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Nexus, uncovered: on the relations between expectancy, avoidance, and somatic sensations

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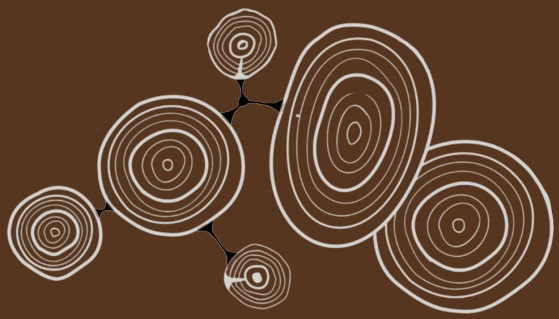
CHAPTER 6



Summary and General Discussion

SUMMARY

As chronic somatic symptoms continue to impact the lives of individuals worldwide, it becomes increasingly important to identify the mechanisms behind chronic somatic symptoms. It has been established in the literature that expectancy (i.e., a general construct that refers to the anticipation of something that will or is about to happen) and avoidance are two key mechanisms that can influence somatic sensations. Throughout the years, theoretical works have been proposed that allude to the dynamic interaction between expectancy and avoidance behavior in somatic sensations, yet these mechanisms are often investigated as two separate entities. Thus, this dissertation aimed to get a better understanding of the expectancy-avoidance relationship which together can influence somatic sensations beyond its functional period, and when targeted, may also help decrease chronic somatic symptoms in the long term. The relationship between these cognitive and behavioral mechanisms was investigated in five different studies. Firstly, a theoretical review was conducted to summarize the evidence on the relationship between expectancy and avoidance in **Chapter 2**. From this, a theoretical model was proposed on the expectancy-avoidance relationship. Then, three experimental studies on pain and itch were conducted to pinpoint whether induced negative expectancies can increase avoidance behavior in **Chapters 3** and **4**. Finally, in **Chapter 5,** the relationship between expectancy, avoidance, and other related psychological mechanisms that constitute cognitive-affective and behavioral factors was observed using an ecological momentary assessment in individuals with chronic low back pain. By investigating the interplay between expectancy and avoidance behavior we can identify the conditions under which they would worsen somatic sensations, thus providing stronger targets to improve treatment. This current chapter will begin by summarizing the findings of this dissertation and continue with the general discussion of the results and their implications.

In **Chapter 2**, we described the state of the art of the expectancy-avoidance relationship in relation to pain, itch, and fatigue, and proposed an integrative theoretical model of how we can perceive somatic sensations through the lens of predictive coding and active inference (i.e., the way we perceive the world through a series of predictions made based on information that we receive from internal and external cues). In this chapter, we illustrate how the relationship between expectancies and avoidance has evolved throughout the years. Despite finding little attention to the expectancy-avoidance relationship in the field of itch and fatigue, we found a growing number of indications that expectancies influence avoidance, but mixed and sparse empirical findings on whether the opposite relationship can occur. We concluded this chapter with a call for more research to investigate the role of expectancies and avoidance across different somatic sensations.

As we found a scarcity of studies directly investigating the role of expectancies and avoidance in **Chapter 2**, we conducted an empirical study that directly investigated this relationship in individuals without chronic pain in **Chapter 3**. In this chapter, we conducted two related experimental studies to test a novel pain avoidance paradigm that measured costly pain avoidance behavior after hyperalgesia induction (i.e., increased sensitivity to pain) using verbal suggestions and classical conditioning. The avoidance paradigm involved playing different versions of a game called the "Tower of Hanoi" that varied in difficulty levels. In both studies, participants could choose between playing a difficult version of the game with a higher chance of receiving less pain or playing an easier version of the game with a higher chance of receiving more pain. Here, costly pain avoidance was measured by selecting the difficult version of the game. Results from *Study 1* and *Study 2* demonstrated that negative expectancies did indeed lead to hyperalgesia, but that it did not lead to more pain avoidance behavior. Notably, participants reported low levels of fear of pain in both studies which may partly explain the lack of pain avoidance behavior. Our findings suggest that other cognitive-affective mechanisms may be at play in the relationship between negative expectancies and pain avoidance behavior in individuals without chronic pain.

