physical pain also impairs the reward processes and the motivation to achieve reward (Susanne Becker et al., 2012; Gandhi et al., 2014), which leads to poor academic performance as rewards are the best predictors of performance in university students and the presence of extrinsic incentives (e.g., monetary rewards) encourages students to perform better in educational settings (Cerasoli et al., 2014). For example, individuals with chronic pain reported a decreased response to environmental incentives and reduced reward responsiveness to monetary rewards via self-report questionnaires (Xinhe Liu et al., 2019). Furthermore, people suffering from physical pain are at high risk of having persistently low mood (Bair et al., 2003). Winning rewards such as money is associated with an increase in mood as evidenced in several studies using behavioral reward tasks in healthy control samples (Kalebasi et al., 2015; Martin-Soelch et al., 2009; Piccolo et al., 2019), whereas an impaired mood responsivity to reward has been shown in individuals with chronic pain (Rizvi et al., 2021).

Taken together, it is seen that there is a high prevalence of physical pain among university students which in turn leads to various mental health problems. Physical pain also impairs the reward processes, which play an important role in students' learning processes in educational settings. However, little is known so far about the interactions between pain and reward processes in a sub-clinical population. Also, most of the studies have examined the prevalence of physical pain symptoms in Western, educated, industrialized, rich, and democratic (WEIRD) societies, particularly in European countries and the United

States, but only a few studies on physical pain in students were conducted in Asia, specifically Southeast Asia, despite its high prevalence.

In this framework, the **first aim** of this thesis was to explore the frequency of physical pain symptoms in a sub-clinical population of university students in Switzerland, in order to yield new insights to suggest that changes in the reward-pain interaction can be identified in the sub-clinical population and therefore providing the information about the effect of pain on the reward processes, avoiding the limitations induced by medication and treatments. The **second aim** of this thesis was to investigate the frequency of physical pain symptoms in a sample of university students in India, replicating the study conducted in Switzerland in a non-WEIRD cultural context. The **third aim** of this thesis was to understand the relationship between mental health markers and protective factors associated with physical pain symptoms in both samples of university students and to understand the possible differences across non-WEIRD and WEIRD samples. To sum up, we aimed at investigating the interactions between specific mental health markers (i.e., depression, anxiety, PTSD symptoms, perceived stress) as well as specific protective factors (i.e., social support and self-efficacy) with physical pain among university students in two different cultures.

The thesis is structured into nine chapters including the present introduction (**Chapter 1**). **Chapter 2** provides an overview of the current literature. **Chapter 3** introduces the aims and hypotheses of the three empirical works included in the present thesis, while **Chapter 4** highlights the general methods applied to answer the questions raised in the thesis. The next three chapters (**Chapters 5, 6, and 7**) are devoted to the three empirical works and their results, with **Chapter 8** providing a summary of the main findings demonstrated in the three empirical works with a general discussion of their implications and limitations. The last **Chapter 9** provides a general conclusion of the present dissertation.

2.1 Physical Pain in University Students

2.1.1 Definition and Prevalence

Physical pain is a common distressing problem that significantly impacts individuals and society (Fayaz et al., 2016). The Global Burden of Disease had declared physical pain as the second-highest contributor to Global Disability in the 2018 (James et al., 2018). Globally, the burden caused by physical pain is increasing, 1.9 billion people were found to be affected by recurrent physical pain symptoms like headaches, low back pain, and neck pain, and these symptoms are found to be the leading causes of disability (Vos et al., 2017). This, in turn, increases the socioeconomic burden both at individual and societal levels, including direct healthcare costs, work absenteeism, and psychological distress (i.e., PTSD, depression, anxiety, and stress) (Blyth et al., 2019). Around 54% of university students are affected by physical pain each year worldwide (Ando et al., 2013). A study conducted in 42 countries identified that 20.6% of young people (18-25 years) experienced pain in at least two sites of headache, stomach, and backache (Gobina et al., 2019). One study concluded that this might be due to the sedentary lifestyle, which involves prolonged sitting during classroom sessions and working on computers for long hours in most of their daily activities (Anggiat et al., 2018). Another study found that students commonly suffer from sleep deprivation (Lubas & Szklo-Coxe, 2019), and sleep deprivation has been reported to be the cause of musculoskeletal pain as well as increased mental health-related risks (Chun et al., 2018). Among university students, physical pain has been reported to result in poor academic performance and decreased leisure time (Ekpenyong et al., 2013).

According to Merskey (1986), physical pain is defined as the "unpleasant sensory and emotional experience associated with actual or potential tissue damage" (p. 226). Braunwald et al. (2005) defined physical pain as, "an unpleasant feeling that is localized to a part of the body" (p. 7-8). In western countries, headaches (8-83%) and abdominal pain (4-53%) are the most common pain complaints in young people, followed by musculoskeletal pain (4-40%) and back pain (12-24%) (Kirtley et al., 2016). For instance, in Switzerland, physical pain is the most disabling disease (Crawford et al., 2018), and over 80% of students report lower back pain and neck pain yearly according to the Swiss Health Survey data

(Angst et al., 2017; Crawford et al., 2018). The prevalence of physical symptoms of pain is also common among university students across different countries. For instance, in the United States of America (USA) majority of the students showed a high prevalence of musculoskeletal discomfort during/after computer use (Hamilton et al., 2005). In the UK prevalence of self-reported physical pain among students within the past six months, was 66.9% (Mallen et al., 2005), and in 2013, the 12-month prevalence of self-reported physical pain in the Netherlands was about 31.4% (neck pain), 30.3% (shoulder pain), and 17.5% (wrist/hand pain) among university students (Bruls et al., 2013). However, not many studies so far have been conducted on the non-WEIRD population even though physical pain is quite common among students in India too, affecting 29-81% of them each year (Madaan & Chaudhari, 2012). A cross-sectional study carried out in one of the universities in India ($N = 160$) showed that the prevalence of physical pain, especially lower back pain, was 45.3% among the students (Aggarwal et al., 2013).

Taken together, it is extremely important to study physical pain due to its high prevalence among university students and there is an urgent need to pay more attention to it as physical pain is also associated with various mental health problems in university students. Currently, this need has been further increased due to the advent of COVID-19.

2.1.2 Measures of Pain

Pain is divided into different categories based on its location, duration, intensity, and quality. The location of pain allows the determination of the possible cause. Common location sites of physical pain experienced by the students are headaches (8-83%) and abdominal pain (4-53%), followed by musculoskeletal pain (4-40%) and back pain (12-24%) (Kirtley et al., 2016). In our **work**, we included six location sites of physical pain ranging from headaches, chest pain, muscle cramps, muscle pain, pain in arms or legs, and backaches. The duration of pain is a measurable characteristic that allows us to classify it into acute and chronic pain. Acute pain usually occurs suddenly and lasts for a limited time (less than 6 months). It is usually caused by some type of damage to tissue – such as bone, muscle, or organs, whereas chronic pain lasts for a longer time (more than 6 months). It is usually linked to a long-term illness, such as osteoarthritis, or in some cases fibromyalgia. Chronic pain can be the result of damaged tissue or nerve damage. In our **work**, the duration of pain was for two weeks or more. Quality refers to the evaluation of the origin of pain. This suggests neural origin which escalates for instance, while coughing, and burning

pain, provoked by any stimulus indicating neuropathy and nerve damage. The intensity of pain experienced by an individual is the most difficult to assess as it depends on the tolerance. For example, many studies have reported that women have the highest tolerance, followed by men, and children (Rao et al., 1987; Vallerand & Polomano, 2000). Also, one of the studies reported that South Asian women have higher endurance to physical pain as compared to American women (Karasz et al., 2007).

Visual-analogue scales (VAS) and Numeric Rating Scales (NRS) are used to evaluate pain in people. These scales are reliable, valid, sensitive to change, and easy to administer for the measurement of the severity of pain and are used to assess pain by an increasing score: from 0 – "*meaning no pain"*, to 10 – "*meaning the strongest pain"* endured in life. We also have self-report measures where an individual can evaluate the intensity of pain on a rating scale ranging from 0 "*never*" to 4 "*very often*" depending on how often these symptoms occurred in the past 2 weeks. A value of 0 stood for "*never*", 1 stood for "*1–2 days*", 2 for "*3–7 days*", 3 for "*8–12 days*", and 4 for "*13–14 days*" (Hardt, 2008b). There is also the Brief Pain Inventory (BPI) (Cleeland & Ryan, 1991) which is another tool to assess pain. The BPI is a 17-items self-rating scale. People are asked to indicate the site(s) of pain by shading a body diagram. It also uses an 11-point NRS to assess the pain intensity in the preceding 24 hours "*most"*" "*least"*, "*average"*, and "*right now*". In addition, it uses an 11-point NRS of interference in seven domains of usual activities/functions (e.g., work, sleep, mood, and relations with other people). Another widely used self-report measure is the McGill Pain Questionnaire (MPQ) (Melzack, 1987). The MPQ consists of 20 subgroups of words describing sensory, affective, evaluative, and miscellaneous components of pain. Each subgroup has a list of words with a given ranking —the word chosen by the people suffering from pain with the highest ranking is used for scoring. The total score—the pain rating index (Vallerand & Polomano)—is a sum of ranked scores. In addition, Present Pain Intensity (PPI) is assessed on a six-point scale (i.e., pain from 0 to 5). We also have Neuropathic Pain Score (NPS) (Galer & Jensen, 1997) used as a screening tool for neuropathic pain. All these scales are usually administered by a clinician.

Though there are several ways to measure pain, in our work, we used the Symptoms Checklist-27-plus (SCL-27-plus) (Hardt, 2008b) as it is a short, multidimensional screening instrument used for assessing not only pain but also a wide range of psychopathological problems (Hardt & Gerbershagen, 2001). It was easy to administer without a need for a clinician and could be adapted on an online platform

due to the pandemic. In addition to this, we saw in our work that the majority of the instruments used to measure physical pain were developed specifically for the western populations and translated into other languages while ignoring the different cultural contexts (Cheung, 2004).

2.1.3 Cultural differences in experiencing pain

Pain perception varies according to the culture. In some cultures, people cope with pain by turning inward, describing pain as a private and personal experience while in other cultures, people verbally express themselves, sometimes crying and screaming (Callister et al., 2003). In one of the studies, it has been seen that people in Eastern cultures have higher pain tolerance than those in the West (Nayak et al., 2000). In Western countries, for instance, in the United States, it is postulated that the willingness to verbalize pain may "be due to the belief that pain is bad, need not be endured, and should be quickly eliminated" (Nayak et al., 2000, p. 146). While in Asian cultures, due to socio-economic pressure, such as lack of access to healthcare facilities and cultural factors like stigma, it is considered better to avoid expressing problems related to pain (Ashing-Giwa et al., 2004). One of the studies conducted in rural Nepal found that back pain was quite a common problem faced by people, yet people did not seek medical help (Anderson, 1984). One possible explanation might be that in many Asian countries people reported a low perceived need to seek medical care, often because they expected their illness or symptoms to improve over time as well as due to the high cost and no health insurance (Taber et al., 2015). One of the cross-cultural studies conducted on university students in Brazil ($N = 153$) and Australia ($N = 618$) using a self-reported chronic pain questionnaire showed that the Brazilian physiotherapy students agreed more strongly with the notion that low back pain justifies disability and activity limitation than Australian physiotherapy students (Rainville et al., 1996). A systematic review conducted between developing and developed nations reported that individuals with chronic low back pain from Tunisia, Morocco, and Ivory Coast endorsed more praying and hoping, seeking social support, and diverting attention as pain-coping responses than individuals from France who seek immediate medical help (Sharma et al., 2020).

Taken together, it shows that perception of pain and coping with pain varies across different cultures. Culture plays an important role in considering the responses to pain in different countries.

2.1.4 Association between Physical Pain and Mental Health

Due to physical pain, several students experience serious negative consequences, for instance, low quality of life, disability, and psychological distress. It is argued that the impact of physical pain includes: loss of physical function; deterioration of general health and loss of social functioning manifested as decreased participation in social and leisure activities, family stress, or loss of group and community relatedness (often associated with decreased income and/or job loss), and disruption of psychological functioning (Patrick & Erickson, 1993). Many of the previous studies reported that physical pain in young adults (18-25 years) can often lead to physical disability, lower quality of life, lower academic performance, and reduced general work productivity (MacDonald et al., 1997). For instance, one of the studies conducted on medical students in the USA (N = 201) reported that 51% of the students showed severe neck and back pain, which led to poorer physical health-related quality of life, such as difficulty in sleeping, standing, sitting, reading, concentrating in the class, enjoying with friends, and traveling (Nolet et al., 2015). Meanwhile, a study by Mesas et al. (2014) showed higher work absenteeism and worse academic performance in the young population due to pain. In addition, another study showed that physical pain also adds to heavy social pressure related to future employment, family, and studies, and students have difficulty addressing interpersonal relationship problems, which becomes challenging for college students (Maher et al., 2017). In a cross-sectional study conducted on students in China (N = 2662), 40.48% of the students reported a high prevalence of chronic pain. Cigarette and alcohol addiction was quite common among them, which often led to increasing rates of insomnia, poor campus life experiences, and poor personal habits. Due to these challenges, university students often encounter mental health issues for example, PTSD, anxiety, depression, and high level of stress (Sokratous et al., 2013).

Undergraduate students in Canada suffering from lower back pain (N = 1013) experienced high rates of depression (Robertson et al., 2017). Similarly, another study conducted by Unalan et al. (2009) on Turkish students (N = 250) found a strong association between the deterioration of mental health due to physical pain. This might, in turn, lead to long-standing negative consequences, for instance, lowered academic achievements, dropouts, and problems in the future (Harrer et al., 2019). Studies of people with chronic pain conditions identified mental health markers such as PTSD, depression, anxiety, and stress as additional risk factors, whereas protective factors like self-efficacy and social support diminish the pain

experienced (Kratzer et al., 2022, Paras et al., 2009, Gómez Penedo et al., 2020). For instance, previous studies have been conducted to understand the relationship between several risk factors and physical pain symptoms. PTSD has been identified as a major risk factor for the development of chronic pain disorders (Paras et al., 2009). A study conducted on adults (24-30 years) (N = 655) showed positive associations between exposure to trauma and somatic symptoms (Kratzer et al., 2022). Another study showed a strong association between depressive and anxiety symptoms in college students diagnosed with chronic pain (Gómez Penedo et al., 2020). Also, students suffering from chronic pain symptoms, i.e., with severe migraine, reported that higher perceived stress was associated with higher pain severity (Vives-Mestres et al., 2021). Depression is ranked as one of the strongest predictors of back pain among university students (Apkarian et al., 2013). According to Marbach and Lund (Marbach et al., 1983) and Garland, Trøstheim (Garland et al., 2020), a high rate of comorbidity between pain and depression has been seen in previous studies conducted on university students (Blackburn-Munro & Blackburn-Munro, 2001; Rizvi et al., 2021). This highlights the fact that pain is associated with psychopathological symptoms among university students, and it is extremely important to further explore this relationship using network analysis to examine the interaction between psychopathological symptoms and physical pain.

In addition, due to the presence of persistent pain, the motivation to work for the reward is reduced (Gandhi et al., 2013) which seems to be an important part of our everyday human behavior. When this reward processing is affected due to pain, it might lead to maladaptive and risky decisions with potentially long-term consequences (e.g., drug use or alcohol addiction) and this is most common in young adults (Fareri et al., 2008). Research has also shown that decreased interest and pleasure in response to positive stimuli (i.e., anhedonia) is a core diagnostic feature of depression and is commonly found in chronic pain patients (Garland et al., 2020; Marbach & Lund, 1981) with greater pain severity being associated with higher prevalence of anhedonia and a general lack of motivation (Carpinelli et al., 2019; Fishbain et al., 2004). People suffering from chronic pain, such as fibromyalgia and complex regional pain syndromes have deficits in improving their performance on reward-related learning tasks (Apkarian et al., 2004; Becker et al., 2011). Learning through reward is important for students as it helps them to keep expectations in line with one's environment. If this reward process is disrupted in students because of pain, they might get predisposed to a greater probability of either developing a disorder, or this could

serve as a mutual maintenance factor for psychopathological symptoms in the future (Rizvi et al., 2021). Taken together, it underlines the importance of understanding the effect of pain on the lives of university students.

2.2 Pain and Reward

2.2.1 Definition

Besides the relationship between psychopathological problems and physical pain, research has shown the interaction between pain and reward processing (Susanne Becker et al., 2012; Gandhi et al., 2013). On the one hand, it has been shown that rewarding stimuli such as food, pleasurable music, and odors decrease pain sensitivity (Leknes & Tracey, 2008), whereas, on the other hand, evidence suggests that pain impairs reward processing. For instance, chronic pain is associated with anhedonia, i.e. the inability to feel pleasure (Marbach & Lund, 1981; Marbach et al., 1983). Also, Field's (2006) motivation-decision model conceptualizes the interaction between reward and pain. In this model, when both pain and reward are presented simultaneously, the brain is presented with a need to decide between pain or reward depending upon the individual's (homoeostatic) state and the magnitude of the potential threats and rewards.

Rewards have been described as any event or object that can produce a positive or pleasurable experience (White, 2011; Gupta, 2019). Rewards effectively motivate people (Murayama, 2019) and involved them in learning processes (Hidi, 2016; Gupta et al., 2019). Obtaining reward is in turn associated with pleasant feelings, which give incentive value to the goal-object (Martin-Soelch et al., 2001). The process of reward has been involved in the survival of the species (Schultz, 2000). Studies have shown the existence of neural circuitry involved in the processing of reward (Schultz, 2000). Reward-related neurons are spread through different brain structures, including the striatum (caudate nucleus, putamen, and the nucleus accumbens; NAcc), amygdala, ventromedial prefrontal cortex (vmPFC), orbitofrontal cortex (OFC), anterior cingulate cortex (Carpinelli et al.), hippocampus, hypothalamus, and midbrain dopamine (DA) neurons (McGinty et al., 2013; Simmonds et al., 2008).

Rewards can be categorized into different types: primary and non-primary rewards. Primary rewards (e.g., homeostatic, and reproductive) are those that evolved to guarantee the survival of the species (Schultz, 2015). Food, for instance, is considered as a primary reward, since its consumption is

essential for the survival of the species, as is mating and reproduction. All other rewards are considered as non-primary (e.g., monetary, social), and they serve to strengthen primary rewards in the long term, thus, also increasing evolutionary fitness. According to Berridge (2009), reward involves three major components: (1) involves liking, which is directly related to pleasure, consciously. (2) involves wanting, and that is related to the motivation for obtaining something. Finally, the last component of reward includes (3) learning, which involves "associations, representations, and predictions about future rewards based on past experiences" (p. 458).

2.2.2 Reward and its importance in students' life

For students, the mechanism of reward plays an important role in motivating them. Reward makes students become more enthusiastic and motivated in learning, which increases their learning outcomes (Ngalim, 2007). When the work of the students is rewarded, they feel encouraged, which in turn helps them gain confidence in themselves (Kouzes & Posner, 1999). Rewards also encourage them to put more effort into their work (Aggarwal, 2010). One of the earliest rewards studies conducted by Deci (1971) examined the influence of external reinforcement, specifically monetary rewards on the intrinsic motivation of university students. They found that external rewards, such as money, encourage students to perform better to a certain extent. After conducting a meta-analysis summarizing 145 reinforcement and reward studies, Cameron et al. (2001) found that monetary rewards increased intrinsic motivation by increasing task interest.

In young adults (18-25 years), inverted U-shaped developmental patterns (i.e., heightened vulnerability to rewards) have been observed in the reward-seeking behavior (Steinberg et al., 2018). For example, young people show peaks in self-reported reward-seeking and sensation-seeking (Romer et al., 2010; Steinberg et al., 2009), such as greater sensitivity to positive feedback during a behavioral gambling task (Cauffman et al., 2010) and heightened preferences and reactivity to sweet substances at a young age (18-24 years) (Post & Kemper, 1993). One of the studies conducted on young drivers (18-25 years) (N = 120) using the Brief Sensation Seeking Scale and Sensitivity to Reward Questionnaire, showed that young people have increased sensation-seeking behavior and reward sensitivity, which has contributed to their participation in risky behavior. For instance, driving at night and exceeding the speed limits increase their risk of injury or death from a road crash (Scott-Parker et al., 2013). Young adults' risk-taking is

hypothesized to be stimulated by a rapid and dramatic increase in dopaminergic activity around the time of puberty, which is presumed to lead to increases in reward-seeking behaviors (Steinberg, 2010). Dopamine has been regarded as an essential neurotransmitter for reward processing and evidence suggests that it is involved in the motivation to obtain reward i.e., wanting, or incentive salience (Barbano & Cador, 2007; Berridge, 2007). If there is an imbalance in dopamine receptors, a "reward deficiency syndrome," is created, producing behavior among young adolescents that leads to an increase in risk-taking/novelty-seeking behaviors and engaging in deviant behaviors, such as alcohol and drug addiction (Steinberg, 2017).

Previous studies have demonstrated a disruption of dopamine homeostasis in the central nervous system due to pain in people suffering from chronic pain (Abdallah et al., 2015; Yang et al., 2020), therefore impairing an individual's ability to respond to rewards. However, when reward processing is altered, this makes an individual vulnerable to various mental health problems (Olino, 2018). Specifically, elevated sensitivity to reward has been shown to buffer against the development of depression in young people (Dennison et al., 2016). One of the studies conducted on adolescents (8-16 years) ($N = 132$) showed that reward processing reflecting motivation to obtain a reward and behavioral sensitivity to reward acted as potential moderators. This suggests that high behavioral sensitivity reward buffers against problems such as anger, excessive verbal aggression, and physical aggression after exposure to trauma (Kasparek et al., 2020). Many studies have shown that psychopathological problems for example, childhood trauma, depression, and social problems have emerged due to an altered reward processing (Kasparek et al., 2020; Olino, 2018). This shows the importance of rewards in motivating the students as well as acting as a protective factor, thus reducing the likelihood of psychopathology.

2.2.3 Measures of Monetary Reward

Monetary rewards are a very powerful motivator as it helps in making an individual meet a variety of basic needs (e.g., food, shelter) and also higher-level needs (e.g., belonging to a group, receiving respect from others, achieving mastery in one's work) (Long & Shields, 2010). Moreover, the effect that monetary rewards have on motivation often translates into other positive outcomes (Jewell & Jewell, 1987). For instance, Locke et al. (1980) found that an employee's productivity increased by an average of 30% after

providing them with monetary incentives. Moreover, Stajkovic and Luthans (2001) conducted a study including more than 7,000 employees and their productivity was higher in a monetary incentive intervention program compared to those who received social recognition or performance feedback instead. In addition, the benefits of monetary rewards seem to be global and have been seen not only in the United States but also in many other countries around the world including China (Du & Choi, 2010), Australia (Cadsby et al., 2007), and England (Campbell et al., 2009).

Sensitivity and responses to monetary rewards have been evaluated by using several different methods and instruments, including behavioral and self-report data. Self-report measures to reward have been assessed by the Behavioral Activation System scale (BAS) (Carver & White, 1994). BAS measures rewarding experiences and responses toward goal pursuing. Another scale is the Sensitivity to Punishment and Sensitivity to Reward Questionnaire (SPSRQ) developed by Torrubia et al. (1995), a 48-item self-report scale measuring sensitivity to reward and sensitivity to punishment. Another self-report scale is the Brief Sensation Seeking Scale (BSSS) (Hoyle et al., 2002) was used to assess sensation seeking. This scale consists of 8-items that measure four aspects of sensation seeking: experience seeking, boredom susceptibility, thrill and adventure seeking, and disinhibition. We also have Money Choice Questionnaire (MCQ) in which there are 27 hypothetical choices between smaller, immediate monetary rewards, and larger, delayed monetary rewards (e.g., what would you prefer $30 today, or $35 in 50 days). Though the main problem with these questionnaires is that they were developed mainly for the WEIRD population. Therefore, these scales prove to be quite subjective in nature. Experimental tasks are usually a better choice to measure responses to reward over self-report measures. For this, in our work, we used an experimental task to measure mood responses to monetary reward.

Many experiments are also designed for investigating monetary reward processing. For instance, one of the widely used tasks is the monetary incentive delay task (Sokratous et al.) (Sokratous et al.). It was developed based on instrumental conditioning paradigms (Knutson et al., 2000; Schultz et al., 1997). This task consists of a sequence of three visual stimulus events, (1) *anticipation,* a learned visual cue representing valence (e.g. financial gain-circle, loss-square, neutral-triangle), which elicits motivational salience, (2) *the target*, another learned visual cue (e.g. rectangle), to initiate the behavior, usually pressing a button on time (a time-dependent motor task), and (3) *feedback* in the form of text or image indicating

consummation (financial gain, loss, neutral) and dependent on performance. Like the MID task, our experimental task comprises an anticipation phase (i.e., cue predicting a reward or no reward), a cognitive phase (i.e., working memory performance), an expectation phase, and a delivery phase (i.e., notification of the monetary reward). In contrast to some versions of the MID task, our reward task did not include any loss condition. Another task is the probabilistic selection task developed by Frank et al. (2004). In this task, participants were verbally instructed on how to perform the task and were told that the task aimed to maximize total gains. Participants sat in front of a computer screen and chose one of two paired stimuli by pressing either the left or right button on a mouse. During the training phase, the stimulus events the 3 different stimulus pairs (AB, CD, EF) that were presented in a random order, such that each stimulus was randomly presented on the right or left side. Feedback was provided after each choice, in the form of a reward (+10 $) or punishment (−10 $). This feedback was probabilistic. For instance, Choosing A led to a reward on 80% of the AB pairs, and led to punishments (−10 $) on 20% of the AB pairs, and so on. Learning achievements were calculated at the end. Another similar task is the Wheel of Fortune task (WOF) (Dichter et al., 2009; Ernst et al., 2004), which also involves probabilistic monetary win or loss. In each trial, two competing options are presented to the participants. Each option is associated with different magnitudes and likelihood of winning this amount of money. When the computer chooses the same choice as the one the participant made during the cognitive/motor phase, the participant wins the amount indicated in the cue presentation phase. For our work, we used the Fribourg Reward Task comprising of an anticipation phase (i.e., cue predicting a reward or no reward), a cognitive phase (i.e., working memory performance), an expectation phase, and a delivery phase (i.e., notification of the monetary reward).

Taken together, various experimental tasks can be used to assess the behavioral and self-report responses to monetary rewards in place of questionnaires to be more objective in nature. In the present work, we are more specifically interested in the behavioral processes involved during reward processing in relationship with physical pain.

2.2.4. Pain and Reward Interaction

Prolonged and severe physical pain affects an individual's mood responses (Noel et al., 2016). It is seen that chronic pain is highly comorbid with mood disorders (Salazar et al., 2013). People suffering from physical pain are at high risk of having persistently low moods (Bair et al., 2003; Dersh et al., 2002). Furthermore, winning rewards such as money is associated with an increase in mood as evidenced in several studies using behavioral reward tasks in healthy control samples (Piccolo et al., 2019; Kalebasi et al., 2015; Martin-Soelch et al., 2009) an impaired mood responsivity to reward has been shown in individuals with chronic pain (Rizvi et al., 2021). For instance, a study conducted on individuals with chronic pain ($N = 28$) and healthy controls ($N = 18$) using the MID task reported reduced neural responses to reward in the chronic pain group compared to healthy controls in regions associated with the cerebral reward system (Kim et al., 2020). Alterations to monetary reward due to pain have been shown in many studies (Tandon, Ledermann, et al., 2022a; Tandon, Piccolo, et al., 2022). For example, individuals with chronic pain reported a decreased response to environmental incentives and reduced reward responsiveness to monetary rewards via self-report questionnaires (Liu et al., 2019). An experimental study using the Behavior Inhibition Scale/Behavior Activation Scale to assess the reward drive and responsiveness showed that reward responsiveness is reduced in individuals with chronic pain (Turner et al., 2021). Another study used MID task and functional magnetic resonance imaging on 17 female individuals with fibromyalgia to understand the neural processing of reward in chronic pain; this study showed that the individuals with chronic pain reported lower arousal ratings and showed reduced medial prefrontal cortex activity during monetary reward anticipation, which is related to lower estimated reward, in comparison to healthy controls (Martucci et al., 2018).

Several studies support the presence of dysfunctional reward pathways in co-occurring pain and mood alterations (Berger et al., 2014; Treadway and Zald, 2011), suggesting reward processing could be a mechanism underlying the relationship between pain and mood disorders (Garland, 2020; Ledermann and Martin-Sölch 2018; Leknes and Tracey, 2008) and increase in mood have been correlated to neural changes in regions associated with the processing of reward (Martin-Soelch et al., 2003).

Taken together, it is shown that pain impairs the reward processes. However, it is interesting to see whether reduced responses to rewards in people suffering from chronic pain can also be observed in university students as most previous studies have been conducted in clinical samples.

2.2.5 Consequences of disruption of reward responses

Reward alternations are the most common indicators of psychopathology in humans. In psychopathology research, reduced reward processing or a lack of responsiveness to reward has been held as a core source of behavioral dysfunction for multiple disorders, particularly depression and schizophrenia and substance use in humans (Blum et al., 1996; Meehl, 1975). People with different psychopathological problems show alterations in reward processing at both behavioral and neural levels. For instance, adults with depression exhibited blunted behavioral sensitivity to the rewards (Pizzagalli et al., 2008) and blunted neural response to rewards in the striatal regions (Luking et al., 2016). Moreover, reduced behavioral approach and reduced neural response to reward in striatal regions have been observed in young adults at risk for depression (Fischer et al., 2019; Gotlib et al., 2010) or predicted later emergence of psychopathological problems in the people (Nelson et al., 2016). For instance, people with depression have been found to demonstrate a reduced willingness to obtain monetary rewards suggesting deficits in motivation (Treadway et al., 2012; Yang et al., 2014). People suffering from chronic pain (N = 488), showed higher levels of anhedonia (i.e., inability to feel pleasure) as compared to the healthy controls (Garland et al., 2020). This shows that reward processing is essential for daily survival and these processes are altered due to chronic pain. However, the relationship between pain and reward processing in a student population has not yet been explored. It will be interesting to further explore these interactions in a population with sub-clinical pain i.e., in university students. This would allow disentangling the influence of medication on the behavioral effect of reward on mood and performance.

2.2.6 Cultural differences in reward processing

Cultural differences play an important role in reward processing. Reward preference is inherently tied to a reward's ability to satisfy an employee's needs and cultural-bound values. Hofstede (1980) provided useful insights into how rewards are likely to vary across different cultures. He reported that in male-dominated cultures for instance in many Asian cultures, the achievement is considered at the top of their respective reward priorities. Unlike the financial emphasis found in masculine countries, female-dominated cultures, for instance in countries like Sweden, Norway, the Netherlands, and Costa Rica have strong social needs, such as for the quality of life, and relationships are more important. Building on this logic, on the one hand, researchers found that collectivists tend to value non-financial rewards (e.g.,

recognition and praise) more, and individualistic cultures, have been shown to elicit a strong desire for financial rewards (Vance et al., 1992). On the other hand, one of the studies conducted in Pakistan argued that individuals in collectivistic societies value monetary rewards and financial success as a means to greater employment security and status (Chiang & Birtch, 2012). In such cultures, financial incentives are likely to be highly attractive (Johnson & Droege, 2004), because affluence and admiration are highly valued, and economic gains are instrumental in achieving them (Hofstede, 1980). This is also consistent with another study that showed that individuals with collectivist values demonstrate a greater preference for monetary benefits as compared to countries with collectivist values (Kickul et al., 2004).

Taken together, these studies indicate that there are cultural differences observed in the preferences of reward. In our study, we used an experimental task that included both monetary and social rewards to understand the possible differences seen among the students between the two countries (India and Switzerland). However, in the current framework of this thesis, we do not include social rewards.

2.3 Protective Factors and Pain

2.3.1 Definition and role

According to Rennie and Dolan (2010), protective factors are those that act as a buffer against the development of psychopathological problems. This might include supportive family relationships, religious or spiritual practices, or communities that support resilience, help people more effectively manage stressful events, and strengthen other characteristics that minimize the risk of mental health (Layous et al., 2014). Even elevated sensitivity to reward has been shown to act as a protective factor against the development of depression in young people (Dennison et al., 2016). One of the studies conducted on adolescents (8-16 years) (N = 132) showed that reward processing reflecting motivation to obtain reward and behavioral sensitivity to reward acted as potential moderators suggesting that high behavioral sensitivity reward buffer against problems such as anger, excessive verbal aggression, and physical aggression after exposure to trauma (Kasparek et al., 2020). However, less is known about protective factors possibly leading to favorable courses of physical pain (Ramírez-Maestre & Esteve, 2013). This is especially important since the mere absence of risk factors does not predict successful adaptation to pain. Additionally, interventions targeted toward specific risk factors are effective only to a certain extent (Kent & Kjaer, 2012). Together, protective factors can lead to resilience – a person's ability to "bounce back" or overcome adversity. Therefore, focusing on protective factors might help in the management of physical pain and promote successful adaptation (Jegan et al., 2017). In people suffering from chronic pain, self-efficacy, and social support acted as protective factors and helped in the reduction of pain intensity (Brister & Baron, 2006; Fernández-Peña, 2018). Self-efficacy is a person's belief in his or her capability to successfully perform a particular task (Heslin & Klehe, 2006), it is a much stronger predictor of how effectively people will perform a given task (Heslin & Klehe, 2006) and social support can be defined as the perception oneself where one feels loved and cared for by others, esteemed and valued, and part of a social network of mutual assistance and obligations (Taylor, 2011). Social support can come from a partner, relatives, friends, coworkers, social and community ties, and even a pet (Allen et al., 2002). A study conducted on women (N = 82) living in Italy and experiencing chronic pain

showed that self-efficacy and social support from family and friends were seen to be effective in coping with pain (Re et al., 2017). A large number of studies suggest that social support is a fundamental buffer against physical pain (Brown et al., 2003; Leary, 2001; Phillips & Gatchel, 2000). People who are lacking social support are prone to physical ailments (Bockian et al., 2000). Research has shown that social support is associated with various types of pain (MacDonald & Leary, 2005). For instance, higher levels of social support are associated with lower levels of chronic pain (Phillips & Gatchel, 2000), labor pain (Klaus et al., 1986), cardiac pain (Chalmers et al., 1995), and postoperative pain (Lidderdale & Walsh, 1998). Experimental findings also demonstrated the link between social support and physical pain (López-Martínez et al., 2008). One of the studies in which undergraduates (N = 101) participated, showed the positive effect of social support in reducing acute pain caused by the cold pressor task (placing a participant's hand in cold water) (Brown et al., 2003). In this study, participants were randomly assigned to perform the cold pressor task either alone or accompanied by a friend. Then they rated the perceived physical pain on a 10-point rating scale. It was seen that participants in the social support condition reported less pain than participants in the alone condition (Brown et al., 2003).

Many studies have shown the association between self-efficacy and health status (Bandura, 1986, 1991; Strecher, DeVellis, Becker, & Rosenstock, 1986). In addition, Kaplan, Ries, Prewitt, and Eakin (1994) reported that self-efficacy was a significant predictor for survival among participants with chronic pain. Seventy-nine patients with knee pain completed the tasks in a controlled laboratory setting. Before completing each task, patients' self-efficacy was assessed. Results demonstrated that self-efficacy contributed significantly to the performance and increased the speed and movement in people with physical pain. Another study examined the effects of self-efficacy on the pain-related behaviors exhibited by patients (N = 72) with rheumatoid arthritis (RA) using a standardized videotaping procedure for rating specific pain behaviors such as limps, facial grimaces, and guarded movements. Results showed that higher self-efficacy was found to be related to fewer pain behaviors (Buescher et al., 1991). A systematic review (N = 5158 citations) showed that self-efficacy acts as a protective factor in people suffering from musculoskeletal pain. This study systematically reviewed and critically appraised the role of self-efficacy on the prognosis of chronic musculoskeletal pain. Study selection was based on longitudinal studies testing the prognostic value of self-efficacy in chronic musculoskeletal pain. The results suggested that

higher self-efficacy levels are associated with greater physical functioning, physical activity participation, health status, work status, satisfaction with the performance, efficacy beliefs, and lower levels of pain intensity, disability, disease activity, depressive symptoms, presence of tender points, fatigue, and presenteeism (Martinez-Calderon et al., 2018).

2.3.2 Cultural differences in Protective factors

The protective factors associated with physical pain among students might differ across WEIRD and non-WEIRD samples. Prior studies conducted in western societies identified specific factors, i.e., protective factors like social support and self-efficacy have been associated with physical pain. For instance, one may seek help from their immediate environment to achieve personal goals (Fiske et al., 1998), whereas in collectivistic cultures, a person is fundamentally connected to others, and the emphasis is placed on group harmony and any efforts made to bring personal problems to the attention of the others may harm the group harmony (Kim & Markus, 1999). This might lead people from non-Western societies not to seek help from their immediate environment. One of the studies conducted on Korean students (N = 56) and American students (N = 56) showed similar results, American students were more likely to mention using social support as a coping strategy than Korean students (Taylor et al., 2004). According to Klassen (2004), findings self-efficacy plays an important role in Western countries having individualistic values as compared to non-Western countries. For instance, in one of the studies, American managers (N = 288) rated their self-efficacy, measured at the specific task level, significantly higher than did the Chinese managers (N = 288) (Earley, 1999). Another study was conducted on 154 Asian students and 372 non-Asian students using a survey and a novel task to show their academic achievement. Results showed that Asian students, out of fear of the consequence of academic failure reported lower levels of self-efficacy beliefs, even though they significantly outperformed their non-Asian counterparts on the task (Eaton & Dembo, 1997).

Taken together, protective factors might have been termed universal in nature, but they might vary across cultures as shown in the above studies and it is important to explore these differences.

2.4 Summary of the theoretical background

In summary, the ability to detect rewards and threats is crucial for survival, well-being, and adjustment to the environment (Sesack & Grace, 2010). Heightened reward sensitivity has been observed in young people around the age of 16-24 years (Romer et al., 2010; Steinberg et al., 2009) which might be due to the increase in dopaminergic activity around the time of puberty, which is presumed to cause an increase in reward-seeking behavior (Steinberg, 2010). For students specifically, the mechanism of reward plays an important role in motivating them and increasing their learning outcomes (Ngalim, 2007). Moreover, rewards encourage them to put more effort into their work and improve their performance (Aggarwal, 2010). If this reward processing is altered, it might make an individual vulnerable to various mental health problems (Olino, 2018). Moreover, elevated sensitivity to reward has been shown to buffer against the development of depression in young people (Dennison et al., 2016). Among students, physical pain seems to be quite high, affecting around 54% of university students each year worldwide (Ando et al., 2013). In Switzerland, around 80% of students report lower back pain and neck pain yearly, according to the Swiss Health Survey data (Angst et al., 2017; Crawford et al., 2018), and in India too, affecting 29-81% of them each year (Madaan & Chaudhari, 2012). Many of the previous studies reported that physical pain in young adults can often lead to physical disability, lower quality of life, lower academic performance, and reduced general work productivity (MacDonald et al., 1997). In addition, students with physical symptoms of pain are at high risk of developing psychopathological symptoms (Maher et al., 2017). Many mental health markers (e.g., PTSD, depression, anxiety, and stress) and protective factors (e.g., self-efficacy and social support) have been identified as associated with pain experienced by people with chronic pain conditions. However, we do not know if this is the same in the case of the sub-clinical population i.e., university students. In addition to this, these mental health markers and protective factors associated with physical pain among students might differ across WEIRD and non-WEIRD countries due to the differences in their cultures. In addition, previous studies indicate that pain impairs reward processing (Becker et al., 2012; Gandhi et al., 2014) and this again may not be a universal phenomenon, but can vary across cultures. Decreased interest and pleasure in response to positive stimuli (i.e., anhedonia) is a core diagnostic feature of depression and is commonly found in people with chronic pain

(Garland et al., 2020; Marbach & Lund, 1981), with greater pain severity being associated with higher prevalence of anhedonia and a general lack of motivation (Carpinelli et al., 2019; Fishbain et al., 2004). To our knowledge, this relationship between pain and responses to monetary reward has always been conducted on the clinical sample, and these studies have focused on populations from high-income countries. Therefore, these findings cannot be generalized to the entire human population or considered universal (Arnett, 2016). Thus, it is important to replicate the studies on a non-western sub-clinical population to make accurate predictions in the future, as there could be possible differences between the two countries (i.e., India and Switzerland).

CHAPTER 3: AIMS AND HYPOTHESES

The literature exploring the relationship between pain and reward interaction in a sub-clinical population made up of university students is scarce. To our knowledge, this relationship between pain and reward has not yet been explored in non-WEIRD cultural contexts. Also, the mechanisms underlying physical symptoms of pain in university students remain unclear, and better knowledge is needed on the one hand about the potential risk factors, in particular PTSD symptoms, depression, anxiety symptoms, and perceived stress, on the other hand about the protective factors such as social support, and self-efficacy related to physical pain. We endeavor to explore these aspects in the sub-clinical population of university students in a Western country, Switzerland, and a non-Western country, India.

This chapter introduces the three empirical works embedded in this thesis and associated with our research questions and hypotheses. These experimental works are presented in Chapters 5, 6, and 7 in the form of three papers, followed by a general discussion summarizing the major findings, their clinical implications, their limits, and finally new perspectives. The objectives of the empirical part of this dissertation are as follows.

General aim: Provide a better understanding of the pain-related impairment in the reward processes in a sub-clinical population, i.e., university students, and explore this interaction in a WEIRD and a non-WEIRD cultural context, i.e., in Switzerland and India.

Aim Empirical Work I: Investigate the frequency of physical pain symptoms in a population of university students in Switzerland and the effect of pain on the mood to monetary reward in participants with clinically significant physical pain symptoms (sub-clinical group) and participants without any clinically significant physical pain symptoms (control group).

Hypotheses Empirical Work I: We hypothesized that participants with sub-clinical pain scores would display a reduction of the effect of monetary reward on mood when compared to the participants without any clinically significant physical pain symptoms. We expected a significant association between mood ratings and monetary winnings in the control group and not in the sub-clinical group. Second, we hypothesized that reward would affect mood and performance (i.e., with reduced reaction times and

increased mood scores in response to reward) and we expected that this effect would be reduced in participants with sub-clinical pain.

Aim Empirical Work II: Investigate the frequency of physical pain symptoms in a sample of university students in India, replicating the study conducted in Switzerland in a non-WEIRD cultural context.

Hypotheses Empirical Work II: First, we hypothesized that participants with sub-clinical pain scores would display a reduction of the effect of monetary reward on mood when compared to the participants without any clinically significant physical pain symptoms. Second, we hypothesized that reward would affect mood and performance (i.e., with reduced reaction times and increased mood scores in response to reward) and we expected that this effect would be reduced in participants with sub-clinical pain.

Aim Empirical Work III: Understanding the relationship between specific mental health markers (i.e., depression, anxiety, PTSD symptoms, perceived stress) as well as specific protective factors (i.e., social support and self-efficacy) and physical pain among university students across two cultures (i.e., Switzerland and India).

Hypotheses Empirical Work III: We hypothesized that there will be differences in the strength of association between the specific factors and physical pain through a network approach. Knowing the possible differences across two cultures will help us develop an intervention that considers the cultural contexts in the future.