To examine the expectancy-avoidance relationship further, we continued our investigation in **Chapter 4** where we evaluated negative expectancy effects on costly avoidance behavior in itch. In this chapter, we induced negative itch expectancies by applying different amounts of cowhage spicules, which are the hairs of a tropical bean that have been known to induce itch. Furthermore, we measured avoidance behavior through effortful gripping and measured this behavior using a dynamometer. This avoidance behavior was selected because gripping, or fist clenching, is often used to prevent scratching an itch but has associated costs because it can induce fatigue. Here we found that both low and medium itch-expectations led to effortful avoidance behavior in individuals without chronic itch, suggesting that itch may not only be an unwanted sensation, but that it also calls for avoidance.

To unravel the interplay between expectancies and avoidance in somatic sensations, it is essential to also evaluate their relationship in individuals with chronic somatic symptoms. Therefore, in **Chapter 5** we conducted an ecological momentary assessment study where we measured the daily changes in pain and related psychological mechanisms that include cognitive-affective and behavioral factors, such as expectancies, avoidance, fear, attention, and negative affect in individuals with chronic low back pain. The relationship between these psychological mechanisms was estimated and visualized through a temporal network (reflecting relationships that happen over time), and a contemporaneous network (reflecting

relationships that happen within one time-point). These networks were estimated both on a group and individual level. In this study, we found that the various cognitive-affective and behavioral factors indeed interacted with one another over time to influence pain. Interestingly, we found that avoidance weakly predicted expectancies at the group level, but not at the individual level. In fact, for some individuals, it was expectancy that predicted avoidance. We also found a large individual variability as to which factor is most prominent in influencing pain, indicating that an individualized approach to treatment would produce the best outcomes.

In short, across four chapters, we found that there is a robust relationship between expectancies and somatic sensation perception; more specifically that negative pain expectancies always lead to more pain. We also found that expectancies do not always lead to avoidance behavior which could indicate that other factors may be a stronger predictor of avoidance behavior. Nevertheless, expectancies provide a concrete target in treatment to reduce chronic somatic symptoms. The implications of these findings are critically evaluated in the general discussion.

GENERAL DISCUSSION

EXPECTANCIES:

Key Factor in Somatic Perception

One consistent finding throughout this dissertation and from previous research is that expectancies shape (somatic) perception, supporting the ample studies demonstrating that expectancies, whether induced verbally, with (partial) conditioning, observational learning, or a combination of learning methods, change how pain and itch is perceived (Blythe et al., 2023; Thomaidou et al., 2023). Furthermore, the expectations that we hold are prone to change, whether it be in small bouts of time (such as in the case of experiments), or longer (e.g., across days, weeks, months). This is in line with the predictive coding perspective that expectancies can change with new information (Friston, 2010; Hohwy, 2017). However, it should be noted that expectancies are more difficult to change when they are highly precise (i.e., contain a high level of certainty) than when they are less precise (Hohwy, 2017). This may indicate that expectancies can be more easily modified in individuals without chronic somatic symptoms than in individuals with chronic somatic symptoms. Some evidence of this can be seen when looking at the expectancy levels of the sample in **Chapters 3-5.** In **Chapter 5**, we see that the cognitive-affective state of individuals with chronic low back pain is relatively stable with only a few outliers, and their expectancies generally remain at a medium level. Yet, when looking at the pain and itch expectancies of individuals without chronic pain in **Chapters 3** and **4**, we see that expectancies already change from one phase to another within an hour. This is in line with what was theorized in **Chapter 2** describing that there are more changes after acquiring new information in individuals with less precise priors (when just learning about something), vs. in individuals with more precise priors (after multiple learning experiences). This effect has also been exhibited in an experimental study in which participants with less learning trials are more prone to change (i.e. extinction) than participants with higher learning trials (Colloca et al., 2010). Therefore, although expectancies influence somatic sensations in individuals with and without chronic somatic symptoms, the relationship may change less dynamically in those with chronic somatic symptoms than in those without.

AVOIDANCE:

Subject to Debate

Chapter 2 of this dissertation elucidates that the relationship between expectancy and avoidance may be bidirectional and that they highly depend on the precision of the expectancies that are held. However, findings from **Chapter 3** to **Chapter 5** demonstrate that other factors may be a stronger predictor of avoidance behavior than expectancies, and that there is not a one-to-one relationship between expecting an aversive sensation and performing an avoidance behavior. This finding is inconsistent with the theoretical view that a key function of expectancies is to guide away from unwanted outcomes (Roese & Sherman, 2007). It is interesting to note, however, that across three experimental studies (in **Chapter 3** and **Chapter 4**), pain and itch expectancies elicit different types of behaviors; whereas medium-to-high and low levels of itch expectancy both led to itch avoidance behavior, medium-to-high levels of pain expectancy did not lead to more pain avoidance behavior. While at the surface level the results may seem to indicate that individuals may be more prone to avoid itch than to avoid pain, the difference in behaviors may be due to the type of avoidance behavior and the trade-off to performing avoidance behavior (discussed further in the following section).

Moreover, **Chapter 5** shows that on a group level, expectancy was a not a strong predictor of avoidance at the next moment in those with – generally moderate symptoms of – chronic low back pain, but it is still unclear whether this relationship also occurs in individuals with more severe chronic low back pain symptoms or in other chronic somatic symptoms. These mixed findings demonstrate that there is still more room to discover on the role of avoidance behavior, especially in itch and fatigue. Nevertheless, it is clear that avoidance behavior does not occur in isolation and is highly influenced by various cognitive-affective and behavioral factors.

SOMATIC SENSATIONS:

More to Discover

The interplay between cognition, affect, and behavior is an intricate process. Our findings seem to show that negative expectancies influence somatic sensations, but do not always lead to avoidance behavior. In **Chapter 3**, although negative expectancies were acquired, the majority of participants did not perform pain-avoidance behavior, whereas in **Chapter 4,**

even low negative expectancies were able to induce effortful itch avoidance behavior. These results could indicate either 1) itch and pain expectancies evoke different types of avoidance responses, 2) avoidance behaviors are influenced by different contextual factors, or 3) other factors may be a stronger predictor of avoidance behavior.

On avoidance responses evoked by different somatic expectancies

One reason to suggest that itch and pain expectancies evoke different types of avoidance responses is through the types of behaviors that are triggered when one is experiencing pain or itch. For example, when an individual feels itch, it usually triggers one common behavioral response (which may happen unconsciously; LaCour et al., 2022; Rinaldi, 2019), that is, to scratch. However, pain evokes *different* types of avoidance behaviors depending on the type of pain. For example, if pain comes from external stimuli (e.g., a hot stove), then one may avoid contact with the specific external stimulus that causes the pain, but if the pain comes from muscle movement, then the way to prevent pain may be to remain sedentary. Thus, it could be the case that as tensing of the hands and fingers is a common strategy to prevent scratching (Melin et al., 1986; Norén et al., 2018), we were able to capture the avoidance behavior even with low levels of itch-expectancy (as it resembles a common response to itch), but unable to capture the correct pain-avoidance response using the avoidance paradigm of **Chapter 3** (as playing the "Tower of Hanoi" game is not a naturally occurring response). Indeed, in previous studies that have found a relationship between expectancies and avoidance, the avoidance behaviors that were measured more closely resembled everyday movement like the robotic arm reaching task (Janssens et al., 2019), or a leg flexion task (Pfingsten et al., 2001) indicating that avoidance behaviors may be more likely performed when they mimic daily motions.

On the role of context surrounding avoidance behaviors

Context also plays a large role in avoidance behaviors in which somatic expectancies may lead to different avoidance responses depending on the costs and benefits that are weighed in performing that avoidance behavior. In **Chapter 4** we demonstrated that the avoidance behavior was highly effective in reducing itch, thus participants had the knowledge that itch could be entirely prevented, whereas in **Chapter 3**, participants could not avoid the pain in its entirety and still received pain (albeit in different intensities) even when they performed the avoidance behavior. Thus, there were additional costs associated with the avoidance behavior designed in **Chapter 3** (i.e., some pain in addition to playing a more

aversive game) than in **Chapter 4** (i.e., significant itch reduction). This alludes to the weighing of options that is done in action selection discussed in **Chapter 2**. According to the active inference perspective, when an individual (partly unconsciously) chooses a behavior to perform, they must weigh the options between behaviors that lead to the most desired outcome (i.e., rewards), and behaviors that can help reduce uncertainty (i.e., in case one is unsure of the specific outcome that a behavior would lead to) (Maisto et al., 2021). Eventually, the behavior that is performed is the one that leads to the most rewards (which are individually defined), and the least uncertainty (Friston et al., 2016; Smith et al., 2022). Thus, as participants in **Chapters 3** and **4** had the certainty that an "easy" behavior would lead to more somatic sensations while a costly behavior would lead to less somatic sensations, participants performed the behavior that would lead them to the most rewards, whether it be experiencing less somatic sensations, or performing a behavior that require less costs.