CHAPTER 4: METHODS

This chapter describes the recruitment and selection of the participants for the three empirical works presented in this thesis (Section 4.1), ethics (Section 4.2), the procedure implemented (Section 4.3), the experimental task and measurements included (section 4.4), and the data analyses (Section 4.5).

4.1 PARTICIPANTS

4.1.1 Recruitment

In Empirical work I, a total of 100 participants was recruited through flyers from psychology courses at the University of Fribourg, Fribourg, Switzerland of whom 79 were included as 21 participants were excluded because they had a score ≥ 11 on the Hospital Anxiety and Depression scale (Bocéréan and Dupret, 2014). The 79 remaining participants were assigned a posteriori, i.e., the participants were categorized into two groups after the completion of the study: a sub-clinical pain group ($N = 39$) and a control group ($N = 40$). The criterion to be included in the sub-clinical pain group was to have a score above the clinical cut-off of 1.77 on the pain subscale based on the manual, Symptom Checklist-27-plus (SCL-27-plus, Hardt, 2008).

In Empirical work II, a total of 88 students were recruited through flyers and emails from several Universities in India and were divided into two groups: a sub-clinical pain group ($N = 40$) and a control group ($N = 48$) according to their self-reported scores on the pain subscale of SCL-27-plus (Hardt, 2008).

In Empirical III, a total of 188 students were recruited through flyers and emails from several Universities in India and Switzerland. Out of those, 87 students were from India, and 101 students were from Switzerland. An illustration of the recruitment process is presented in Figure 4.1 and participants' characteristics are summarized in Table 4.1.

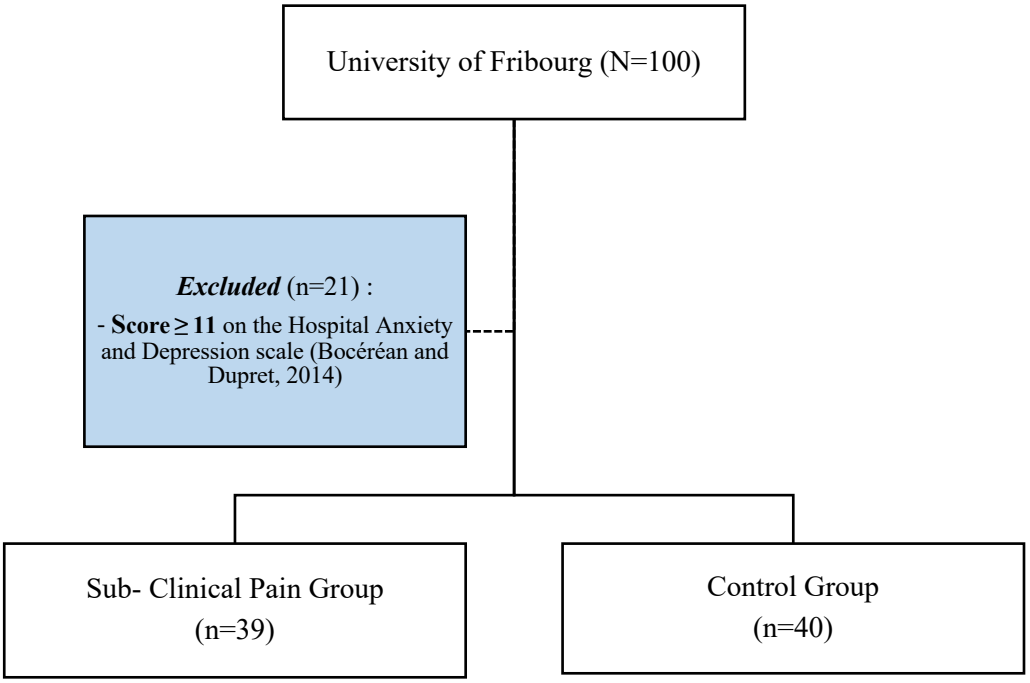


Figure 1a: *Process for recruiting participants and participants' allocation for Empirical work I.*

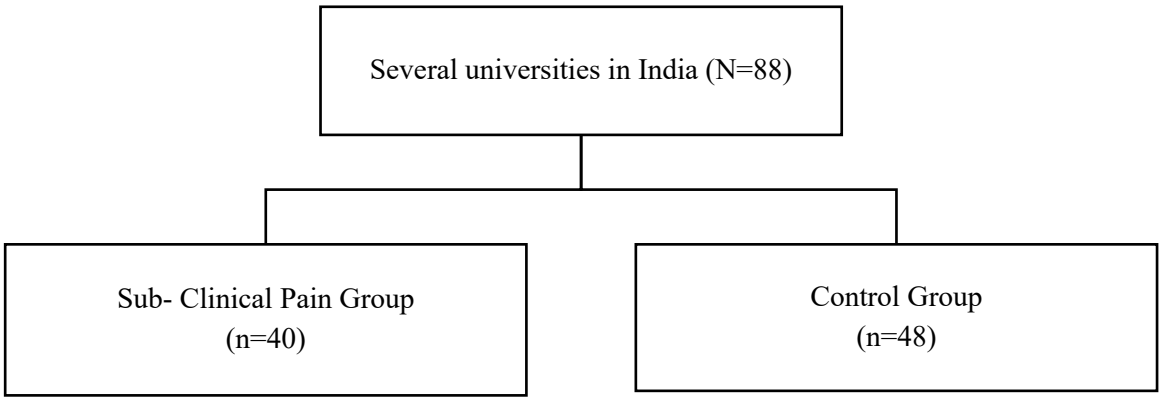


Figure 1b*: Process for recruiting participants and participants' allocation for Empirical work II.*

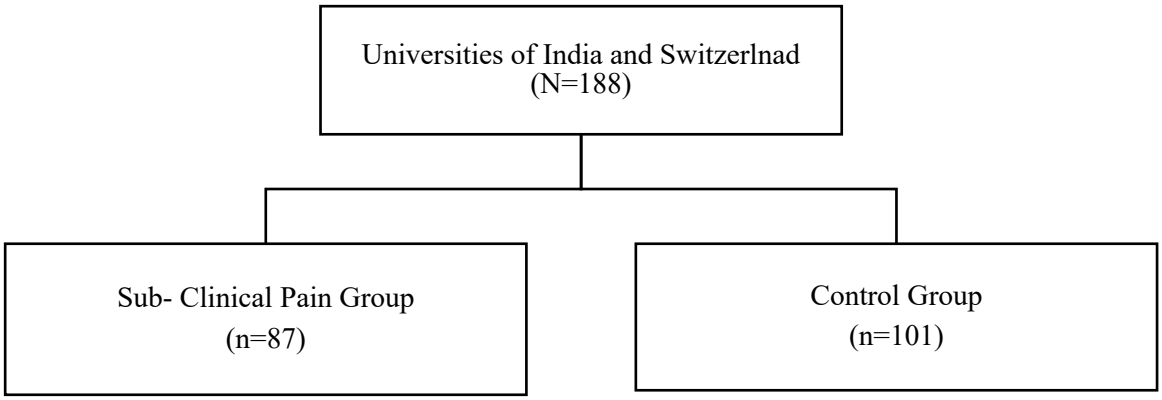


***Figure 1c**: Process for recruiting participants and participants' allocation for Empirical work III.*

4.1.2 Inclusion and exclusion criteria

General inclusion criteria for all three empirical works comprised of students being above 18 years of age and having a good command of French for Swiss students and English for Indian students.

General exclusion criteria for all three empirical works comprised of current or past depression and history of psychiatric disorder as tested with the structured interview based on the Mini-International Neuropsychiatric Interview (M.I.N.I; Sheehan et al., 1998), use of any psychopharmacological medication and having a score ≥11 on the Hospital Anxiety and Depression Scale (Bocéréan and Dupret, 2014).

4.2 ETHICS

The study was approved by the Institutional Review Board at the University of Fribourg in Switzerland (2017/IRB 334A). Participants were thoroughly informed about the study and written informed consent was obtained from all the participants in our study. All research was performed according to the Declaration of Helsinki. The privacy rights of participants were always observed during our study.

Table 1: *Participants' sociodemographic characteristics and clinical scores.*

Empirical Work I										
	Sub-Clinical Group (N=39)				**Control group** (N=40)				**Statistics**	
	N (%)				**N (%)**				**Test Value**	**Significance *(p)***
Gender **Female** **Male** **Other**	37(46.8%) 2(0.025%) -				35(44.3%) 5(0.06%) -				$\chi^2 = 0.44$	0.23
Language **French** **Other**	35 (89.7%) 4(10.3%)				30 (75%) 10 (25%)				$t_{(64)=}2.35$	0.189
	Mean (SD)				**Mean (SD)**					
Age	24.5 (9.17)				23.5(3.88)				$t_{(77)=}0.75$	0.457
Psychometric Measures	**Mean**	**SD**	**Min.**	**Max.**	**Mean**	**SD**	**Min.**	**Max.**		
HADS (Anxiety)	12.33	4.56	0	20	12.25	5.75	0	19	$t_{(73)=}0.368$	0.714
SCL-27-plus Socio-phobic symptoms	1.20	0.72	0	2.60	1.22	0.93	0	3.40	$t_{(68)=}0.363$	0.718
SCL-27-plus - Vegetative symptoms	0.76	0.58	0	2.20	0.70	0.55	0	1.80	$t_{(68)=}0.527$	0.600
SCL-27-plus - Agoraphobic symptoms	0.38	0.48	0	1.75	0.34	0.48	0	1.75	$t_{(68)=}0.247$	0.807
SCL-27-plus - Depressive symptoms	0.47	0.48	0	2.80	0.49	0.59	0	1.80	$t_{(73)=}1.73$	0.863
SCL-27-plus - Pain symptoms	1.87	0.64	1.92	3.59	0.75	0.32	0.59	1.76		
Headaches	2.03	0.96	0	4	1.17	0.66	0	3		
Chest Pains	0.97	1.01	0	4	0.31	0.53	0	2		
Muscle Cramps	1.92	1.15	0	4	0.83	0.75	0	2		
Muscle Pain/Sore Muscles	1.89	0.94	0	4	0.83	0.75	0	2	$t_{(78)}=11.53$	0.00 significant p<0.01
Pain in Arms or legs	1.28	0.86	0	4	0.31	0.53	0	2		
Backaches	2.53	0.91	1	4	1.02	0.86	0	3		
SCL-27-plus - Lifetime assessment for depressive symptoms	1.3	0.33	1	2	2	1.35	1	2	$t_{(73)=}0.958$	0.342
Empirical Work II										
	Sub-Clinical Group (N=40)				**Control group** (N=48)				**Statistics**	
	N (%)				**N (%)**				**Test Value**	**Significance *(p)***
Gender **Female** **Male** **Other**	20 (51.3%) 19(48.7%) -				22(50%) 22(50%) -				$\chi^2 = 0.14$	0.91
Language **French** **Other**	35 (89.7%) 4(10.3%)				30 (75%) 10 (25%)				$t_{(79)=}2.35$	0.189
	Mean (SD)				**Mean (SD)**					
Age	21.32 (2.31)				22.25(2.33)				$t_{(81)=}1.81$	0.07

Psychometric Measures	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.		
HADS (Anxiety)	9.45	4.43	0	17	8.66	4.30	0	17	$t_{(81)=}1.98$	0.052
HADS (Depression)	7.25	3.64	0	15	5.97	3.62	0	17	$t_{(81)=}1.96$	0.053
SCL-27-plus Socio-phobic symptoms	2.49	1.01	0	4	2.00	1.09	0	4	$t_{(81)=}1.56$	0.122
SCL-27-plus - Vegetative symptoms	2.00	0.89	0	3.80	1.99	0.88	0	3.2	$t_{(81)=}1.78$	0.078
SCL-27-plus - Agoraphobic symptoms	1.32	0.91	0	3.25	1.00	0.91	0	2.7	$t_{(81)=}1.51$	0.135
SCL-27-plus - Depressive symptoms	2.09	1.00 1	0	4	1.98	1.01	0	4	$t_{(81)=}1.48$	0.142
SCL-27-plus - Pain symptoms	2.31	0.47	1.33	4	1.00	0.59	0	3		
Headaches	2.87	0.61	2	4	1.70	1.37	0	4		
Chest Pains	1.84	1.40	0	4	0.55	1.20	0	4		
Muscle Cramps	2.56	0.85	0	4	1.11	1.33	0	4		
Muscle Pain/Sore Muscles	2.76	0.77	0	4	1.09	1.37	0	4	$t_{(81)}=11.1$	<0.01
Pain in Arms or legs	1.84	1.11	0	4	0.84	0.99	0	4		
Backaches	1.97	1.03	0	4	0.70	0.85	0	4		
SCL-27-plus - Lifetime assessment for depressive symptoms	1.41	0.39	1	2	1.51	0.35	1	2	$t_{(73)=}-0.85$	0.398

Empirical Work III

	Swiss students (N=101)				**Indian students** (N=87)				**Statistics**	
	N (%)				**N (%)**				**Test Value**	**Significance (*p*)**
Gender										
Female	87(87%)				43(50%)				$t_{(187)}$ = 0.47	0.69
Male	14(13%)				43(50%)					
Other	-				-					
	Mean (SD)				**Mean (SD)**					
Age	21.53 (4.39)				22.77(2.3)				$t_{(187)=}0.49$	0.64
Psychometric Measures	**Mean**	**SD**	**Min.**	**Max.**	**Mean**	**SD**	**Min.**	**Max.**		
HADS (Anxiety)	8.54	3.98	0	17	8.08	4.6	0	17	$t_{(187)=}0.74$	0.46
HADS (Depression)	4.18	2.99	0	11	8.01	3.6	0	17	$t_{(187)=}-7.96$	p<0.001
PCL-5 (Post-Traumatic stress Disorder)	22.62	15.3	0	61	29.57	18.8	0	73	$t_{(187)=}-2.60$	0.010
PSS (Perceived Stress)	27.36	7.63	0	43	17.14	5.64	0	30	$t_{(187)=}10.32$	p<0.001
GSES (General Self-Efficacy)	30.36	5.93	0	40	30.21	5.90	0	40	$t_{(187)=}0.17$	0.87
SCL-27-plus – Physical Pain symptoms)	1.37	0.71	0	3.5	1.55	0.88	0	4	$t_{(187)=}-1.59$	0.113
MSPSS (Social Support)	71.44	11.8	0	84	59.63	15.7	0	84	$t_{(187)=}5.87$	p<0.001

Note. This table demonstrates participants' sociodemographic characteristics and the clinical scores of Empirical Work I, II, and III on different psychometric measures used in the study. *SCL-27-plus*: Symptom Checklist, *HADS:* Hospital Anxiety and

Depression Scale, *Sub-Clinical Group* participants with clinically significant pain symptoms, *Control Group* participants without clinically significant pain symptoms. *PCL-5:* Post-Traumatic Stress Disorder Checklist, *PSS:* Perceived Stress Scale, *MSPSS:* Multidimensional Scale of Perceived Social Support, *GSES*: General Self-Efficacy.

4.3 PROCEDURE

For Empirical work I, participants performed all measurements over a duration of approximately two weeks. At the beginning of the project, we conducted a first interview to inform participants thoroughly about the study procedure, to assess their eligibility to take part in the study and to ensure that they met inclusion criteria. This first interview encompassed the administration of the M.I.N.I. (Sheehan et al., 1998). At the end of this initial interview, eligible subjects who met the inclusion criteria and who agreed to participate signed the informed consent, and a study visit was scheduled. The study visit took place at the lab of the Department of Clinical and Health Psychology, University of Fribourg, Switzerland. During the study visit, participants performed a computer-based reward task called the Fribourg reward task. On the same day, participants received a link by e-mail for the completion of a battery of self-reported questionnaires online using LimeSurvey® (LimeSurvey GmbH, Hamburg, Germany. URL http://www.limesurvey.org) at home. Participants completed 7 questionnaires in total.

For Empirical work II and III, all experiences were conducted online, due to the pandemic of COVID-19. The participants were asked to sign an online version of the informed consent. Participants were then asked to complete a battery of questionnaires online using LimeSurvey® (LimeSurvey GmbH, Hamburg, Germany (URL http://www.limesurvey.org) as well as perform an adapted online version of the Fribourg reward task at their respective home without the experimenter. Participants completed 7 questionnaires in total. Measurements included in the Empirical works I, II, and III presented in this thesis are illustrated in Figure 4.2.

(A) Initial Screening using M.I.N.I. **(B)** Computer-based Fribourg Reward **(C)** Self-report questionnaires

Figure 2. Illustration of the procedure. (A) Before entering the study, an initial interview **(20 mins)** was conducted to assess subjects' eligibility and inclusion criteria. (B) During the study visit, participants performed an experimental task called the Fribourg reward task **(30 mins)**. (C) At home, participants completed computerized self-reported questionnaires **(20 mins)**.

4.4 MEASURES

This section introduces the measures collected for this thesis. The subsections describe the clinical interview (subsection 4.4.1), the seven self-reported questionnaires included in our empirical works (subsection 4.4.2), and the Fribourg reward task (subsection 4.4.3).

4.4.1 Clinical interview

The short structured Mini-International Neuropsychiatric Interview (M.I.N.I; Sheehan et al.,1998) was conducted for assessing psychiatric disorders according to the Diagnostic and Statistical Manual of Mental Disorders, fourth edition (DSM-IV-TR; American Psychiatric Association, 2000), and ensure that the inclusion criteria stipulating the absence of any current or past depression and history of psychiatric disorder were met.

4.4.2 Self-reported questionnaires

4.4.2.1 Socioeconomic status

The Indice de Position Socio-Economique scale (IPSE; (Genoud, 2011) provides a good estimation of the individual's socioeconomic position relative to the population. This scale indicates the age, education achievement (educational level completed), and occupational category of the participant.

4.4.2.2 Pain Measure

The Symptom Checklist (SCL-27-plus; Hardt, 2008) is a multidimensional assessment instrument for assessing mental health status (Kuss et al., 2017). With 27 items rated on a 5-point Likert-type scale, it consists of five dimensions: depressive, vegetative, agoraphobic, social phobia and pain symptoms, and a global severity index. A lifetime assessment of depressive symptoms and a screening question for suicidality are also included. Participants rated the following pain symptoms: headaches, chest pain, muscle cramps, muscle aches, arm/leg pain, and lower back pain for 0 "*never*" to 4 "*very often*" on a pain subscale depending on how often these symptoms occur in the past 2 weeks. A value of 0 stood for "*never*", 1 stood for "*1-2 days*", 2 for "*3-7 days*", 3 for "*8-12 days*", and 4 for "*13-14 days*". A mean score of ≥ 1.77 indicates physical symptoms of pain according to SCL-27 (Hardt, 2008). Previous studies reported significant pain symptoms in university students using the SCL-27 (Conley et al., 2017; Recabarren et al., 2019).

4.4.2.3 Depression and Anxiety Symptoms (HADS)

Hospital Anxiety and Depression Scale [HADS; (Bocéréan & Dupret, 2014a; Zigmond & Snaith, 1983)] is a self-assessment scale that consists of a 14-item scale (7 relating to anxiety symptoms and 7 to depression); each item is coded 0 to 3. The total score can range from 0 to 42. The clinical cut-off score on depression or anxiety scales is equal to or greater than 11 on each symptom.

4.4.2.4 Perceived Stress Scale (PSS)

The Perceived Stress Scale [PSS; (Cohen et al., 1994; Lesage et al., 2012)] is a well-validated instrument used for measuring the perception of stress, assessing the degree to which situations in one's life are appraised as stressful. There are 14 items on a 5-point Likert-like scale from 0 "*never*" to 4 "*very often*", designed to tap into how unpredictable, uncontrollable, and overloaded respondents find their lives. A total score is calculated by adding the 14 items (0 to 56), with higher scores indicating higher levels of perceived stress. A total score higher than 20 indicates high perceived stress and a total score less than 20 indicates low perceived stress on this scale.

4.4.2.5 Posttraumatic Stress Disorder Checklist (PCL-5)

The PTSD Checklist (PCL-5, [Weathers, Litz, et al., 2013]) is a new self-report rating scale for assessing post-traumatic stress disorder (PTSD). The PCL-5 is a 20-item self-report measure designed to assess the *DSM–5* symptoms of PTSD. For each symptom, respondents provide a severity rating ranging from 0 to 4 that indicates the degree of distress associated with each symptom (0 "*not at all"* to 4 "*extremely")*. PTSD symptoms severity is measured by summing scores across the 20 items. A total score ranges from 0-80. The cutoff score between 31-33 is indicative of probable PTSD.

4.4.2.6 General Self-Efficacy Scale (GSES)

The General Self-Efficacy Scale [GSES; (Dumont et al., 2000; Schwarzer & Jerusalem, 1995)] is a 10-item scale that assesses general self-efficacy and self-beliefs to cope with various challenging demands in life. The items are rated on a 4-point-Likert-like scale going from 1 "*not at all true*" to 4 "*exactly true*." The total score is calculated by adding up the score of each item and can range from 10 to 40. The higher the score, the greater the feeling of self-efficacy.

4.4.2.7 Multidimensional Scale of Perceived Social Support (MSPSS)

This MSPSS (Zimet, Dahlem, Zimet, & Farley, 1988) measures perceived social support and is composed of 12 items that cover three dimensions: Family, Friends, and Significant others. The items are rated on a 7-point-Likert scale ranging from 1 = "*very strongly disagree"*; 7 = "*very strongly agree"*. A total score is calculated by summing all items: the higher the score the higher the perceived social support. Scores for each scale can be also calculated.