Furthermore, studies have shown that positive outcome expectancies are a predictor of adherence (Constantino et al., 2011; Cormier et al., 2016; Eicher et al., 2019), meaning that individuals are more likely to continue performing a behavior if that behavior is expected to be effective. Thus, if an individual is aware that performing a costly avoidance behavior does not significantly reduce their somatic sensation, then they may be less likely to perform it. All these factors combined (i.e., behavioral responses, outcome expectancies, the costs to performing a behavior) could explain why negative expectancies do not always lead to avoidance behavior.

On different factors that may influence avoidance behavior

In **Chapter 2** we highlight that expectancies influence somatic perception and avoidance behavior, but that there is still a lack of empirical evidence on whether avoidance influences expectancies. Indeed, in the current dissertation, the expectancy-avoidance effect was only directly assessed in one direction (how expectancies influence avoidance behavior), but not the opposite direction (how avoidance behavior influences subsequent expectancies), and their associations were only indirectly explored through the network of **Chapter 5.**

Although the findings of **Chapter 5** show that avoidance weakly predicts future expectancies on a group level, different relationships were found at an individual level. Specifically, expectancies predict avoidance in some individuals, but this relationship was absent in most individuals. Different relationships were also found between avoidance and pain, where avoidance can predict pain in some, but not in all individuals. This suggests that individual

variability needs to be considered when investigating the expectancy-avoidance relationship, and that more studies should be conducted investigating why we see a relationship between expectancies and avoidance in certain individuals, but not in others.

Additionally, the findings from this dissertation demonstrate that other factors should be taken into consideration when evaluating the expectancy-avoidance relationship. Take for example, the role of fear. Ample studies have shown that there is a strong influence of fear on avoidance behavior (e.g., Lenaert et al., 2018; Meulders, 2020; Vlaeyen et al., 2016; Vlaeyen & Linton, 2000) and that higher levels of fear are common in those with chronic somatic symptoms such as fibromyalgia (Nijs et al., 2013; Turk et al., 2016), and chronic fatigue syndrome (Nijs et al., 2013). However, in our studies, our samples reported low levels of fear towards the pain (**Chapter 3**) and itch stimuli (**Chapter 4**), and those with chronic low back pain reported low levels of daily fear and worry of pain (**Chapter 5**). Based on the literature, the outcome of the results in **Chapters 3** and **4** (i.e., avoidance behavior) may have been different if higher levels of fear were present. Thus, fear may be an important factor in the expectancy-avoidance relationship. However, this poses a conundrum on how to best evaluate the role of fear in the expectancy and avoidance relationship as those who participate in somatic research may generally be less fearful of the somatic stimuli. Even in our observational study (**Chapter 5**) some participants declined to participate in a momentary assessment study about pain as these individuals did not want to be asked about or reminded of their symptoms multiple times per day (which is in some form a type of avoidance that is not officially measured in research). This further complicates the search to understanding the interaction between the cognitive-affective and behavioral factors behind somatic sensations and raises a general gap in research that requires further addressing.

LIMITATIONS AND FUTURE DIRECTIONS

Although this dissertation approached the research aims through different angles and perspectives, some limitations need to be addressed. Only one of the studies in this dissertation examined the relationship between expectancies and avoidance in individuals with lived experiences, and of these individuals, many were still active in daily life and had low levels of chronic pain symptoms such as low negative affect, disability, and low fear. Therefore, our findings may not be generalizable to individuals with more severe chronic pain symptoms, nor to those with other types of chronic somatic symptoms such as chronic itch or chronic fatigue syndrome. Future research should evaluate the expectancy-avoidance relationship in more diverse samples to gain a better understanding of how the two mechanisms interact.

Furthermore, the findings of **Chapter 3** and **Chapter 4** illustrate the difficulty in developing an ecologically valid model to study avoidance behavior in the laboratory setting. Many factors are at play in avoidance in daily life such as approaching valued goals that impact avoidance (Claes et al., 2014, 2015). A possible solution to capture these factors may be to combine quantitative and qualitative methods in longitudinal momentary assessments to catch the dynamic changes in multiple cognitive-affective and behavioral factors and symptoms. However, it should be noted that although the ecological momentary assessment design of **Chapter 5** allowed us to see changes in expectancies and avoidance behavior over time, it only allowed the measurement of conscious expectancies and required participants to report only specific aspects of their avoidance behavior (i.e., specific daily activities that may cause pain or harm their back). Thus, in addition to using quantitative and observational methods, future studies could consider using qualitative methods and collect data from multiple sources such as sensor data and data from social circles to gain a larger scope on the interaction between expectancies and avoidance behavior.

Finally, there is still limited evidence on how avoidance can affect expectancies. While the relationship is theoretically present (see **Chapter 2**), our findings in **Chapter 5** do not indicate that there is a bidirectional relationship between expectancies and avoidance. Further research on this topic could provide support for the active inference model on how motor behaviors can change (the formation of) expectancies. Additionally, the findings of the current dissertation are limited to how expectancies can exacerbate sensations and (costly) avoidance behavior, but the opposite relationship – whether expectancies can reduce (costly) avoidance behavior – is still unexplored, which opens an interesting pathway for future research to investigate. A recent study has already proposed that resilience should be taken into account in the fear-avoidance model of chronic pain as it provides a more comprehensive view on a person's pain trajectory (Slepian et al., 2020). Assessing how we can utilize expectancies to minimize dysfunctional avoidance behaviors may help uncover one of many protective factors that contribute to resilience. Ultimately, there is still more to explore between the expectancy-avoidance relationship, particularly in somatic sensations like itch and fatigue.

IMPLICATIONS

Due to the robust effects of expectancies on somatic sensations, our results indicate that expectancies may be a good target to change somatic perception. As illustrated in **Chapter 2**, this has already been done in practice through existing treatments like expectancy-based

manipulations, cognitive behavioral therapy, counterconditioning, and exposure therapy (Caneiro et al., 2017; Carlino et al., 2014; Clark & White, 2005; den Hollander et al., 2016; Karacaoglu et al., 2023; Piedimonte et al., 2015). Different types of expectancies can be targeted in treatment, for example, targeting treatment expectancies by inducing positive expectancies on the efficacy of a treatment, targeting symptom related expectancies, or targeting self-efficacy expectancies (Hsiao-Wei Lo et al., 2016; Peerdeman et al., 2016; Sondermann et al., 2021).

As we found many individual differences across the findings of our studies, both research and clinical practice should have a stronger focus on individualized approaches. Research has shown that developing treatments based on group-level testing is not always effective (Tanious & Onghena, 2019) which have led a growing number of researchers calling for a personalized approach as a better way to move forward to treat chronic conditions (Roefs et al., 2022; van der Feltz-Cornelis et al., 2018). In fact, although a standardized protocol has been developed for most biomedical and psychological treatments, physicians most often try to address the most pressing issues that affect their patients, exhibiting that an individualized approach has already been done in clinical practice.

Additionally, findings from **Chapter 5** also show that many cognitive-affective and behavioral factors influence pain in tandem, and findings from **Chapters 3** and **4** allude to other mechanisms that may be at play in the expectancy-avoidance relationship. This indicates that focusing on how the system of mechanisms work together, as opposed to focusing on a single cause, can give a better picture of where the main problems occur. The network approach provides a method to look at the entire system in clinical practice, both on the group level and on the individual level. There is already some evidence of the utility of the network approach to inform individualized treatment in psychopathology (e.g., Scholten et al., 2024) which can possibly be applied in pain (see for example Hofmann et al., 2024 for a proof of concept study) and itch by first mapping the personalized network of each individual to identify the key relations between chronic somatic symptoms and cognitive-affective and behavioral factors. It can then be used to identify specific cognitive-affective and behavioral factors to target in therapy to reduce chronic somatic symptoms.

CONCLUSION

This dissertation evaluated the relationship between expectancies and avoidance behavior to gain a better understanding of the mechanisms behind chronic somatic symptoms. Through a series of experimental and observational studies, we found that negative expectancies can increase somatic sensations. However, whether negative expectancies can increase avoidance differs per individual and may be context dependent. These results demonstrate that there is still more to uncover on the relationship between expectancies and avoidance behavior in somatic sensations. Improving expectancy-based treatment may be a crucial first step to minimizing somatic symptom worsening, but further research is required to assess its efficacy on minimizing avoidance behavior. All in all, it is vital that the work be continued in discovering the influence of expectancies and avoidance in somatic sensations.

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