4.4.3 Fribourg Reward Task

We used two versions of the Fribourg reward task (Martin-Soelch et al., 2009). One version was used before COVID-19 (Empirical Work I) and the second version was used during COVID-19 (Empirical Work II); it was an online adapted behavioral version of the Fribourg reward task. This task is used to measure reaction times, and mood reactions to monetary rewards. Neuroimaging studies using this task have successfully elicited neural activation in regions associated with the cerebral reward system (Gaillard et al., 2019), including the striatum, a putative region for reward processing. In short, the task was originally programmed using E-Prime software (version 1.1.3, Psychology Software Tools Inc., Pittsburg,

Pa., USA) and made available online using OpenSesame (Mathôt et al., 2012), a graphical experiment builder for the social sciences.

For Empirical work I before COVID-19 (**see Fig. 3a**), we used the experimental task which had six block conditions, comprising two levels of difficulty (3 circles: low difficulty or 7 circles: high difficulty) and three reward conditions (no reward, small reward, and high reward) and using a Latin-square design. The six-block conditions were: 3 circles (i.e., low difficulty) with no reward, 3 circles (i.e., low difficulty) with a small reward, 3 circles (i.e., low difficulty) with high reward, 7 circles (i.e., high difficulty) with no reward, 7 circles (i.e., high difficulty) with small reward 7 circles (i.e., high difficulty) with high reward. Each block condition consisted of 12 trials and the order of the blocks was pseudo-randomized. After the presentation of a fixation cross (500 ms), participants saw an array of yellow circles (3 circles, 1500 ms). A fixation cross (3000 ms) was presented before the visual target (1500 ms). The visual target (a green circle) was displayed in any position on the screen and signaled that the participant should decide as quickly as possible whether this circle was in the same position as one of the circles presented previously. After response execution and a variable jittered interstimulus interval (ISI; 0 ms or 2000 ms), the feedback screen (1000 ms) informed the participant of his or her winnings. A blank screen was displayed for no reward trials; "1 CHF" for high-reward trials and "0.10 CHF" for small-reward trials, followed by a feedback screen (1000 ms) indicating the cumulative amount of earned money (reward trials) or a blank screen (no reward trials). Correct responses were associated with monetary gains ("1 CHF" for high-reward trials and "0.10 CHF" for small-reward trials) in the reward condition. Correct responses were not associated with monetary gains (0 CHF) in the no-reward condition. Also, we asked the participants to rate their momentary mood using a visual analogue scale from 0 (bad mood)- 100 (good mood). With smileys at the anchor points (0= 

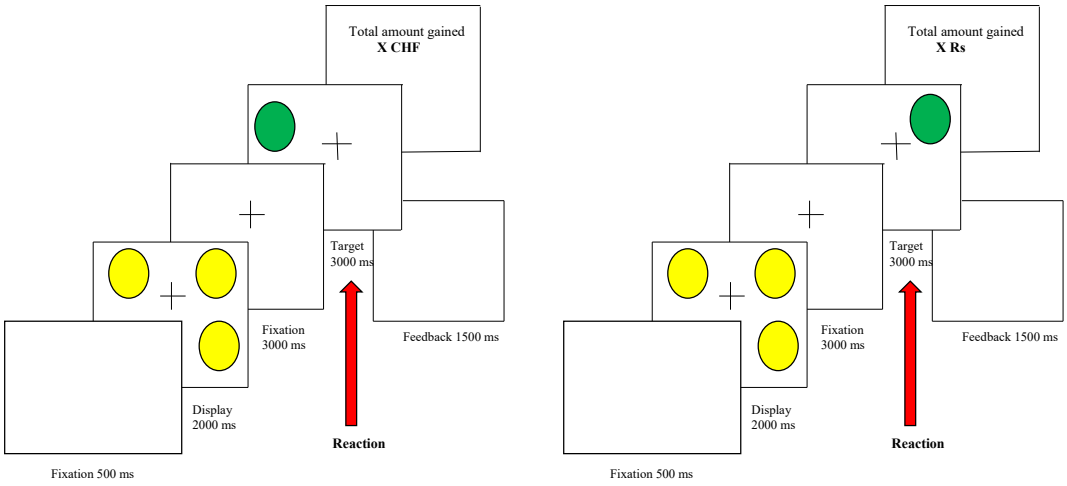
); (100= 

). Only the schematic faces were seen by the participants. The participants rated their momentary mood on a scale of 0–100 at baseline, at the beginning of the experimental session, and before and after each block for a maximal duration of 20 seconds.

For Empirical work II, an online version of the task (**see Fig 3b**) was presented in three block conditions, comprising reward conditions (monetary reward, social reward, and no reward). Here,

we focused only on the monetary versus no-reward conditions to investigate whether physical symptoms of pain affect the responses to monetary reward to replicate Empirical Work I. Each block condition consisted of 12 trials and the order of the blocks was pseudo-randomized. In the three-reward conditions, at the onset of each trial, a visual cue (1500 milliseconds) was presented (3 yellow circles), along with the reward associated with performance. Like the previous version, after the presentation of a fixation cross (500 ms), participants saw an array of yellow circles (3 circles, 1500 ms). A fixation cross (3000 ms) was presented before the visual target (1500 ms). The visual target (a green circle) was displayed in any position on the screen and signaled that the participant should decide as quickly as possible whether this circle was in the same position as one of the circles presented previously. After response execution and a variable jittered interstimulus interval (ISI; 0 ms or 2000 ms), the feedback screen (1000 ms) informed the participant of his or her winnings. For the monetary reward condition, a screen with "Rs 0" was shown for incorrect trials or "Rs 10" for correct trials, in the social reward condition, a "neutral" face smiley was shown for incorrect trials or a "win" face smiley for correct trials and in the no-reward condition, a blank screen was shown for every correct or incorrect trial. In the end, a feedback screen (1000 ms) indicating the cumulative amount of monetary reward or social reward (smileys) earned (in the monetary and social reward conditions) or a blank screen in the no-reward condition. Correct responses were associated with monetary gains ("Rs 10") in the monetary reward condition. Correct responses were not associated with any gains in the no-reward condition. We asked participants to rate their momentary mood and stress level using a visual analog scale from 0 (*bad mood*) to 10 (*good mood*). Participants rated their momentary mood and stress level on a scale of 0 to 10 at baseline, at the beginning of the experimental session, and before and after each block for a maximal duration of the 20s.

In both versions, participants were informed that they would receive the total sum in cash at the end of the session. Participants underwent a training phase before proceeding to the main task. A criterion of 70% correct responses was chosen to prevent arbitrary guessing and thereby verify understanding of the task and ensure that participants would win similar amounts of money.



3a) Before COVID-19 for Empirical Work I

3b) During COVID-19 for Empirical Work II

Figure 3: *Illustration of the Fribourg Reward Task for Empirical Work I and II*

Note. Schematic representation of a trial of the Fribourg Reward Task with 3 circles. This figure shows the schematic representation of a trial of the Fribourg reward task with 3 circles. In the first display, an array of yellow circles (3 circles) was presented for 2000 ms after a fixation time of 500 ms. After a delay of 3000 ms, a green circle appeared, and the subject had 1500 ms to decide whether the position of the green circle was the same as that of one of the preceding yellow circles. If so, the correct response for participants was to press a button with their right hand. If not, the participants had to press a button with their left hand. After the response time had elapsed, the circle disappeared, and the accumulated amount of money earned appeared on the screen in the reward condition or nothing is shown on the screen in the no-reward condition. During the reward condition, the participants should earn a monetary reward for every correct response.

4.5 DATA ANALYSES

This section describes briefly the statistical methods used to analyze the data presented in our three empirical works.

4.5.1. Statistical Analyses for Empirical Work I

In order to test the influence of reward on mood in participants in the sub-clinical pain group and in the control group, a repeated-measures analysis of variance (ANOVA) was conducted using the Statistical Package for the Social Sciences (SPSS; IBM SPSS Statistics, Version 25.0, Armonk, NY, USA), using mood as the dependent variable, with the following factors: groups (with pain symptoms and without clinically significant pain symptoms) as a between-group factor, reward conditions (no, low, and high), and levels of difficulty (low and high) as within-group factors. Two additional mixed ANOVAs using the same factors were applied using response accuracy and reaction time as the dependent variables with the same factors to test the effect of reward on performance and to compare the possible performance differences between the two groups of participants. In addition, we hypothesized that there would be a significant positive correlation between mood ratings and monetary gains in the rewarded conditions in the control group, but not in the sub-clinical group. To test this hypothesis, the Pearson product–moment correlation between average mood scores and average monetary wins over-all reward conditions were performed in each group of subjects separately.

4.5.2. Statistical Analyses for Empirical Work II

Since we wanted to replicate empirical work I, we used the same analyses as done in empirical work I. To test the effect of reward on mood in participants in the sub-clinical pain group and the control group, a repeated-measures ANOVA was conducted, using mood as the dependent variable, with the following factors: groups (sub-clinical pain group and control group) as a between-group factor, reward conditions (monetary reward and no-reward) as within group factors. Additional mixed ANOVA using the same factors was applied using reaction time as the dependent variable to test the effect of reward on performance and to compare possible performance differences between the two groups of participants. In addition, we postulated that there would be a significant positive correlation between mood ratings and monetary gains in the reward condition in the control group, but not in the sub-clinical group based on

our empirical work I. To test this hypothesis, the Pearson product-moment correlation between mood scores and monetary wins in reward conditions was performed separately in each group.

4.5.2. Statistical Analyses for Empirical Work III

We performed a network analysis as this allowed us to observe the dynamic relationship between psychopathological symptoms and protective factors, resulting in a network of connected symptoms that activates or influence physical pain. For this, we estimated a partial correlation network between psychopathological symptoms and protective factors associated with physical pain symptoms in university students in India and Switzerland. Data were inputted into JASP (Version 0.14.1.0), a statistical software package (https://jasp-stats.org), with analyses written in either R or C++ used in the study to conduct the network analysis (Epskamp, Borsboom & Fried, 2018). Networks were created using the *qgraph* (Epskamp et al., 2012) R-package. We examined strength centrality for each node within the Swiss and Indian networks, which represents the sum of absolute edge weights connecting that node to all other nodes in the network. We used *degree* centrality (rather than other indices of centrality such as closeness or betweenness). Lastly, we compared psychopathological symptoms and protective factors with symptoms of physical pain networks between Indian students versus Swiss students by using the *NetworkComparisonTest* (NCT) package in R (Van Borkulo et al., 2022) using 1000 iterations. NCT compared networks, estimated with EBICglasso (Epskamp et al., 2012), on both network invariance and global strength.

The Relationship between Behavioral and Mood Responses to Monetary Rewards in a Sample of Students with and without Reported Pain

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Tandon, T., Ledermann, K., Gupta, R., Morina, N., Wadji, D. L., Piccolo, M., & Martin-Soelch, C. (Tandon, Ledermann, et al.). The relationship between behavioral and mood responses to monetary rewards in a sample of students with and without reported pain. *Humanities and Social Sciences Communications*, *9*(1), 1-8.

ABSTRACT

Pain impairs reward processing and people suffering from physical pain are at high risk of having a persistently low mood. Although individuals with chronic pain have reported reduced reward responsiveness and impaired mood, it is not clear if reward responsiveness and mood is impaired in samples with sub-clinical pain scores otherwise healthy. Investigating a sub-clinical group is important to disentangle the influence of medication on the behavioral effect of reward on mood and performance. Here, we aimed to investigate the effects of reward on mood and performance in a sample of university students divided into a control group without clinically significant pain symptoms (N= 40) and the sub-clinical group with significant pain symptoms (N=39). We used the Fribourg reward task and the pain sub-scale of the Symptom Checklist (SCL-27-plus) to assess the physical symptoms of pain. A significant positive correlation was found between average mood ratings and average monetary reward in the control group ($r_{38} = 0.42$, $p = 0.008$) and not significant in the sub-clinical group ($r_{37} = 0.12$, $p = 0.46$). The results might yield first insights into the relationship between pain and reward in sub-clinical populations without the confound of medication.

KEYWORDS. Monetary reward, mood, pain, experimental study

Introduction

In everyday life, a reward describes any event or object that is able to produce a positive or pleasurable experience (White, 2011). Rewards are effective in motivating people (Murayama, 2019) and involved in learning processes (Hidi, 2016).

Pain and reward have been shown to interact (Gandhi et al., 2013). The interaction between reward and pain is conceptualized in Field's (2006) motivation-decision model. In this model, when both pain and reward are presented simultaneously, the brain is presented with a need to decide between pain or reward depending upon the individual's (homeostatic) state and the magnitude of the potential threats and rewards. The effect of pain on reward processing has been confirmed experimentally in humans (Becker et al., 2013). For example, individuals with chronic pain reported a decreased response to environmental incentives and reduced reward responsiveness to monetary reward via self-report questionnaires (X. Liu et al., 2019). An experimental study conducted using the Behavior Inhibition Scale/Behavior Activation Scale to assess the reward drive and reward responsiveness showed that reward responsiveness is reduced in individuals with chronic pain (Turner et al., 2020). Another study used a monetary incentive delay task and functional magnetic resonance imaging on 17 female individuals with fibromyalgia to understand the neural processing of reward in chronic pain; this study showed that the individuals with chronic pain reported lower arousal ratings and showed reduced medial prefrontal cortex activity during monetary reward anticipation, which is related to lower estimated reward, in comparison to healthy controls (Martucci et al., 2018). The previous studies indicate that pain impairs reward processing (S. Becker et al., 2012; Gandhi et al., 2014).

Chronic pain is highly comorbid with mood disorders (Salazar et al., 2013). People suffering from physical pain are at high risk of having persistently low mood (Bair et al., 2003; Dersh et al., 2002). Furthermore, while winning rewards such as money is associated with increase in mood as evidenced in several studies using behavioral reward tasks in healthy control samples (Kalebasi et al., 2015; Martin-Soelch et al., 2009) an impaired mood responsivity to reward has been shown in individuals with chronic pain (Rizvi et al., 2021). For instance, a study conducted on individuals with chronic pain (N=28) and

healthy controls *(N*=18) using the Monetary Incentive Delay (Sokratous et al.) task reported reduced neural responses to reward in the chronic pain group compared to healthy controls in regions associated with the cerebral reward system (Kim et al., 2020). Indeed, several studies support the presence of dysfunctional reward pathways in co-occurring pain and mood alterations (Berger et al., 2014; Treadway & Zald, 2011), suggesting reward processing could be a mechanism underlying the relationship between pain and mood disorders (Garland, 2020; Leknes & Tracey, 2008) and increase in mood have been correlated to neural changes in regions associated with the processing of reward (Martin-Soelch et al., 2003).

Given the observed relationship between pain and reward processing, it is interesting to further explore these interactions in a population with sub-clinical pain. This would allow to disentangle the influence of medication on the behavioral effect of reward on mood and performance. Therefore, in the present study, we investigated the relationship between behavioral and mood responses to monetary rewards between subjects reporting clinically significant pain symptoms (i.e., pain scores above the clinical threshold) and a control group not reporting clinically significant pain in everyday life. Based on the findings that pain-related impairments in reward processing were evidenced in clinical patients (Ledermann et al., 2017), we hypothesized that participants with sub-clinical pain scores would display a reduction of the effect of monetary reward on mood when compared to the participants without any clinically significant physical pain symptoms of pain. To test that, we used a validated spatial delay task that had successfully differentiated mood responses between sub-clinical and control samples in previous studies (Kalebasi et al., 2015; Martin-Soelch et al., 2009a). Since monetary reward has been shown to have positive effects on performance and self-reported mood in healthy participants (Martin-Soelch et al., 2003, 2009), we expected a significant association between momentary mood ratings defined as the current subjective feeling of wellbeing (Martin-Soelch et al*.,* 2009) and monetary winnings in the control group. The reward task was used to measure reward functioning (Gaillard et al., 2019). We also investigated whether task difficulty influences the interaction between mood, reward and performance, since previous studies (Martin-Soelch et al., 2009d) showed that task difficulty strongly affects reward processing. We included a task with different levels of difficulty (low and high) in order to test the

relationship between reward, levels of difficulty, and performance. We divided the participants into two groups (sub-clinical group; participants with clinically significant pain symptoms and the control group) as we aimed to replicate the effects of reward on mood and performance and understand the associations of these effects expressed in the two groups.

Method

Participants

Participants were recruited through flyers at the University in Switzerland. Each participant was screened for the exclusion and inclusion criteria using a short structured clinical screening based on the DSM-5 (American Psychiatric Association, 2013) criteria for the most frequent mental disorders. General exclusion criteria included current or past depression and history of psychiatric disorder as tested with the structured interview based on the M.I.N.I (Sheehan et al., 1998), use of any psychopharmacological medication and having a score ≥ 11 on the Hospital Anxiety and Depression Scale (Bocéréan & Dupret, 2014b). A total of 100 participants were recruited in our study of whom 79 were included as 21 participants were excluded because they had a score ≥ 11 at the Hospital Anxiety and Depression scale (Bocéréan & Dupret, 2014b) in order to avoid an effect of significant anxiety symptoms on reward as anxiety was shown to affect reward reaction (Mikita et al., 2016) and is often associated with pain (Gravani et al., 2021). The 79 remaining participants were then divided into two groups: of sub-clinical pain group and a control group. The criterion to be included in the sub-clinical pain group was to have a score above the clinical cutoff of 1.77 on the pain subscale based on the manual of Symptom Checklist-27-plus (Hardt, 2008b). The cut-off is the official cut-off specified in the manual. The type of effect size used in our study is Partial eta squared (η^2_p) that is estimated to be 0.027 on the basis of the similar study by Kim et al. (2020) which investigated differences in mood and behavioral responses to reward between chronic pain patients and healthy controls using an ANOVA. We used the recommendations formulated by Lakens (2013b) to enter the parameters in G-Power using a partial eta squared (η^2_p) of 0.027 that led to the estimated F value of 0.17. Using G-Power, the estimated sample size needed would be 80 to have the actual power with 5% alpha error, 95% power, and $p < 0.05$ as the significance level for the ANOVA

with repeated measures and within-between interaction.

The participants were thoroughly informed about the study and gave their written consent according to the Declaration of Helsinki. The privacy rights of participants were always observed during our study. The study was approved by the internal review board (2017/IRB 334A) at the Department of Psychology at the University.

Of the 79 participants included in this study, all were bachelor psychology students[1] aged between 18 and 55 years (M = 23.98 years, SD = 6.98 years), 72 (91.1%) were women, and 82.2% were native French speakers or spoke French fluently. Participants were categorized into a group of 39 participants (37 women; M = 24.5, SD = 9.17) who reported physical symptoms of pain and a control group of 40 participants (35 women; M = 23.5, SD = 3.88) with no clinically significant physical symptoms of pain (shown in Table 1).

Procedure

Fribourg Reward Task

We used an adapted behavioral version of the reward task (Martin-Soelch et al., 2009), Fribourg Reward Task, to measure reaction times, accuracy, and mood reactions to reward. Neuroimaging studies using this task have successfully elicited neural activation in regions associated with the cerebral reward system (Gaillard et al., 2019), including the striatum, a crucial cerebral region for reward processing. The task was programmed using E-Prime software (version 1.1.3, Psychology Software Tools Inc., Pittsburg, Pa., USA) and presented on a high-resolution color monitor. The monitor's resolution was 1024 × 768 pixels, and the presentation of the stimuli was synchronized with the refresh rate of the monitor. The display was viewed from a distance of 50 cm. The experimental task was presented in six block conditions, comprising of two levels of difficulty (3 circles: low difficulty or 7 circles: high difficulty) and three reward conditions (no reward, small reward and high reward) and using a Latin-square design. The six block conditions were: 3 circles (i.e., low difficulty) with no reward, 3 circles (i.e. low difficulty) with small reward, 3 circles (i.e. low difficulty) with high reward, 7 circles (i.e. high difficulty) with no reward,

[1] The participants studying psychology were given experimental points as compensation as part of their bachelor's curriculum.

7 circles (i.e. high difficulty) with small reward 7 circles (i.e. high difficulty) with high reward. Each block conditions consisted of 12 trials each and the order of the blocks were pseudo-randomized.

At the onset of each trial (see Fig.1), a visual cue (1500 ms) was presented (low difficulty: 3 circles; or high difficulty: 7 circles), along with the monetary reward associated with performance (a blank screen for no reward trials or "$$" for reward trials). After the presentation of a fixation cross (500 ms), participants saw an array of yellow circles (3 or 7 circles, 1500 ms). A fixation cross (3000 ms) was presented before the visual target (1500 ms). The visual target (a green circle) was displayed in any position on the screen and signaled that the participant should decide as quickly as possible whether this circle was in the same position as one of the circles presented previously. After response execution and a variable jittered interstimulus interval (ISI; 0 ms or 2000 ms), the feedback screen (1000 ms) informed the participant of his or her winnings (blank screen for no reward trials; "1 CHF" for high-reward trials and "0.10 CHF" for small-reward trials), followed by a feedback screen (1000 ms) indicating the cumulative amount of earned money (reward trials) or a blank screen (no reward trials). Correct responses were associated with monetary gains ("1 CHF" for high-reward trials and "0.10 CHF" for small-reward trials) in the reward condition. Correct responses were not associated with monetary gains (0 CHF) in the no reward condition. The monetary reward increased according to the difficulty of the task, i.e., CHF 0.10 in the block with three circles vs. CHF 1 in the block with seven circles. Each level of difficulty comprised 12 trials. We asked the participants to rate their momentary mood using a visual analogue scale from 0 (bad mood)- 100 (good mood). With smileys at the anchor points (0= 

); (100= 

). Only the schematic faces were seen by the participants. The participants rated their momentary mood on a scale of 0 to 100 at baseline, at the beginning of the experimental session, and before and after each block for a maximal duration of 20s. Participants were informed that they would receive the total sum in cash at the end of the scanning session. Participants underwent a training phase before proceeding to the main task. A criterion of 70% correct responses was chosen to prevent arbitrary guessing and thereby verify understanding of the task and ensure that participants would win similar amounts of money.

Psychometric Measures

Anxiety was measured using the Hospital Anxiety and Depression scale (HADS; ([Bocéréan & Dupret, 2014b; Zigmond & Snaith, 1983)]. This is a self-rating scale that consists of 14 items: 7 items measuring symptoms of depression and 7 items measuring symptoms of anxiety. Each item is coded from 0 to 3, yielding a score between 0 and 21 for each scale. This scale was used only for the selection of the participants. In our study, we used only 7 items to measure the symptoms of anxiety for screening purposes. Participants with any symptoms of anxiety (score ≥ 11) were excluded from the study.

Measures of Pain

The Symptom Checklist (SCL-27-plus; (Hardt, 2008a) is a multidimensional assessment instrument for mental health status (Kuss, 2017). With 27 items rated on a 5-point Likert-type scale, it consists of five dimensions: depressive, vegetative, agoraphobic, social phobia and pain symptoms, and a global severity index. A lifetime assessment of depressive symptoms and a screening question for suicidality are also included. Previous studies reported significant pain symptoms in university students using the SCL-27 (Conley et al., 2017; Recabarren et al., 2019).

Participants rated the following pain symptoms: headaches, chest pain, muscle cramps, muscle aches, arm/leg pain, and lower back pain for 0 "*never*" to 4 "*very often*" on a pain subscale depending on how often these symptoms occur in general. A value of "0" stood for never, "1" stood for 1-2 days, "2" for 3-7 days, "3" for 8-12 days, and "4" for 13-14 days. A score ≥1.77 indicates physical symptoms of pain according SCL-27 (Hardt, 2008b). The Cronbach's alpha coefficient in this study was 0.73.

Data Analysis

Analyses were calculated using IBM SPSS Inc 25. The normality tests were performed, and the data were found to be normally distributed using Shapiro-Wilk Test W (79) = 0.98, p = 0.75. Baseline mood ratings were compared among the groups using a one-way ANOVA. As we did not find any significant group differences at baseline, these ratings were not included into the further analyses of mood as proposed in Martin-Soelch et al., (2009) results. We also performed exploratory analyses comparing the mean mood ratings between groups in the no reward conditions to test the specificity of our results. In order to test the influence of reward on mood in participants in the sub-clinical pain group and in the

control group, a repeated-measures ANOVA was conducted, using mood as the dependent variable, with the following factors: groups (with pain symptoms and without clinically significant pain symptoms) as a between group factor, reward conditions (no, low, and high), and levels of difficulty (low and high) as within group factors. Two additional mixed ANOVAs using the same factors were applied using response accuracy and reaction time as the dependent variables with the same factors to test the effect of reward on performance and to compare the possible performance differences between the two groups of participants.

In addition, we postulated that there would be significant positive correlation between mood ratings and monetary gains in the rewarded conditions in the control group, but not in the sub-clinical group. To test this hypothesis, Pearson product moment correlation between average mood scores and average monetary wins over all reward conditions was performed in each group of subjects separately according to the similar studies done previously (Kalebasi, 2015; Martin-Soelch, 2009). To adjust for the multiple comparisons, a Bonferroni correction was implemented. Only *p*-values less than 0.025 (0.05/2) were deemed significant. Additional explorative correlations were performed between the mean mood scores and the response accuracy for each condition separately. The corrected p-value for these explorative analyses was 0.013 (0.05/4).

Results

Reward and Mood

Average mood scores in the reward and no reward condition are summarized in **Table 2**. Baseline mood scores were 74.27 ± 20.90 (mean ± SD) for the control group and 73.66 ± 14.44 for the sub-clinical pain group. The results of the one-way ANOVA showed no significant difference in mood between groups at the baseline ($F_{1,79}$ = 2.09, p = 0.13). We also performed exploratory analyses comparing the mean mood ratings between groups and the no reward conditions and no significant differences were found ($F_{10,68}$ = 0.309, p = 0.998). The results of the repeated-measures ANOVA of mood showed no significant interaction effect between groups and levels of difficulty ($F_{1,77}$ = 0.056, MSE = 0.798, p = 0.81, η^2_p = 0.001). A significant main effect was seen only for the factor of reward ($F_{2,154}$ = 4.159, MSE = 93.48, p = 0.004 significant at 0.01, η^2_p = 0.05). Participants reported higher mood scores in response to high

reward (*M*= 75.80, *SD* = 17.98) compared to small reward (*M*= 74.33, *SD* = 17.68). No significant main effect was seen for difficulty ($F_{1,77}$ = 3.477, *MSE* =49.86, p = 0.027, η^2_p = 0.043), groups ($F_{1,77}$ = 0.447, *MSE* =856.632, p = 0.5, η^2_p = 0.006), for the interactions between difficulty and reward ($F_{2,154}$ = 0.25, *MSE* = 6.57, p = 0.78, η^2_p = 0.003), between groups and reward ($F_{2,154}$ = 1.453, *MSE* = 32.655, p = 0.24, η^2_p = 0.019) nor between difficulty, groups and reward ($F_{2,154}$ = 0.587, *MSE* = 15.45, p = 0.56, η^2_p = 0.008).

Table 2*. Means and standard errors for mood scores in the reward and no reward conditions for each level of difficulty of the task.*

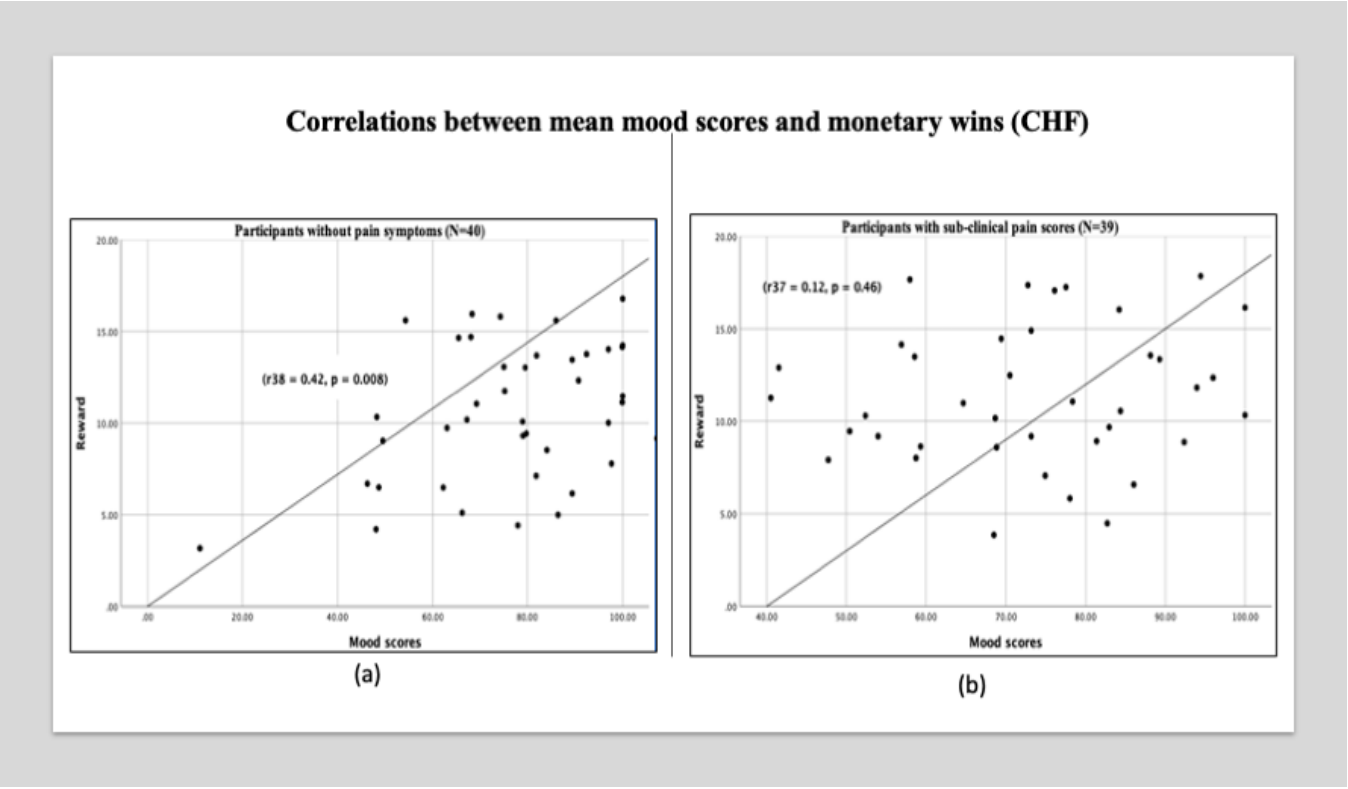
Group	N	Difficulty (number of circles)	Reward conditions		No reward conditions
			Small	High	
Sub-Clinical	39	3	73.11 ± 2.69	74.92 ± 2.48	72.17 ± 3.12
		7	73.07 ± 2.56	72.37 ± 2.61	72.5 ± 2.60
Control	40	3	76.23 ± 2.93	76.66 ± 3.20	76.43 ± 3.07
		7	74.9 ± 3.24	75.51 ± 3.13	74.55 ± 3.18

Note*.* This table demonstrates the scores of both the groups. The sub-clinical group showed lower mood scores than the control group at both levels of difficulty (low and high) of the reward conditions (small and high).

Correlations Between Mood and Reward

In the control group, a significant positive correlation was found between average mood scores and average monetary wins across conditions (r_{38} = 0.42, p = 0.008, Bonferroni- corrected). However, in the sub-clinical group, no significant correlation was found between average mood scores and average monetary wins across conditions (r_{37} = 0.12, p = 0.46, Bonferroni-corrected) (shown in **Fig. 4**).

Figure 4: *Correlations between the mean mood scores and the amount of monetary reward received.*



Note: The above figures demonstrate the correlations between the mean mood scores and the amount of monetary reward received during the two levels of difficulty (high and low). The value of the y-axis shows the sum win (in CHF) obtained by adding the monetary wins overall reward conditions with high and low difficulty. The subjects as represented as dots (•).

Reward and Performance

Results for accuracy of responses for each level of difficulty are summarized in **Table 3**.

The mixed ANOVA of accuracy showed no significant effect for the interaction between groups and levels of difficulty ($F_{1,77} = 2.092$, MSE = 0.023, $p = 0.15$, $\eta^2_p = 0.026$). A significant main effect was seen for the factor of reward ($F_{2,154} = 153.261$, $MSE = 1.98$, $p = 0.00$ significant at 0.01, $\eta^2_p = 0.666$). Performance was significantly more accurate in the high reward condition ($M = 0.91$, $SD = 0.09$) compared to the small reward condition ($M = 0.67$, $SD = 0.17$). There was also a significant main effect seen for the factor of difficulty ($F_{1,77} = 76.90$, $MSE = 0.846$, $p = 0.003$ significant at 0.01, $\eta^2_p = 0.500$), with higher accuracy in the low difficulty level ($M = 0.91$, $SD = 0.86$) than in the high difficulty level ($M = 0.67$, $SD = 0.14$). No significant main effect was seen for groups ($F_{1,77} = 0.229$, $MSE = 0.009$, $p = 0.633$, $\eta^2_p = 0.003$). A significant effect was seen for the interaction between difficulty and reward ($F_{2,154} = 43.534$,

MSE = 0.541, p = 0.008 significant at 0.01, η^2_p = 0.361) but not for the interaction between groups and reward ($F_{2,154}$ = 0.416, *MSE* = 0.005, p = 0.66, η^2_p = 0.005) or between difficulty, groups, and reward ($F_{2,154}$ = 0.075, *MSE* = 0.001, p = 0.93, η^2_p = 0.001).

The mixed ANOVA of reaction time showed no significant effect for the interaction between groups and levels of difficulty ($F_{1,77}$ = 0.749, MSE = 3.549E+10, p = 0.39, η^2_p = 0.010), factor of reward ($F_{2,154}$ = 0.007, *MSE* = 286757154, p = 0.99, η^2_p = 0.000), factor of difficulty ($F_{1,77}$ = 0.874, *MSE* = 4.136E+10, p = 0.87, η^2_p = 0.011), groups ($F_{1,77}$ = 2.32, *MSE* = 2.491E+10, p = 0.13, η^2_p = 0.029) nor for the interaction between difficulty and reward ($F_{2,154}$ = 1.750, *MSE* = 6.549E+10, p = 0.178, η^2_p = 0.022), groups and reward ($F_{2,154}$ = 0.565, *MSE* = 2.386E+10, p = 0.57, η^2_p = 0.007) nor between difficulty, groups and reward ($F_{2,154}$ = 0.206, *MSE* = 7.708E+9, p = 0.81, η^2_p = 0.003) reached the significance.

Table 3*. Means and standard errors for accuracy of responses in the reward and no reward conditions for each level of difficulty of the task.*

Group	n	Difficulty (number of circles)	Reward conditions		No reward conditions
			Small	High	
Sub-Clinical	39	3	0.88 ± 0.017	0.92 ± 0.012	0.89 ± 0.016
		7	0.68 ± 0.021	0.66 ± 0.20	0.66 ± 0.027
Control	40	3	0.89 ± 0.018	0.90 ± 0.015	0.89 ± 0.018
		7	0.69 ± 0.022	0.69 ± 0.023	0.68 ± 0.026

Note. Accuracy is measured as the number of correct responses, with a maximum of 12 correct responses for each trial. No significant results were found in all comparisons between the reward and the no reward conditions in both group of subjects.

Correlations Between Mood and Response Accuracy

Additional explorative correlations were performed between mean mood scores and response accuracy found significant positive correlations in the control group during the condition with the high level of difficulty (r_{38} = 0.32, p = 0.04) but was no more significant after Bonferroni correction was applied for 4 comparisons, p< 0.013. During the condition with the low level of difficulty no significant correlation was found (r_{38} = -0.03, p = 0.84). In the sub-clinical pain group, no significant positive correlations were

found during the condition with the high level of difficulty ($r_{37} = 0.03$, $p = 0.88$) and with the low level of difficulty ($r_{37} = 0.08$, $p = 0.64$).

Discussion

The main aim of the present study was to investigate the relationship between behavioral and mood responses to monetary rewards between a sub-clinical group reporting clinically significant physical pain symptoms and a control group without any clinically significant physical pain symptoms in everyday life. We hypothesized that the sub-clinical group would show a reduction in the effect of a monetary reward on mood ratings compared to the control group. We used the Fribourg Reward Task (Martin-Soelch et al., 2009), including two levels of difficulty and three reward conditions, in order to test the relationship between monetary reward, mood scores, and performance in the two groups. We also investigated the influence of task difficulty on mood, reward, and performance.

Interestingly in the present study, 49% of the university students tested reported high levels of physical symptoms of pain which is in line with a previous study in a similar sample of students (Recabarren et al., 2019). One of the reasons for this high frequency of pain symptoms could be that the university students are prone to inactivity for long period of time which is characterized by prolonged sitting (Felez-Nobrega et al., 2018).

With regard to our hypothesis that the effect of reward on mood and performance would be reduced in participants with sub-clinical pain, our ANOVA results did not show any significant interaction between monetary wins, levels of difficulty and groups neither for mood scores nor for the outcomes related to performance, i.e., response accuracy and reaction time. These results suggest that the significant interaction reported by several studies (Navratilova et al., 2016; Loggia et al., 2014; Seixas et al., 2016) in relation to pain and reward might be mostly related to individuals with chronic pain and these associations are not seen in the sub-clinical population. The significant interaction between reward and levels of difficulty for the outcomes related to performance replicate previous findings obtained with this

task (Gaillard et al., 2019).

Our results showed a significant positive correlation between mood ratings and monetary wins in the control group, but not significant in the sub-clinical group in agreement with our hypothesis. These results suggest that there is a reduced association between monetary reward and mood in the sub-clinical group. This is in agreement with previous studies conducted on students with chronic pain that found reduced reward functioning and mood responses as compared to the healthy controls (Berger et al., 2014) as well as with findings obtained in chronic pain patients (Treadway & Zald, 2011). To our knowledge, these results are the first to suggest that changes in the reward-pain interaction can be identified in sub-clinical pain population, and therefore provide information about the effect of pain on the processing of reward without the limitation of medication and treatment. In addition, our finding of a blunted association between mood and reward in a sub-clinical population might yield first insights to develop preventive intervention. In that context, a former study showed that a stress prevention in University students could significantly reduce self-reported pain symptoms for instance (Recabarren et al., 2019). It could be also beneficial to test in future studies the preventive effect of interventions that showed a bettering of reward mechanisms in chronic pain patients, such as Mindfulness-Oriented Recovery Enhancement (MORE) training for instance (Garland et al., 2020) in university students reporting significant pain symptoms.

Limitations

Some limitations merit attention. First, the measurement of pain based only on the Symptom Checklist-27-plus (Hardt, 2008b) is certainly a limitation of the present study and the use of self-report instruments can lead to memory bias and greater subjectivity in the responses. Especially, the length of our online questionnaires may have led to less accurate answers due to fatigue, even though the participants could take breaks. Second, the sample consisted mainly of female students from the university, which limits the generalization of our results. Students had an additional motivation factor for their participation: they could receive experimental points instead of financial reimbursement in order to meet the requirements of their bachelor studies.

In conclusion, our findings provide very promising evidence of the interaction between pain and

reward, and that its effects can also be found in a sub-clinical population. The investigation of a sub-clinical population might help to disentangle the complex relationship between pain and reward without the limitation of medication, treatment, adaptation to pain and comorbidities associated with the investigation of participants with chronic pain. This relationship in a sub-clinical population provides first insight into the development of preventive interventions. More research is needed to study the pain–reward interaction in healthy participants with sub-clinical pain symptoms and the continuum between sub-clinical and clinical pain.

Relationship between Behavioral and Mood Responses to Monetary Rewards in a Sample of Indian Students with and without Reported Pain

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Abstract

Physical pain has become a major health problem with many university students affected by it worldwide each year. Several studies have examined the prevalence of pain-related impairments in reward processing in Western, Educated, Industrialized, Rich, and Democratic (WEIRD) countries but none of the studies have replicated these findings in a non-western cultural setting. Here, we aimed to investigate the frequency of physical pain symptoms in a sample of university students in India and replicate our previous study conducted on university students in Switzerland, which showed reduced mood and behavioral responses to reward in students with significant pain symptoms. We grouped students into a sub-clinical ($N = 40$) and a control group ($N = 48$) to test the association between pain symptoms and reward processes. We used the Fribourg reward task and the pain sub-scale of the Symptom Checklist (SCL-27-plus) to assess physical symptoms of pain. We found that 45% of the students reported high levels of physical symptoms of pain and interestingly, our ANOVA results did not show any significant interaction between reward and the groups either for mood scores or for outcomes related to performance. These results might yield the first insights that pain-related impairment is not a universal phenomenon and can vary across cultures.

Keywords: Physical pain, reward processes, Indian students, mood

Introduction

Pain and reward have been shown to interact (Gandhi et al., 2013; Navratilova et al., 2012). More specifically, several studies report the effects of chronic and acute pain on the neural processing of the reward (Susanne Becker et al., 2012; Ledermann et al., 2017). For instance, a study conducted on twenty-eight patients with chronic pain showed pain-related alterations in the brain regions (i.e., reduced striatal activation) involved in reward processing while performing the Monetary Incentive Delay (Sokratous et al.) task as compared to healthy controls (Kim et al., 2020). Similarly, chronic pain is highly comorbid with mood disorders (Kim et al., 2020; Salazar et al., 2013) and several studies report the presence of dysfunctional reward pathways in co-occurring pain and mood alteration (Berger et al., 2014; Treadway & Zald, 2011). For instance, winning rewards such as monetary rewards are associated with an increase in self-reported mood in healthy controls (Martin-Soelch et al., 2009; Piccolo et al., 2019; Tandon, Ledermann, et al., 2022a) whereas impaired mood responsivity has been shown in people suffering from chronic pain (Rizvi et al., 2021). This suggests that reward processing could be a mechanism underlying the relationship between pain and mood disorders (Ledermann & Martin-Sölch, 2018) and an increase in mood responses have been associated with neural changes in regions involved in reward processes (Martin-Soelch et al., 2003).

Pain also alters reward responsivity in non-chronic samples (Tandon, Ledermann, et al., 2022a; Wang et al., 2020). Based on the findings of pain-related impairments in reward processing, we tested whether pain-related impairment in reward processing could also be observed in a sub-clinical population i.e., university students. Our results showed that 49% of the students (n = 79) reported high levels of physical symptoms of pain. Moreover, students reporting non-chronic yet significant sub-clinical physical pain symptoms showed reduced mood responses to monetary reward (i.e., lower mood scores) when compared to students without sub-clinical pain symptoms(Tandon, Ledermann, et al., 2022a).

Physical pain has become a major health problem among university students, with around 54% of them being affected by it each year worldwide (Ando et al., 2013). In western countries, for instance, in Switzerland, physical pain is the most disabling disease (Crawford et al., 2018), and over 80% of the

students report lower back pain and neck pain yearly according to the Swiss Health Survey data (Angst et al., 2017; Crawford et al., 2018). In the UK, the prevalence of pain is 66.9% among students (Mallen et al., 2005). In the Netherlands, the 12-month prevalence was about 31.4% (neck pain), 30.3% (shoulder pain), and 17.5% (wrist/hand pain) (Bruls et al., 2013). Finally, in the USA, 81% of the students showed a high prevalence of musculoskeletal discomfort during/after computer use (Hamilton et al., 2005). These studies have mainly been conducted in Western, Educated, Industrialized, Rich, and Democratic (WEIRD) countries and might not be representative of other cultural contexts which, on the other hand, include a large part of the world's population (Henrich et al., 2010c).

While several studies have examined the prevalence of physical pain symptoms in European countries and the United States (Gerdle et al., 2008; Hardt et al., 2008), only a few studies on physical pain in students in Asia specifically Southeast Asia (Saxena et al., 2018) were conducted, despite its high prevalence. This is important because, for instance, in India, physical pain is quite common among students, affecting 29%-81% of them each year (Madaan & Chaudhari, 2012). Another cross-sectional study carried out in one of the universities in India (N = 160) showed that the prevalence of physical pain, especially lower back pain, was 45.3% among the students (Aggarwal et al., 2013). To our knowledge, none of the studies have shown an Indian perspective on the interaction between pain and reward processes though there seem to be differences in the experiences of pain in different cultures (Eachus et al., 1999). For instance, studies on the management of chronic chest pain showed that South Asian people waited twice as long as Europeans to visit a medical doctor after experiencing an onset of chest pain (Shaukat et al., 1993). This has been suggested that it might be due to lower disease awareness and health-seeking behavior in South-Asian cultures than in European cultures (Hawthorne et al., 1993; Misra & Khurana, 2011) but further research is needed. Also, in many South Asian countries when compared to Western countries, individuals are encouraged to avoid pain even when they do experience it (Unger & Schwartz, 2012) due to socio-economic factors such as lack of financial support or lack of access to health care (Green et al., 2003) since suffering from pain might lead to an increase in the financial burden of the families. Likewise, the perception of reward also differs across cultures, for example, a study by Jang, Shen, Allen, and Zhang (Jang et al., 2018) showed cultural variations in the relationship between reward

and motivation. For instance, in a country like Pakistan, which is characterized by a collectivist culture (Hofstede, 1984) and predominantly masculine values (Shamim & Abbasi, 2012), monetary rewards were evaluated as highly attractive as masculine societies emphasize success based on material gain (Hofstede, 2001) in such societies, individuals with high collectivist values demonstrate a greater preference for monetary benefits (Kickul et al., 2004). Finally, Chiang and Birtch (Chiang & Birtch, 2012) found that employees in Hong Kong with collectivist values demonstrated a higher monetary reward orientation than Finnish employees with individualistic values. Due to these potential cultural differences in the perception of pain and reward, it is important to extend the current literature on this topic to non-western cultures.

Investigating the association between pain and reward processing is important since research has shown that reward processes and the motivation to achieve rewards play an important role in students learning processes in educational settings (Baranek, 1996). For instance, a meta-analysis by Cerasoli et al. (Cerasoli et al., 2014) showed that extrinsic incentives (e.g., such as monetary rewards) are the best predictors of performance in university students and the presence of extrinsic incentives encourages students to perform better. Therefore, if these reward processes are affected due to chronic or acute pain, it might lead, in turn, to poorer academic performance in students, higher absenteeism, and poorer peer and social functioning (Gorodzinsky et al., 2011) which are also important factors to experience reinforcing activities during student's life.

Considering that few studies have focused on the frequency of pain in students in India and the lack of studies investigating reward and pain interaction in non-WEIRD populations, the first aim of our study was to investigate the frequency of physical pain symptoms in a sample of university students in India which although being educated, represents non-western cultural aspects. The second aim was to replicate our previous study conducted on university students in Switzerland (Tandon, Ledermann, et al., 2022a) in a non-western cultural context i.e., in India. We hypothesized that university students in India would report a high frequency of physical pain and that participants with sub-clinical pain scores would display a reduction of the effect of monetary reward on mood when compared to the participants without any clinically significant physical pain symptoms. We hypothesized that there would be an effect of reward on mood and performance (i.e., with reduced reaction times and increased mood scores in response

to reward) and that this effect would be reduced in participants with sub-clinical pain. To test that, we used the Fribourg Reward task that had successfully differentiated mood responses between sub-clinical and control samples in a previous study of our group performed in a sample of Swiss students (Tandon, Ledermann, et al., 2022a). Similar to (Tandon, Ledermann, et al., 2022a), students were categorized into a sub-clinical group, i.e., university students with non-chronic yet clinically significant pain symptoms, and a control group, i.e., university students without reported physical pain *a posteriori* and based on their self-reported pain scores. We compared the groups and investigated the effects of reward on mood and performance using the Fribourg reward task (Martin-Soelch et al., 2009) in each group to test the association between pain symptoms and reward processes in Indian students.

METHOD

Participants

Participants were recruited through flyers and emails from several Universities in India. General inclusion criteria were that students should be 18 years of age and have a good command of English. **Table 1** provides the participants' demographics. The sample comprised 88 students (M_{age} = 21.77 years, SD = 2.31; 50% Females). We used a cross-sectional design and assigned the participants *a posteriori*, i.e., the participants were categorized into two groups after the completion of the study: a sub-clinical pain group (N = 40) and a control group (N = 48) according to their self-reported scores on the pain subscale of Symptom Checklist-27-plus [43] using the cut-off score specified in manual. We used this scale because it is a well-validated instrument with a specified clinical threshold that allowed us to differentiate between groups using the cut-off score specified in the manual. The criterion to be included in the sub-clinical pain group was to have a score above the clinical cut-off of 1.77 on the pain subscale based on the manual of Symptom Checklist-27-plus (Hardt, 2008a). The cut-off is the official cut-off specified in the manual. As we had used this methodology before in a similar study conducted on university students in Switzerland (Tandon, Ledermann, et al., 2022a), we wanted to use the same methodology and data analyses to be able to compare the results. The type of effect size used in our study is Partial eta squared (η^2_p), estimated to be 0.027 based on our previous study (Tandon, Ledermann, et al., 2022a), which investigated differences in mood and behavioral responses to reward

between students with sub-clinical pain symptoms and healthy controls using an ANOVA. We used the recommendations formulated by Lakens (2013a) to enter the parameters in G-Power using a partial eta squared (η^2_p) of 0.027, which led to the estimated Cohen's F value of 0.17. Using G-Power, the estimated sample size needed would be 80 to have the actual power with 5% alpha error, 95% power, and $p < 0.05$ as the significance level for the ANOVA with repeated measures and within-between interaction. Both groups did not differ in depression and anxiety scores ($p>0.05$). In addition, the depression mean scores were below the threshold of a score of 11 for significant depression score (mean /SD control:7.25 ± 3.64; subclinical group:5.97 ± 3.62).

The study was approved by the Institutional Review Board at the University of Fribourg in Switzerland (2017/IRB 334A). Participants were thoroughly informed about the study and gave their electronic consent. All research was performed according to the Declaration of Helsinki. The privacy rights of participants were always observed during our study.

Procedure

Students completed a battery of questionnaires online using LimeSurvey® (LimeSurvey GmbH, Hamburg, Germany. URL http://www.limesurvey.org) as well as an adapted online version of the Fribourg reward task (Martin-Soelch et al., 2009; Tandon, Ledermann, et al., 2022a). In addition, the adapted version of the Fribourg reward task was performed online by the participants at their respective homes (due to the COVID situation) without the experimenter. Participants were allowed to terminate the survey at any time. The survey was anonymous, and the confidentiality of information was maintained.

Psychometric Measures

Symptom Checklist (SCL-27-plus) for pain:

Symptom Checklist (SCL-27-plus; [28]) is a multidimensional assessment instrument for the mental health status (Kuss et al., 2017). With 27 items rated on a 5- point Likert-type scale, it consists of five dimensions: depressive, vegetative, agoraphobic, social phobia, and pain symptoms. A lifetime assessment of depressive symptoms and a screening question for suicidality are also included. Participants rated the following pain symptoms: headaches, chest pain, muscle cramps, muscle aches, arm/leg pain,

and lower back pain for 0 "*never*" to 4 "*very often*" on a pain subscale depending on how often these symptoms occur in the past two weeks. A value of 0 stood for "never", 1 stood for "1-2 days", 2 for "3-7 days", 3 for "8-12 days", and 4 for "13-14 days". A mean score of ≥1.77 indicates physical symptoms of pain according to SCL-27 (Hardt, 2008a). Previous studies reported significant pain symptoms in university students using the SCL-27 (Conley et al., 2017; Recabarren et al., 2019; Tandon, Ledermann, et al., 2022a). The overall Cronbach's alpha coefficient in this study was 0.87, which is good.

Hospital Anxiety and Depression Scale

Hospital Anxiety and Depression Scale (HADS; ([Bocéréan & Dupret, 2014b; Zigmond & Snaith, 1983)]. is a self-assessment scale that consists of a 14-item scale (7 relating to anxiety symptoms and 7 to depression); each item is coded 0 to 3. The total score can range from 0 to 42. The clinical cut-off score on depression or anxiety scales is equal to or greater than 11 on each symptom. The overall Cronbach's alpha coefficient in this study was 0.80, which is good.

Fribourg Reward Task

We used an online adapted behavioral version of the Fribourg reward task (Martin-Soelch et al., 2009) to measure reaction times, and mood reactions to monetary reward. Neuroimaging studies using this task have successfully elicited neural activation in regions associated with the cerebral reward system (Gaillard et al., 2019), including the striatum, a putative region for reward processing. In short, the task was originally programmed using E-Prime software (version 1.1.3, Psychology Software Tools Inc., Pittsburg, Pa., USA) and made available online using OpenSesame, a graphical experiment builder for the social sciences. The experimental task was presented in three block conditions, comprising reward conditions (monetary reward, social reward, and no-reward). Here, we focus only on the monetary versus no-reward conditions to investigate whether physical symptoms of pain affect the responses to monetary reward in Indian students as we evidenced in Swiss students (Tandon, Ledermann, et al., 2022a). Each block condition consisted of 12 trials and the order of the blocks was pseudo-randomized. In the three-reward conditions, at the onset of each trial (see Fig.1), a visual cue (1500 ms) was presented (3 yellow

circles), along with the reward associated with performance. After the presentation of a fixation cross (500 ms), participants saw an array of yellow circles (3 circles, 1500 ms). A fixation cross (3000 ms) was presented before the visual target (1500 ms). The visual target (a green circle) was displayed in any position on the screen and signaled that the participant should decide as quickly as possible whether this circle was in the same position as one of the circles presented previously. After response execution and a variable jittered interstimulus interval (ISI; 0 ms or 2000 ms), the feedback screen (1000 ms) informed the participant of their winnings. For the monetary reward condition, a screen with "Rs 0" was shown for incorrect trials or "Rs 10" for correct trials, in the social reward condition, a "neutral" face smiley was shown for incorrect trials or a "win" face smiley for correct trials and in the no-reward condition, a blank screen was shown for every correct or incorrect trial. In the end, a feedback screen (1000 ms) indicating the cumulative amount of monetary reward or social reward (smileys) earned (in the monetary and social reward conditions) or a blank screen in the no-reward condition. Correct responses were associated with monetary gains ("Rs 10" for participants in India) in the monetary reward condition. Correct responses were not associated with any gains in the no-reward condition. We asked participants to rate their momentary mood and stress level using a visual analog scale from 0 (bad mood) - 10 (good mood). With smileys at the anchor points (0= 

); (10= 

). Participants rated their momentary mood and stress level on a scale of 0 to 10 at baseline, at the beginning of the experimental session, and before and after each block for a maximal duration of the 20s. Participants were informed that they would receive the total sum in cash at the end of the session. Participants underwent a training phase before proceeding to the main task. A criterion of 70% correct responses was chosen to prevent arbitrary guessing and thereby verify understanding of the task and ensure that participants would win similar amounts of money.

Data Analysis

Analyses were calculated using IBM SPSS Inc 25. Normality tests were performed for mood and reaction time, and the data were found to be normally distributed using Shapiro-Wilk Test ($p > 0.05$). Descriptive statistics are presented in **Table 1** for both groups. Baseline mood ratings were compared

between groups using t-tests. We also performed exploratory analyses comparing the mean mood ratings between groups in the no-reward conditions to test the specificity of our results. To test the effect of reward on mood in participants in the sub-clinical pain group and the control group, a repeated-measures ANOVA was conducted, using mood as the dependent variable, with the following factors: groups (sub-clinical pain group and control group) as a between-group factor, reward conditions (monetary reward and no-reward) as within group factors. Additional mixed ANOVA using the same factors was applied using reaction time as the dependent variable to test the effect of reward on performance and to compare possible performance differences between the two groups of participants.

In addition, we postulated that there would be a significant positive correlation between mood ratings and monetary gains in the reward condition in the control group, but not in the sub-clinical group based on our previous study (Tandon, Ledermann, et al., 2022a). To test this hypothesis, the Pearson product-moment correlation between mood scores and monetary wins in reward conditions was performed separately in each group, similar to previous studies (Kalebasi et al., 2015; Martin-Soelch et al., 2009; Tandon, Ledermann, et al., 2022a).

Results

Reward and Mood

Average mood scores in the reward and no-reward conditions are summarized in **Table 4.** Baseline mood scores were 6.67 ± 1.62 (mean ± SD) for the control group and 6.37 ± 1.51 for the sub-clinical pain group. The results of the t-test showed no significant difference in mood between groups at the baseline (t_{54}) = 1.74, p = 0.88), suggesting both groups showed similar mood scores. We also performed exploratory analyses comparing the mean mood ratings between groups and the no-reward conditions and no significant differences were found (t_{59}) = 1.72, p = 0.09), suggesting both groups showed similar mood in no-reward conditions. The results of the repeated-measures ANOVA for mood showed no significant interaction effect between group and reward conditions ($F_{1,59}$ = 0.298, MSE = 0.528, p = 0.59, η^2_p = 0.001). A significant main effect was found only for the factor of reward ($F_{1,59}$ = 6.127, MSE = 31.88, p = 0.004 significant at 0.01, η2p = 0.07). Participants reported higher mood scores in response to reward (M = 7.00, SD = 1.80) compared to no-reward (M = 6.58, SD = 2.05). No significant

main effect of the groups was seen ($F_{1,59}$ = 0.002, MSE = 0.004, p = 0.96, η2p = 0.05).

Table 4: *Means and standard errors for mood scores in the reward and no reward conditions. The results of the t-test showed no significant difference in mood between groups at the baseline (t_{54}) = 1.74, p = 0.88).*

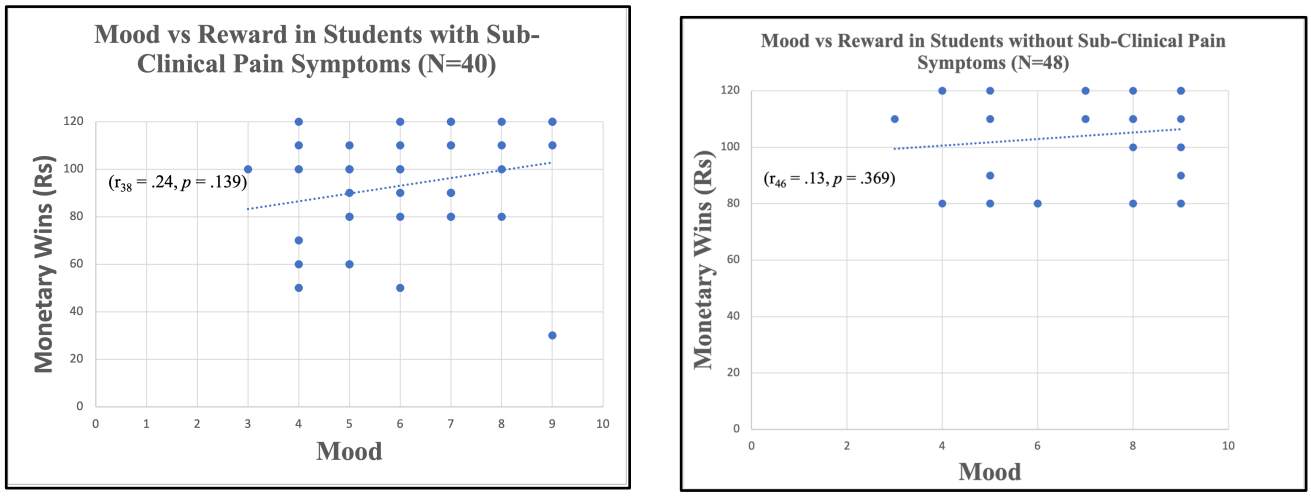
Groups	N	Reward Condition Mean ± SE	No-Reward Condition Means ± SE
Sub-Clinical	40	6.45 ± 0.33	6.50 ± 0.38
Control	48	7.51± 0.29	7.39 ±0.36

Note. This table demonstrates the scores of both the groups. The sub-clinical group showed lower mood scores than the control group.

Correlations Between Mood and Reward

Additional correlations were performed between mood scores and monetary wins. In the control group, no significant correlation was found between mood scores and monetary wins (r_{30} = -0.085, p = 0.646). Also, in the sub-clinical group, no significant correlation was found between mood scores and monetary wins (r_{27} = 0.11, p = 0.58) (See **Fig. 5**). Because non-parametric tests are more sensitive in the case of a non-linear association, we replicated the analyses using a non-parametric Spearman correlation and found that in the control group, no significant correlation was found between mood scores and monetary wins (r_{30} = -0.069, p = 0.709). Also, in the sub-clinical group, no significant correlation was found between mood scores and monetary wins (r_{27} = 0.254, p = 0.184).

***Figure 5**: Correlations between the mean mood scores and the amount of monetary reward received.*



Note. The above figures demonstrate the correlations between the mean mood scores and the amount of monetary reward. The value of the y-axis shows the sum win (in Rs) obtained by adding the monetary wins in reward conditions. The subjects as represented as dots ( ).

Reward and Performance

Results for reaction time in the two reward conditions are summarized in **Table 5.** The mixed ANOVA of reaction time showed no significant effect for the interaction between groups and reward conditions ($F_{1,63}$ = 0.003, MSE = 4160.893, p = 0.96, η^2_p = 0.00), A significant main effect was seen for the factor of reward ($F_{1,63}$ = 4.45, MSE = 6656851.47, η^2_p = 0.066, p = 0.03). Participants were slower in the no-reward condition (M = 7937.25, SD = 6084.73) compared to the reward condition (M = 7470.64, SD = 5572.71). No significant main effect of the groups was seen ($F_{1,63}$ = 0.198, MSE = 14077891.91, p = 0.66, η^2_p = 0.00).

Table 5*. Means and standard errors for Reaction Time (in ms) in the reward and no reward conditions.*

Groups	N	Reward Condition Mean ± SE	No-Reward Condition Means ± SE
Sub-Clinical	40	7470.65 ± 1034.83	7937.25 ± 1129.91
Control	48	8144.03± 1026.31	8587.87 ±1032.82

Note*.* Participants reported faster reaction time to reward trials as compared to non-reward trials.

Discussion

The main aim of the present study was to investigate the frequency of physical pain symptoms in a sample of university students in India. The second aim was to replicate our previous study conducted to investigate the relationship between monetary reward and pain (Tandon, Ledermann, et al., 2022a) in university students in Switzerland in a non-western cultural context i.e., in India. We hypothesized that students reporting physical pain symptoms would show a reduction in the effect of a monetary reward on mood ratings (i.e., reduced mood scores in response to reward) and performance (i.e., higher reaction times in response to reward) compared to the control group. To our knowledge, this is one of the first studies to study the interaction between pain and reward processes in the Indian sample.

Forty-five percent of the university students in India reported high levels of physical symptoms of pain, which are in line with our previous study conducted on a sample of students in Switzerland (Recabarren et al., 2019; Tandon, Ledermann, et al., 2022a). In general, studies show that students spend approximately 5 hours/day in a sitting position and prolonged sedentary behavior adds up to this problem (Kokic et al., 2019; Moroder et al., 2011). Specifically, in India, certain fields of education demand long working hours from students. For example, in the field of medicine, many competitive exams are conducted for undergraduate and postgraduate medical courses which are difficult to pass and lead to a lack of physical activity, stress, and excess use of laptops and phones (Santoshi et al., 2019). This makes

some students more prone to developing musculoskeletal pain-related issues (Behera et al., 2020). Regarding our hypothesis that the effect of reward on mood and performance would be reduced in participants with sub-clinical pain, our ANOVA results did not show any significant interaction between reward and groups neither for mood scores nor for the outcomes related to performance, i.e., reaction times. Even though, an effect was seen for reward (i.e., independently of pain status, participants' mood and faster reaction time to reward was higher compared to non-reward trials). Interestingly, the time taken by the participants to respond to the stimuli in our study was longer than 8000 ms. However, this is still an intriguing result, because the results obtained in a group of Swiss students showed mean reaction times between 1500 and 4000 ms and a previous study using this task also obtained average reaction times between 2500 ms and 3000 ms (Kalebasi et al., 2015). This could be related to the fact that no maximal reaction times were fixed in the version of the task used for this study. In addition, the task was performed online (due to the COVID situation) without the experimenter while in previous studies the experiment was performed in the lab with the presence of an investigator.

Our results did not show a significant correlation between mood ratings and monetary wins. Interestingly, this is not in line with our previous study conducted on university students in Switzerland (Tandon, Ledermann, et al., 2022a). In many previous studies which were performed on WEIRD samples, it is seen that pain alters the motivation to obtain reward and leads to reduced mood responses (Apkarian et al., 2004; Elvemo et al., 2015). However, we did not see this effect of pain on reward processes in the Indian students, although pain symptoms were reported in our sample. This might be explained as the experience of pain and pain-related impairments differ across cultures (Campbell et al., 2005; Edwards et al., 2001; Green et al., 2003). For instance, one of the studies on chronic pain conducted in India and the US showed that people in India endorsed high pain tolerance and less frequently experienced pain-related impairments as compared to their counterparts in the US (Nayak et al., 2000). On one hand, this could be explained as individuals in South Asian countries are encouraged to avoid pain due to a lack of financial support to seek a medical doctor as compared to western countries (Green et al., 2003; Unger & Schwartz, 2012) and on the other hand, this could also be explained as India is a collectivistic society (Jha & Singh, 2011) having strong family ties and friendship groups and many previous studies have shown that social

support which is one of the qualities of the collectivistic culture might act as a protective factor, leading to lower levels of high pain experience in people with chronic pain (Martire et al., 2013; Sturgeon et al., 2014). Secondly, pain-related impairments are often augmented by psychopathological problems (Dersh et al., 2002). For example, depression is ranked as one of the strongest predictors of back pain (Apkarian et al., 2013). According to Marbach and Lund (1981) and Garland et al. (2020), one of the reasons for blunted responses to monetary reward might be due to decreased interest and pleasure in response to positive stimuli (i.e. anhedonia) which is one of the key features of people suffering from depression and from a clinical standpoint, high rate of comorbidity between pain and depression has been seen in the previous studies (Blackburn-Munro & Blackburn-Munro, 2001; Rizvi et al., 2021). One of the studies conducted on university students in North America (N = 618) showed that students higher with psychopathological problems showed a higher prevalence of chronic pain (Lindsey et al., 2009) . In our sample, however, both groups did not differ with regard to depression scores and their mean scores were below the clinical threshold for clinically significant depressive symptoms. This might indicate that our sub-clinical population did not show pain-related impairment due to lower symptoms of psychopathological problems. However, there is a stigma related to mental health (at least to consulting a mental health specialist) in India (Gaiha et al., 2020; Venkatesh et al., 2015) and this might have biased the self-reported depression ratings. Finally, it is important to address that the cut-off for significant pain was the one available from Symptom Checklist-27-plus (Hardt, 2008a), and might not represent the reality of the Indian population. This aspect remains to be investigated in future studies.

Taken together, contrary to our previous findings in the Swiss students (Tandon, Ledermann, et al., 2022a), pain-related impairment on monetary-reward processes was not observed in this sub-clinical Indian sample. This shows that pain-related impairment may not be a universal phenomenon, and it can vary across cultures (Janca et al., 2006). Furthermore, it may show that different levels of pain are needed across cultures to reflect an impact on reward processing. Most of the previous studies related to pain were carried out in Western samples (Henrich et al., 2010a), and, to our knowledge, none of the studies have investigated the relationship between reward-pain from non-Western specifically from an Indian perspective.

The absence of replication of our findings with Swiss students in our Indian sample highlights the importance of investigating non-WEIRD populations, as there is an underrepresentation of studies focusing on non-WEIRD samples. For instance, people might tend to view pain-related impairments in reward processes as a universal human phenomenon, while this process might be more specific to some cultures than others. Therefore, our study conducted on Indian students fills this gap and provides insight into the fact that the blunted association between mood and reward in a sub-clinical population i.e., impaired responses to monetary reward might not be universal.

Some limitations merit attention. First, the measurement of pain based only on the Symptom Checklist-27-plus (Hardt, 2008a) is a limitation of the present study and the use of self-report instruments can lead to memory bias and greater subjectivity in the responses, in particular for questions related to stigma such as those related to depression. However, self-report is potentially the best way to obtain responses related to mood and pain. Also, the length of our online questionnaires may have led to less accurate answers due to fatigue, even though participants could take breaks. Second, transforming a variable from continuous (i.e., self-reported pain scores) to categorical (i.e., control group vs sub-clinical pain group**)** might have reduced the statistical power. In that context, using linear model analyses could have been better, considering the variability of our data. However, we chose a data analysis strategy that allowed for comparison with our previous study performed in a Swiss sample. Third, there was no cut-off given in the Symptom Checklist-27-plus (Hardt, 2008a) manual for the Indian population, the cut-off used in our study, was for a European population, which might not be representative of the Indian reality. Future studies should seek to validate this instrument in Indian and other non-WEIRD samples as well as determine specific cut-offs for these populations. Fourth, our data only comprised undergraduate students which limits the interpretation of our results to this population. Fifth, there was a trend seen in the p-value of HADS (Depression) to be statistically significant, however, the depression mean scores were below the threshold of a score of 11 for a significant depression score.

In conclusion, our findings provide very promising evidence of the cultural variations between pain and reward processes. Our study is the first to study the relationship between pain and reward in university students in India. This relationship in a sub-clinical population provides the first insight into

the development of culturally specific preventive interventions. This study also highlights that students all around the world are suffering from high symptoms of pain and more research is needed to explore the association between psychopathological problems and physical pain.

Mental Health markers and Protective factors in students with Symptoms of Physical Pain across WEIRD and non-WEIRD samples – a Network Analysis

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Abstract

Physical pain has become a major public health concern worldwide, with a high frequency among students. Research has shown that pain symptoms significantly impact around 54% of students every year in Western countries. While research in non-Western, Educated, Industrialized, Rich, and Democratic (WEIRD) samples is less frequent, we recently reported 45% of university students with physical pain symptoms in India. Prior studies conducted in Western societies identified specific factors, i.e., PTSD, depression, anxiety, perceived stress, and protective factors like social support and self-efficacy have been associated with physical pain. However, we expect that there might be possible differences between the two countries, i.e., India and Switzerland, due to the differences in their cultures. Our study aimed to understand the possible differences and similarities across non-WEIRD and WEIRD samples in the interaction between specific mental health markers (i.e., depression, anxiety, PTSD, perceived stress) as well as specific protective factors (i.e., social support and self-efficacy) and physical pain among university students using network analysis. Our results indicated no significant differences in the network structure of the two countries i.e., no significant difference was found between the mental health markers and protective factors related to physical pain in the two countries. PTSD symptoms came to be the most central symptom in both countries. However, for Swiss students, perceived stress and self-efficacy, and for Indian students, anxiety, other than PTSD symptoms were related to physical pain.

Keywords: Physical pain, mental health markers, protective Factors, network analysis, university students

Introduction

Physical pain has become a major public health concern worldwide, with a high frequency among students (Angst et al., 2017; Crawford et al., 2018). Research has shown that pain symptoms significantly impact around 54% of students every year in Europe (Ando et al., 2013), 49% in Switzerland (Tandon, Ledermann, et al., 2022), 66.9% in the United Kingdom (Mallen et al., 2005), and 17.5% (wrist/hand pain) to 31.4% (neck pain) in the Netherlands (Bruls et al., 2013). While research in non-Western, Educated, Industrialized, Rich, and Democratic (WEIRD) samples is less frequent (Henrich et al., 2010c), we recently reported 45% of university students with physical pain symptoms in India (Tandon, Ledermann, et al., 2022b; Tandon, Piccolo, et al., 2022).

Research in Psychology has been dominated by samples from the WEIRD countries for decades, this bias expands beyond the field of pain. For instance, a survey showed that 96% of the subjects in psychology research were from WEIRD nations (Arnett, 2016) even though such nations constitute only 12% of the world's population (Henrich et al., 2010b) while neglecting the rest of the world. This highlights the need for psychology to the fact that there is a need for broader psychological research that takes into account diverse cultures around the globe and the diversity of the population, especially focusing on cultural contexts (Arnett, 2016). For example, in countries like India and China, due to the strenuous demands of daily life, this might be due to unequal distribution of wealth, and higher rates of unemployment, people tend to value interdependence over independence (Kitayama, Duffy, & Uchida, 2006; Schlegel & Barry, 1991), especially in comparison to the western world, where living conditions are better. Also, families in developing countries tend to be larger and focus on family obligations and mutual support which is also part of a cultural milieu (Silverstein et al., 2006). Many findings from previous studies have shown that psychological processes are universal, for instance, the relationship between personality traits and depression studies (Boudouda & Gana, 2020) or the very famous Müller-Lyer illusion which was not experienced by non-WEIRD samples (Jones, 2010). These studies have focused on populations from high-income countries, and their findings should not be generalized to the entire human population or

considered a universal (Arnett, 2016). Therefore, it is important to replicate studies on non-WEIRD samples to make accurate predictions in the future and investigate the role of culture on the psychological processes investigated.

Although the pain has impaired reward processing (Becker et al., 2012; Gandhi et al., 2014), it is unclear whether this effect holds across cultures. For example, Swiss students with sub-clinical pain symptoms reported reduced mood responses to monetary reward (Tandon, Ledermann, et al., 2022b). However, this effect did not occur in Indian students with sub-clinical pain (Tandon, Piccolo, et al., 2022), although pain symptoms were reported in both samples (Tandon, Piccolo, et al., 2022). This might be explained as the experience of pain, and pain-related impairments differ across cultures.

Many mental health markers have been identified that increase (risk factors) or decrease (protective factors) the likelihood of physical pain experienced by young people. Students with physical pain are likely at high risk of developing psychopathological symptoms. For instance, undergraduate students in Canada suffering from lower back pain (*N*=1013) experienced high rates of depression (Robertson et al., 2017). Similarly, another study conducted by Unalan et al. (2009) on Turkish students (*N*=250) found a strong association between the deterioration of mental health due to physical pain. This might, in turn, lead to long-standing negative consequences for both the individual and society, such as lower academic achievements, dropouts, and problems in the future life (Harrer et al., 2019). Previous studies have sought to understand the relationship between several risk factors (such as post-traumatic stress disorder (PTSD) and physical pain symptoms. For example, a study conducted on adults (*N*=655) showed positive associations between exposure to trauma and pain (Kratzer et al., 2022). Similarly, another study showed a strong association between depressive and anxiety symptoms (Gómez Penedo et al., 2020), as well as higher perceived stress (Vives-Mestres et al., 2021) in people diagnosed with chronic pain and/or reporting higher pain severity. On the other hand, less is known about the protective factors that can help decrease the likelihood of physical pain. Protective factors are very important as the absence of risk factors does not predict a successful adaptation to pain (Ramírez-Maestre & Esteve, 2013). Therefore, focusing on protective factors might help in the management of physical pain and promote successful adaptation. In patients with pain, self-efficacy and social support acted as protective factors

and helped in the reduction of pain intensity (Brister & Baron, 2006; Fernández-Peña, 2018). For instance, a study conducted on women (*N*=82) living in Italy and experiencing chronic pain showed that self-efficacy and social support from family and friends were seen to be effective in coping with pain (Re et al., 2017).

Prior studies conducted in WEIRD and non-WEIRD societies identified specific factors, i.e., PTSD, depression, anxiety, perceived stress, and protective factors like social support and self-efficacy have been associated with physical pain. However, we expect that there might be possible differences between the two countries, i.e., India and Switzerland, due to the differences in their cultures. Considering that, to our knowledge, none of the studies so far have been conducted to investigate the interaction between mental health markers as well as protective factors associated with physical pain symptoms in the two countries (India and Switzerland), our study aimed to understand the possible differences and similarities across non-WEIRD and WEIRD samples in the interaction between specific mental health markers (i.e., depression, anxiety, PTSD, perceived stress) as well as specific protective factors (i.e., social support and self-efficacy) and physical pain among university students. To test that, we used network analysis. So far, to our knowledge, no network analysis has been conducted in this field to explore the relationship between psychopathological factors and protective factors with physical pain in university students. Network analysis approaches allow us to observe the dynamic relationship between symptoms, resulting in a network of connected symptoms that activates or influence symptoms, which in turn promotes the activation of other symptoms in a cascading system leading to the onset of a mental disorder (Borsboom, 2017). Identifying the strength of association between the specific factors and physical pain through a network approach and knowing the possible differences across two different cultures will help us in the future to develop an intervention that takes into account the cultural contexts.

METHOD

Participants

Participants were recruited through flyers and emails from several universities in India and Switzerland. Eligible students had to be at least be 18 years of age and have a good command of English (India) and French (Switzerland). **Table 1** provides the participants' demographics. A total of 188 students

(131 women, and 57 men) participated, reflecting a participation rate of 94%. Out of those, 87 students (M_{age} = 21.77 years, SD = 2.31; 50% Females) were from India, and 101 students were from Switzerland (M_{age} = 21.75 years, SD = 3.81; 87% Females). The mean age of the sample was 21.77 years (SD= 3.22 years). The socio-demographic characteristics of participants are shown in Table 1.

The study was approved by the Institutional Review Board at the University of Fribourg in Switzerland (2017/IRB 334A). Participants were thoroughly informed about the study and gave their consent. All research was performed according to the Declaration of Helsinki. The privacy rights of participants were always observed and preserved during our study.

Procedure

An online link to the survey was sent to the students from the universities in Switzerland and India. Online informed consent was obtained from all participants. The participants were allowed to terminate the survey at any time they desired. The survey was anonymous, and the confidentiality of information was maintained. Data were collected from April 2020- April 2021. The data was collected using LimeSurvey® software (LimeSurvey GmbH, Hamburg, Germany. URL http://www.limesurvey.org).

Psychometric Measures

Symptom Checklist (SCL-27-plus)

The Symptom Checklist (SCL-27-plus; (Hardt, 2008a) is a multidimensional assessment instrument for mental health status. With 27 items rated on a 5-point Likert-type scale from 0 “never” to 4 “very often”, it consists of five dimensions: actual depression (5 items), vegetative symptoms (5 items), agoraphobic (4 items), and social phobia (5 items) and pain symptoms (6 items). A lifetime assessment for depressive symptoms (5 items) and screening questions for suicidality (3 items) are also included. The global score can range from 0 up to 100. The overall Cronbach’s alpha coefficient in this study was 0.92.

Hospital Anxiety and Depression Scale (HADS)

The Hospital Anxiety and Depression Scale (HADS; (Bocéréan & Dupret, 2014b; Zigmond & Snaith, 1983) is a self-assessment scale for the screening of depression and anxiety symptoms (Hardt, 2008a). It consists of a 14-item scale (7 relating to anxiety symptoms and 7 to depression); each item is coded 0 to 3. The total score can range from 0 to 42. The clinical cut-off score on depression or anxiety scales is equal to or greater than 11 on any symptoms. The overall Cronbach’s alpha coefficient in this study was 0.91.

Perceived Stress Scale (PSS)

The Perceived Stress Scale (PSS; (Cohen et al., 1994; Lesage et al., 2012) is a well-validated instrument used for measuring the perception of stress, assessing the degree to which situations in one's life are appraised as stressful. There are 14 items on a 5-point Likert-like scale from 0 "never" to 4 "very often", designed to tap into how unpredictable, uncontrollable, and overloaded respondents find their lives. A total score is calculated by adding the 14 items (0 to 56), with higher scores indicating higher levels of perceived stress. A total score higher than 20 indicates high perceived stress and a total score less than 20 indicates low perceived stress on this scale. The overall Cronbach's alpha coefficient in this study was 0.70.

Posttraumatic Stress Disorder Checklist (PCL-5)

The PTSD Checklist (PCL-5, [Weathers, Litz, et al., 2013]) is a new self-report rating scale for assessing post-traumatic stress disorder (PTSD). The PCL-5 is a 20-item self-report measure designed to assess the *DSM–5* symptoms of PTSD. For each symptom, respondents provide a severity rating ranging from 0 to 4 that indicates the degree of distress associated with each symptom (0 " *not at all"* to 4 "*extremely")*. PTSD symptoms severity is measured by summing scores across the 20 items. A total score ranges from 0- 80. The cutoff score between 31-33 is indicative of probable PTSD. The overall Cronbach's alpha coefficient in this study was 0.70.

Statistical Analysis

Network estimation. We estimated a partial correlation network between mental health markers and protective factors associated with physical pain symptoms in university students in India and Switzerland. Data were inputted into JASP (Version 0.14.1.0), a statistical software package (https://jasp-stats.org), with analyses written in either R or C++ used in the study to conduct the network analysis (Epskamp, Borsboom & Fried, 2018). Networks were created using the *qgraph* (Epskamp et al., 2012) R-package. With this package, a partial correlation network was created using the Extended Bayesian Information Criterion Graphical Least Absolute Shrinkage and Selector Operator (EBICglasso) method, an operation adjusted from the Least Absolute Shrinkage and Selector Operator (LASSO) regularization method (Tibshirani, 1996). The EBIC glasso method estimates the partial correlation between all variables, shrinking absolute weights to zero. This shrinkage occurs when data values are shrunk towards the mean, resulting in smaller edge weights shrunk to zero and subsequently reducing the need for a test for multiple comparisons. The hyperparameter, which determines the degree of shrinkage, was set to 0.5, which is the default for EBICglasso on excluding spurious edges (Epskamp et al., 2018). These networks can be visualized such that nodes (mental health markers and protective factors) appear as circles connected by lines representing the edge weights (i.e., the partial correlation between individual nodes). Thicker lines

represent a stronger absolute magnitude of correlations, with blue lines representing positive associations and red lines representing negative associations.

Centrality. Centrality indicates the extent to which any given node (mental health markers and protective factors) is important in the overall network. We examined strength centrality for each node within the Swiss and Indian networks, which represents the sum of absolute edge weights connecting that node to all other nodes in the network. We used *degree* centrality (rather than other indices of centrality such as closeness or betweenness). It.I is usually more stable than other centrality indices (Epskamp et al., 2018).

Network comparison. Lastly, we compared mental health markers and protective factors with symptoms of physical pain networks between Indian students versus Swiss students by using the *NetworkComparisonTest* (NCT) package in R (Van Borkulo et al., 2022) using 1000 iterations. NCT compared networks, estimated with EBICglasso (Epskamp et al., 2012), on both network invariance and global strength. Network invariant structure (*M*) represents the extent to which the structure of the network as a whole (i.e., distribution of edge weights) is identical across groups (i.e., Indian versus Swiss students). Global strength (*S*) represents the extent to which the overall connectivity among nodes is similar across groups, regardless of similarities or dissimilarities in network structure.

Results

Descriptive statistics for the network variables are presented in Table 1. Indian students (N= 87) versus Swiss students (N = 101) did not differ in age ($t_{(187)=}$ 0.49, p=0.64) and gender ($t_{(187)=}$ 0.47, p=0.69) . No statistical difference was seen in pain scores between the two groups (p=.11). However, a statistically significant difference was seen for depression (p <.001), perceived stress (p <.001), and social support (p <.001), between the two groups. We found that Swiss students had higher stress levels as compared to Indian students, whereas Indian students reported higher levels of depression compared to the Swiss students. Social support seemed to be higher in Swiss students than the Indian students.

Graphical LASSO and strength centrality

Regularized partial correlation networks are presented in Fig 6. (left: Swiss students; right: Indian students). Degree centrality indices (Table 6) indicated the most important nodes for Swiss samples were perceived stress (*PSS*), post-traumatic stress disorder (PCL), and self-efficacy (GSES), while for the Indian sample, the most important nodes were anxiety (HA) and post-traumatic stress disorder (PCL).

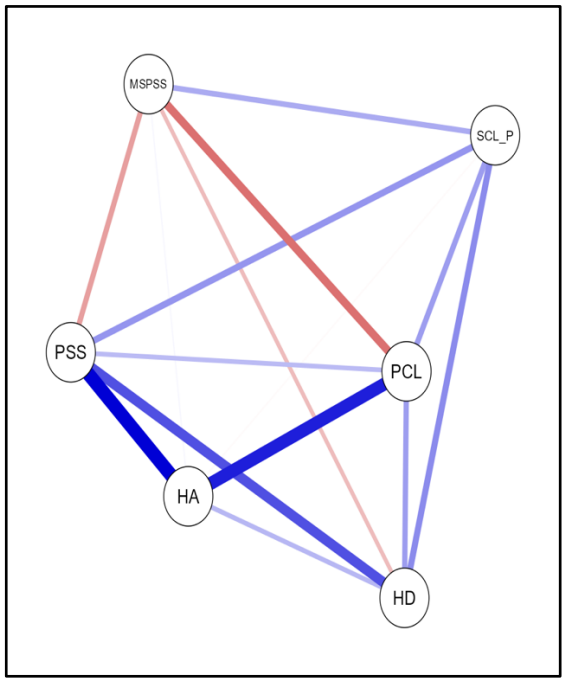
Table 6: *Centrality measures per variable*

Factors	Swiss Students (*N*=101)				Indian (*N*=87)			
	Betweenness	Closeness	Strength	Expected influence	Betweenness	Closeness	Strength	Expected influence
Pain	-0.816	-0.947	-1.082	0.242	-0.598	-1.066	-0.997	-0.519
Anxiety	0.408	0.404	0.223	0.805	1.793	1.399	1.614	0.650
Depression	-0.816	-0.453	-0.088	0.224	-0.598	0.145	-0.108	0.406
Stress	1.633	1.298	1.343	0.633	-0.598	0.019	-0.201	0.529
Social Support	-0.816	-1.152	-1.170	-1.960	-0.598	-1.187	-0.960	-1.817
PTSD	0.408	0.850	0.775	0.056	0.598	0.690	0.652	0.751

Note. This table demonstrated the centrality measures of each variable in Swiss and Indian Students. For, the Swiss sample perceived stress (*PSS*), post-traumatic stress disorder (PCL), and self-efficacy (GSES) came out to be the most central symptoms, while for the Indian sample, the most important nodes were anxiety (HA) and post-traumatic stress disorder (PCL).

Network comparison test

NCT results indicated that no statistically significant difference was found between mental health markers (i.e., depression, anxiety, perceived stress, and PTSD) and protective factors (i.e., social support and self-efficacy) associated with physical pain symptoms for Swiss students versus Indian students ($M = 0.325$, $p = .11$). Networks for Swiss versus Indian students did not differ in global strength ($S = 0.29$, $p = .803$).



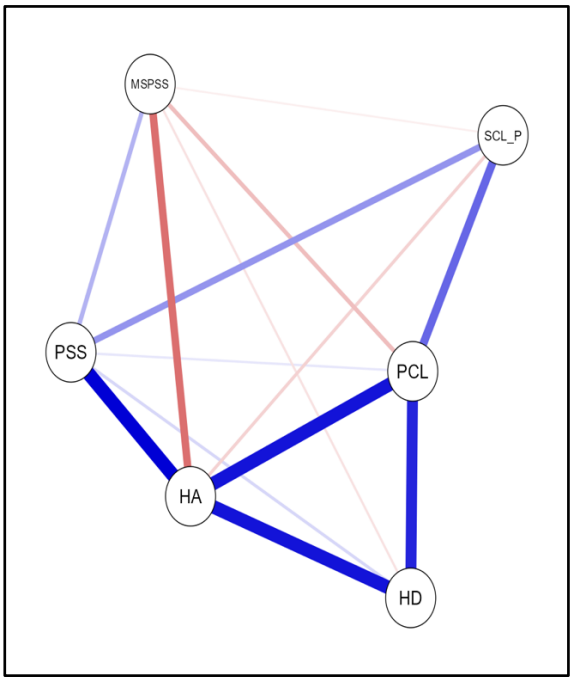


Fig.6(a) Swiss students **Fig. 6(b) Indian students**

Fig 6: Shows the Network structure of the two countries using the Regularized partial network — Glasso method between mental health markers and protective factors with physical pain. SCL_P: physical pain; HA: anxiety; HD: depression; PSS: perceived stress; PCL: post-traumatic stress disorder; MSPSS: social support. The blue color shows a positive relationship vs. red color a negative relationship and the width of the lines (assumed to correspond to the strength of the relationship).

Discussion

This study aimed to understand the possible differences across non-WEIRD and WEIRD samples in the interaction between specific mental health markers as well as specific protective factors and physical pain among university students in India and Switzerland. To our knowledge, this is the first study to acknowledge these possible differences using a network analysis approach. In this study, we saw that 52% of the Swiss students suffered from high levels of anxiety, 55% of them struggled with perceived stress as compared to the Indian students, and 26% of the Indian students suffered from depression. We found that our groups differ in depression, perceived stress, and social support scores. Surprisingly, our study found that social support seemed to be higher in Swiss students than the Indian students. This is contrary to the intuitive prediction based on the relationships between WEIRD and non-WEIRD countries. This counterintuitive cultural pattern may be explained as in Western countries, relationships are seen as promoting individual goals. For instance, one may seek help from their immediate environment to achieve personal goals (Fiske et al., 1998), whereas in collectivistic cultures, a person is fundamentally connected

to others, and the emphasis is placed on group harmony and any efforts made to bring personal problems to the attention of the others may harm the group harmony (Kim & Markus, 1999). This might lead people from non-WEIRD societies not to seek help from their immediate environment. One of the studies conducted on Korean students (*N*=56) and American students (*N*=56) showed similar results, American students were more likely to mention using social support as a coping strategy than Koreans (Taylor et al., 2004). Also in our study, we found that Swiss students had higher stress levels than Indian students, whereas Indian students reported higher levels of depression than Swiss students. This highlights that mental health is a major health concern in developing and developed nations, although mental health markers might differ across countries. countries

Interestingly, in our network analyses, perceived stress, self-efficacy, and PTSD symptoms were the most central symptoms in Swiss students, whereas anxiety and PTSD symptoms were the most central symptoms in Indian students. No significant differences were found in network structure and global strength. PTSD symptoms seemed to be the most central symptom in both networks, regardless of age and gender. This is consistent with the previous findings that trauma is a global mental health marker (Koenen et al., 2017). According to Benjet et al. (2016), cross-national data revealed that 70% of the population in the 24 countries studied, including western and non-western countries, reported exposure to a traumatic event once in their lives. Also, self-efficacy came out to be a central symptom in the Swiss network. This aligns with Klassen (2004) findings that self-efficacy plays an important role in Western countries having individualistic values as compared to non-Western countries. For instance, in one of the studies, American managers (*N*=288) rated their self-efficacy, measured at the specific task level, significantly higher than did the Chinese managers (*N*=288) (Earley, 1999). Also, in the Swiss network, perceived stress came out to be a central symptom. University students all around the world struggle with various stressors, including the transition to college, parental pressure, fear of failure, parental or relationship problems, and finances (Teixeira et al., 2022). In the Indian network, anxiety came out to be a central symptom. This is quite common in Indian students as there is continued pressure from society on students in India to excel in studies and secure a job due to increasing unemployment (Kamboj et al., 2023). One of the studies conducted on medical students (*N*=686) in India showed that 34% of university

students struggled with anxiety due to a high level of competition in passing the examination and parental pressure (Sarkar et al., 2017).

From the above results, we can say that the high level of frequency of physical pain among the university students of India and Switzerland might be due to the mental health markers, specifically PTSD symptoms, stress, and anxiety that were related to physical pain and it is similar for both the countries. Many studies have reported that physical pain is often associated with psychopathological problems (Dersh et al., 2002; Polatin & Mayer, 1996). This relationship is well-documented in the literature (Gatchel, 2004). Kroenke et al. (1994) reported that people with stress, anxiety, or depressive disorders have more physical pain symptoms, and conversely physical pain symptoms increase the likelihood of stress, anxiety, or depressive disorders. On the other hand, our results might to some extent reflect the fact that our data was collected during the COVID-19 lockdown, a situation which might have increased the mental health problems faced by the students.

Network theory predicts that a clinical intervention targeting the central symptoms in the network should lead to a reduction in other symptoms (Borsboom & Cramer, 2013). Our study suggests that designing an intervention targeting perceived stress, depression, anxiety, and PTSD and increasing self-efficacy in the Swiss population might lead to the reduction of physical pain symptoms.

A notable strength of our study is investigating the mental health markers and protective factors in university students using a network approach in two different cultural contexts. To our knowledge is the first study to explore this. Keeping in mind, the cultural context while designing an intervention for the future will help. Even if our network comparisons brough forth more similarities than differences, it is essential to take full account of cultural specificities because they can be pivotal to understand and meaningfully handle both risk and protective factors.

Several limitations deserve to be mentioned. First, the use of self-report instruments in our study can lead to memory bias and greater subjectivity due to social desirability bias in the responses, in particular for questions related to stigmas such as those related to depression or other mental health problems, especially in India where stigma towards, and discrimination against, people with mental

disorders is an important barrier to mental health service utilization. Also, the length of our online questionnaires may have affectedaffected participants' responses due to fatigue, even though participants could take breaks. Second, the cut-off used in our study was for a Western population, which might not be representative of Indian reality as well as a lack of validation of instruments in the Indian population. Future studies should seek to validate these instruments in Indian and non-WEIRD samples and determine specific cut-offs for these populations.

In conclusion, our findings provide promising evidence of the cultural variations between mental health markers and protective factors related to physical pain in the two countries. Our study is the first to explore this relationship using the network analyses approach. This relationship with the university students provides the first insight into the development of culturally specific preventive interventions.

CHAPTER 8: GENERAL DISCUSSION

The purpose of the present thesis was to examine the relationship between physical pain symptoms and reward processes in the sub-clinical population i.e., in university students, and to do so in two different cultural contexts, i.e., in Switzerland and India. To our knowledge, this relationship has not yet been explored in a non-WEIRD cultural context and there is a high frequency of physical pain symptoms among Indian students. We also wanted to understand the relationship between physical pain symptoms and potential risk factors, in particular symptoms of PTSD, depression, anxiety symptoms, and perceived stress, and to investigate the incidence of protective factors such as social support, and self-efficacy in relation to high physical pain in students of both countries, since these aspects are not yet documented.

To answer these questions, the first aim of this thesis was to investigate the frequency of physical pain symptoms in a sub-clinical population of university students in Switzerland and the effect of pain on the mood to monetary reward in participants of the control group (without any clinically significant physical pain symptoms) and sub-clinical group (participants with clinically significant physical pain symptoms). The second aim of this thesis was to investigate the frequency of physical pain symptoms in a sample of university students in India, replicating the study conducted in Switzerland in a non-WEIRD cultural context. The third aim of this thesis was to understand the relationship between specific mental health markers (i.e., depression, anxiety, PTSD symptoms, perceived stress) as well as specific protective factors (i.e., social support and self-efficacy) and physical pain among university students across two cultures (i.e., Switzerland and India).

Our results showed that university students of the sub-clinical groups reported high levels of physical symptoms of pain both in India (45%) and in Switzerland (49%). We observed a significant correlation between mood responses and monetary wins (amount won) in Swiss students of the control group, but not in the sub-clinical group. Interestingly, the Indian students of the control group showed no significant correlation between mood ratings and monetary wins in the control group. We went further to compare the relationship between specific mental health markers, protective factors, and physical pain, using network analysis. We found no significant difference between mental health markers and protective

factors related to physical pain in the two countries. PTSD symptoms came out to be the most central symptom in both countries. However, for the Swiss students, the two most central symptoms other than PTSD symptoms, were perceived stress and self-efficacy that were related to physical pain. For Indian students, the most central symptom, other than PTSD symptoms, was anxiety. Additional analysis revealed significant statistical differences between the two countries. The two countries showed significant statistical group differences regarding perceived stress, depression, and social support. Swiss students emphasized social support and perceived stress; Indian students showed greater importance to depression.

The above results make us question the fact that what could be the reason behind the high frequency of physical pain observed in students in both countries. Interestingly, based on our results we can say that it might be due to the mental health markers, specifically PTSD symptoms, stress, and anxiety that were related to physical pain. Many studies have reported that physical pain is often associated with psychopathological problems (Dersh et al., 2002; Polatin & Mayer, 1996). This relationship is well-documented in the literature (Gatchel, 2004). Kroenke et al. (1994) reported that people with stress, anxiety, or depressive disorders have more physical pain symptoms, and conversely physical pain symptoms increase the likelihood of stress, anxiety, or depressive disorders. A high rate of comorbidity between pain and depression has been evidenced in various studies (Blackburn-Munro & Blackburn-Munro, 2001; Rizvi et al., 2021). In our study, PTSD symptoms came out to be the most strongly related to physical pain in the students of both countries. On the one hand, this is consistent with the existing literature that says trauma is a global mental health marker (Koenen et al., 2017), and with Benjet et al. (2016), who mentions that 70% of the youth population in the 24 countries studied, including western and non-western countries, reported exposure to a traumatic event once in their lives. On the other hand, our results might to some extent reflect the fact that our data was collected during the COVID-19 lockdown, a situation which might have increased the mental health problems faced by the students. Taken together, our results confirm that the high frequency of physical pain symptoms among students is not only due to long-sitting hours but also to the psychopathological symptoms related to physical pain.

Our results showed that pain impaired the reward processing in the sub-clinical group of Swiss students, but it was not the case in the corresponding Indian group. This indicates that pain-related impairment might not be a universal phenomenon and can differ across cultures. Our sample mainly comprised university students recruited from different universities in India and Switzerland sharing the same educational level and age, but it was still representative of certain WEIRD and non-WEIRD cultural aspects. Therefore, the reason behind this could be explained by possible cultural differences. For instance, the threshold for physical pain was mainly designed for the western population and might not have been high enough to cause impairment in the non-western i.e., in the Indian sample. The research observed that people in India endorsed high pain tolerance and less frequently experienced pain-related impairments as compared to their counterparts in the United States (Nayak et al., 2000). Another reason could be that people in India tend to ignore the pain until it interferes with their daily lives, and this might be due to the lack of access to medical care facilities and finances to afford proper treatment. For instance, greater delays were experienced by south Asians compared with Europeans in receiving appropriate care for their chronic pain problems until it affected their normal routine (Chaturvedi et al., 1997).

Finally, based on our results, we can say that physical pain was reported by many university students in Switzerland and in India. This high frequency of pain could be due to the psychopathological symptoms associated with physical pain which are similar in both countries. However, in our work, we also saw that a specific protective factor i.e., self-efficacy seemed to be strongly related to physical pain in the Swiss students. This aligns with the findings of Klassen (2004), which show that self-efficacy plays an important role in Western countries. For instance, in comparison with people from Western countries (like, the USA, Canada, and countries in Europe), people from Asian countries demonstrated low levels of self-efficacy (Schmitt & Allik, 2005), and this might be due to the cultural norms of modesty that makes them suppress their self-efficacy scores and make them less boastful about their talents and competencies (Cai et al., 2007; Heine et al., 2007; Sedikides et al., 2003). The role of the protective factors is to help individuals in the management of physical pain and to promote a successful adaptation (Jegan et al., 2017). Therefore, self-efficacy could play a key role in the design of an intervention aimed at Swiss students. Interestingly, in the additional analysis of group comparison (i.e., Indian students versus Swiss

students), we saw that social support came out to be high in Swiss students as compared to Indian students. However, this was contrary to our predictions based on the existing literature. A possible explanation for this counterintuitive cultural pattern might be that in western countries, where individualistic values prevail, people may seek help from their immediate environment to achieve personal goals (Fiske et al., 1998), whereas in non-western countries, with collectivistic cultures, where a person is fundamentally connected to others, and the emphasis is placed on the harmony of the group, and any efforts made to bring personal problems to the attention of the others may harm that harmony (Kim & Markus, 1999). For example, in Asian cultures such as India, China, and Japan, cultural beliefs discourage people from talking about their problems to friends and family for fear of disturbing the relational harmony (Lee, 1996; Matsumoto, 1996; Taylor et al., 2004). Also, in many Asian nations, seeking help from others is often associated with a loss of face and feelings of shame (Matsumoto, 1996). All this might be the reason for the high social support in Swiss students as compared to their Indian colleagues.

The above results bring us to the conclusion that physical pain is quite common among university students in India and in Switzerland, and this is related to various mental health problems. Physical pain impaired the reward processes which plays an important role in students' learning processes in educational settings. Physical pain among university students is not only due to long-sitting hours for students: psychopathological symptoms are at play as well. Interventions designed to targeting perceived stress, depression, anxiety, and post-traumatic stress and to increase self-efficacy might reduce physical pain symptoms. Keeping in mind, the cultural context while designing an intervention for the future will help. Even if our network comparisons brought forth more similarities than differences, it is essential to take full account of cultural specificities, because they can be pivotal to understand and meaningfully handle both risk and protective factors.

8.1 LIMITATIONS AND METHODOLOGICAL CONSIDERATIONS

Along with the encouraging findings they brought forth, our empirical works should be seen in the context of several limitations, described hereafter. These limitations have the advantage to point out the methodological challenges future studies will need to address.

8.1.1 Measure of Pain and other self-report measures

The fact that the measurement of pain was based only on the SCL-27-plus (Hardt, 2008) is certainly a limitation of this thesis. W used other self-report instruments for other mental health problems even though we were aware that they can lead to memory bias and greater subjectivity in the responses due to social desirability bias, in particular for questions related to stigmas such as those related to depression or other mental health problems. This is especially true in India where stigma towards, and discrimination against, people with mental disorders is an important barrier to mental health service utilization. However, self-report is potentially the best way to obtain responses related to mood and pain and they are easy to use and require little training before using them.

Also, the length of our online questionnaires may have led to less accurate answers due to fatigue, even though participants could take breaks.

8.1.2 Sample

Our sample for empirical work I and II consisted of mainly female students, which limits the generalization of our results. For empirical work III, we conducted a network analysis. The use of a big sample might have been a better option to identify the possible differences between the two countries, though there are no criteria given for it.

8.1.3 Methodology

We transformed a variable from continuous (i.e., self-reported pain scores) to categorical (i.e., control group vs sub-clinical pain group**)**, which might have reduced the statistical power. In that context, using linear model analyses could have been better, considering the variability of our data (Royston et al., 1999).

8.1.4 The cut-off for measuring pain for the Indian sample

The questionnaires used in our study were mostly designed for the Western population. For instance, in the SCL-27-plus the cut-off was set for a Western population, not for Indians; it was possibly not representative of the Indian reality, as the level of physical pain differs across cultures. Future studies should seek to validate this instrument for Indian and other non-WEIRD samples, and to determine specific cut-offs for these populations.

8.2 Strengths and Future Directions

In the present thesis, we focused on (i) the relationship between physical pain and reward processes in the sub-clinical population in Switzerland, (ii) the relationship between physical pain and reward processes in the sub-clinical population in India, and (iii) identifying the strength of association between specific psychopathological symptoms and protective factors related to physical pain. We chose a network approach, although we knew the possible differences between the two different cultures. The three empirical works developed in this thesis provide encouraging findings that open new questions and avenues.

First, our results suggest that pain-related impairment can also be observed in a sub-clinical population i.e., in university students. A large extent of studies documented that people suffering from chronic pain might show dysfunctional reward processing including reduced mood responses to a monetary reward task (Treadway & Zald, 2011). However, it remains often complex to disentangle the influence of medication on the behavioral effect of reward on mood and performance. To our knowledge, the results from this study are the first to suggest that changes in the reward-pain interaction can be identified in the sub-clinical pain population and therefore provide information about the effect of pain on the processing of reward without the limitation of medication and treatment. Therefore, further studies are needed to investigate these processes in sub-clinical populations.

Second, our findings indicate that the cultural context has an impact. Most of the previous studies, performed on WEIRD samples, show that pain alters the motivation to obtain rewards and leads to reduced

mood responses (Apkarian et al., 2004; Elvemo et al., 2015). However, we did not see this effect of pain on reward processes in the Indian students. This indicates that pain and pain-related impairments differ across cultures. To the best of our knowledge, there has been no replication of the findings on a non-WEIRD sample, which highlights the importance of investigating non-Western populations, as there is an underrepresentation of studies focusing on non-WEIRD samples. Therefore, the part of our study conducted on Indian students fills this gap and provides insight into the fact that the blunted association between mood and reward in a sub-clinical population, i.e., impaired responses to monetary reward, might not be universal. Future studies should seek to use a well-validated pain scale specially designed for the Indian population while keeping given levels of pain experienced by Indians and determining specific cut-offs for this population.

Finally, we explored the psychopathological symptoms and protective factors associated with physical pain in the two countries, i.e., Switzerland and India, to identify the possible differences using a network analysis approach. To our knowledge, this is the first study to explore this. Our results provides a first insight into the development of culturally specific preventive interventions. Future studies should seek to include well-validated instruments, designed specifically for Indian populations, to measure mental health problems as well as protective factors. In addition, instead of having all questionnaires in the form of self-reported measures, it might be useful to include short interviews to have a more accurate idea of the problems.

Also, small sample sizes have restricted the analyses and interpretations of findings as discussed in the limitations. They nevertheless contribute to making a step towards a better understanding of the possible cultural differences.

In sum, our work has the potential to help to building a clearer understanding of pain and reward processes, and of the factors related to physical pain, in order to draw new cultural-specific prevention and treatment procedures.

8.3 Societal Implication of our Work

We highlighted the fact that it is important to take into account the possible cultural differences when conducting studies on pain-related impairments across countries. In our theoretical background, we

stressed the fact that Western knowledge is still considered universal in nature, ignoring the plight of huge numbers of non-Western people. Through this work, we want to emphasize the necessity to replicate the studies conducted on the Western population in non-Western cultural contexts, using methodologies that are validated and adapted for that population.

We also found some similarities across countries. For instance, mental health markers related to physical pain are similar in both countries and they are strongly related to physical pain. These findings have important clinical implications because they suggest that interventions should focus on weakening the connections between these specific mental health markers and that this reduction in symptom connections might be conducive to healthier functioning.

CHAPTER 9: CONCLUSION

In general, reward systems drive our behavior towards pleasurable stimuli such as food, sex, alcohol, etc.; the motivation to pursue, experience, and/or learn about these rewards is crucial in ensuring survival and well-being (Berridge, 2004). In students specifically, the mechanism of reward plays an important role in motivating them to learn with more enthusiasm and purpose, which increases the learning outcomes. Rewards also encourage them to put more effort into their work. If this reward process is altered, it may contribute to an individual's vulnerability to psychopathology following various mental health problems. Previous research has shown that lower levels of motivation to receive rewards are associated with higher levels of both depression symptoms and other mental health problems (Kasparek et al., 2020; Vujanovic et al., 2017). For instance, many studies evidenced that people suffering from chronic pain have reported lower arousal ratings and showed reduced blunted responses to reward during monetary reward anticipation, which is related to lower estimated reward, in comparison to healthy controls (Martucci et al., 2018; Turner et al., 2021). This shows that pain impairs reward processing (Becker et al., 2012; Gandhi et al., 2014). But to the best of our knowledge, not many studies have been conducted to investigate this relationship between reward and pain in sub-clinical population, as this can provide information about the effect of pain on the processing of reward without the limitation of medication and treatment.

In this framework, the objective of the present thesis was to provide a better understanding of the pain-related impairment in the reward processes in a sub-clinical population i.e., in university students, and to explore further this relationship in a different cultural context, i.e., in Indian students, as most of the previous works to the best of our knowledge have been done on Western samples. Our findings indicated that pain-related impairment in monetary-reward processes was observed in this sub-clinical population in Switzerland, whereas it was not observed in the sub-clinical Indian sample. This finding suggests that pain-related impairment may not be a universal phenomenon and that it can vary across cultures. Also, our results gave new insights into the relationship between psychopathological symptoms and physical pain, as well as between protective factors and physical pain. We wanted to explore the reason behind the high frequency of physical pain among students and the possible differences between

the two cultures. Our results indicated that symptoms of PTSD were found to be strongly related to physical pain in both countries. However, perceived stress was found to be the most central symptom associated with physical pain in the Swiss network, and anxiety appeared to be the most central symptom in the Indian network. Also, self-efficacy came out to be an important protective factor among Swiss students. These findings show the possible differences between the two cultures and might yield first insights to develop cultural-specific preventive interventions which aim to improve reward mechanisms in students, interventions that could be further used in chronic pain patients.

Finally, the empirical works developed in this thesis will contribute, in the long run, to provide new insights enabling the emergence of more efficient prevention for pain-related psychopathological symptoms which might in turn reduce the high frequency of physical pain among students.

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