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

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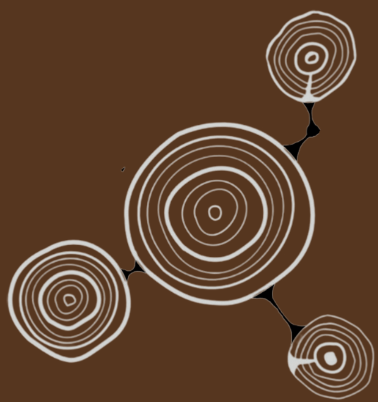
CHAPTER 4

The Influence of Negative Expectancies on Itch-Related Avoidance Behavior



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ABSTRACT

Objective: Itch expectancies play a key role in itch perception and may elicit avoidance behaviors to prevent itch, even when it is costly. Despite theoretical evidence that expectancies can influence avoidance behaviors, no studies have empirically investigated this association in the context of itch. The aim of this study was to investigate whether negative expectancy manipulation led to more costly itch-related avoidance behavior.

Methods: This study was conducted using a within-subjects repeated measures experimental design. 34 participants underwent an instructional learning and conditioning procedure in which a sham experimental solution paired with "high" quantity of cowhage spicules was used to induce high itch-expectations. A control solution paired with medium quantity of cowhage spicules was used to induce medium itch-expectations. Subsequently, participants learned that by effortfully gripping a dynamometer above a certain level, they could avoid strong itching. In anticipation of two other itch stimuli after re-application of the experimental solution and the control solution, average grip strength (reflecting costly itch-avoidance behavior) was measured.

Results: Results indicated that negative itch expectations were successfully induced ($p < 0.001$, $d = 1.16$). However, while participants engaged in avoidance behavior in both experimental and control trials, negative expectancy learning did not lead to more costly avoidance behavior ($p = 0.74$, $\eta_p^2 = 0.003$).

Conclusion: Results suggested that acute itch induced avoidance behavior regardless of expectations towards itch. Extending the research on the role of avoidance and its impact on itch may shed light on new approaches for itch management.

Preregistration*:* https://osf.io/d2yhv/?view_only=7c6dd4c1c85447fa90c268d8b4c95c98

Keywords: pruritus, cowhage, expectancies, avoidance

1. INTRODUCTION

Itch is a somatic sensation that can invoke the urge to scratch (Savin, 1998). The perception of itch is influenced by a number of biopsychosocial factors such as inflammation, stress, attention, and stigma (Verhoeven et al., 2008). In the chronic phase, itch can be particularly debilitating as treatments used to break the itch-scratch cycle are not always effective (Misery et al., 2020). While itch is a common symptom of chronic skin conditions (Weisshaar & Dalgard, 2009), the occurrence and intensity of itch can be difficult to predict based on disease severity alone. Recently, a growing number of studies have shown how psychological factors, specifically expectancies, can play an important role in the itch-scratch cycle (Evers et al., 2019). These expectancies can be acquired through learning mechanisms such as Pavlovian, instrumental, and instructional learning (Blythe et al., 2019). Once acquired, expectancies can alter the perception of itch. For example, in clinical populations, positive expectancies of treatments may lead to significant clinical itch reduction (van Laarhoven et al., 2015), whereas negative itch expectancies have been shown to induce higher levels of evoked itch in healthy individuals (Thomaidou et al., 2023).

As expectancies can exacerbate itch, it can subsequently also influence behaviors that may stop or prevent itch (Evers et al., 2019; van Beugen et al., 2021). Scratching can be seen as a notable example of escape behavior in itch as it is often performed *after* the itch has occurred. However, individuals with itch may also try to *prevent* itch from occurring by avoiding triggers of itch. This can manifest in various ways such as not wearing clothing made out of wool and avoiding exercises that produce sweat (Silverberg et al., 2018). Although these avoidance behaviors are supposedly performed to prevent itch, they may be costly and could, in the long term, lead to negative effects (Verhoeven et al., 2006). For instance, too much refraining from physical activities or exercise to prevent itch may instead increase the risk of developing other health problems such as cardiac and musculoskeletal disorders (Park et al., 2020). Additionally, tensing the muscles to avoid itching and scratching may instead invoke pain and fatigue, and avoiding social activities can lead to isolation. Thus, itch-avoidance behaviors could become dysfunctional, yet the factors influencing these costly avoidance behaviors have not been clearly identified.

There is evidence that expectancies, particularly when related to fear, may influence avoidance behavior (e.g., Lovibond, 2006; Nadinda et al., 2024; Pfingsten et al., 2001). It has been proposed that somatic symptoms, like itch, can change based on expectancies that are formed though the combination of prior experience and incoming sensory input, which subsequently influences avoidance behavior (Nadinda et al., 2024). In other words, by knowing what to expect, one can learn to avoid certain stimuli, which further reinforces the expectation that avoidance prevents an aversive outcome and maintains fear beliefs. This expectancy-avoidance relationship can be seen in different settings both in experimental studies as well as in daily life. For example, those with spider phobia tend to show more avoidance behavior when they have higher expectancies of encountering an inanimate spider (Lemmens et al., 2024; Olatunji et al., 2008). Similarly, in pain, individuals tend to engage in more avoidance behaviors when they expect to feel more pain (Boersma & Linton, 2006). However, the causal link between expectancy and avoidance has never been investigated in the context of itch, and the evidence on the costs of itch-related avoidance is still scarce. Considering that itch perception may be influenced by the interaction between expectancies and avoidance behavior (Nadinda et al., 2024), it is imperative that these mechanisms be further investigated.

The primary aim of this study was to investigate whether a negative itch expectancy manipulation via verbal suggestions and conditioning led to more costly itch-related avoidance behavior. We hypothesized that if participants expect to receive a high itch stimulus (experimental condition), they are more likely to engage in more costly avoidance behavior (defined as effortful gripping), compared to when they expect to receive a medium itch stimulus (control condition). Our secondary aim was to investigate whether induced negative expectancy mediates the relationship between condition (experimental vs. control) and avoidance behavior. Furthermore, we explored the intercorrelation among factors such as itch, urge to scratch, expectancy, fear of itch, and avoidance to examine possible related factors in itch.

2. METHODS

2.1 Participants

Based on power analysis using G-power for repeated measures ANOVA, a total of 34 participants were required to obtain a medium sized effect (f = 0.25, power = 0.8, alpha = 0.05). Participants were included in the study if they were between the age of 18 – 35 years old and were fluent in English. Based on self-reports, participants were excluded if they had severe medical or psychiatric conditions, a diagnosis of chronic itch or chronic skin conditions (e.g., psoriasis, atopic dermatitis), used recreational drugs more than 3 times per month, reported a disability in the upper body, had uncorrected visual impairments, or were pregnant or breastfeeding at the time of the experiment.

2.2 Ethics

This study was approved by the Psychological Research Ethics Committee at Leiden University (approval code: 2023-06-29- A.W.M. Evers-V1-4880). This study was also preregistered in the Open Science Framework Registries following the template from AsPredicted.org (https://osf.io/d2yhv/?view_only=7c6dd4c1c85447fa90c268d8b4c95c98). Data collection for this study was conducted from March 2023 until September 2023.

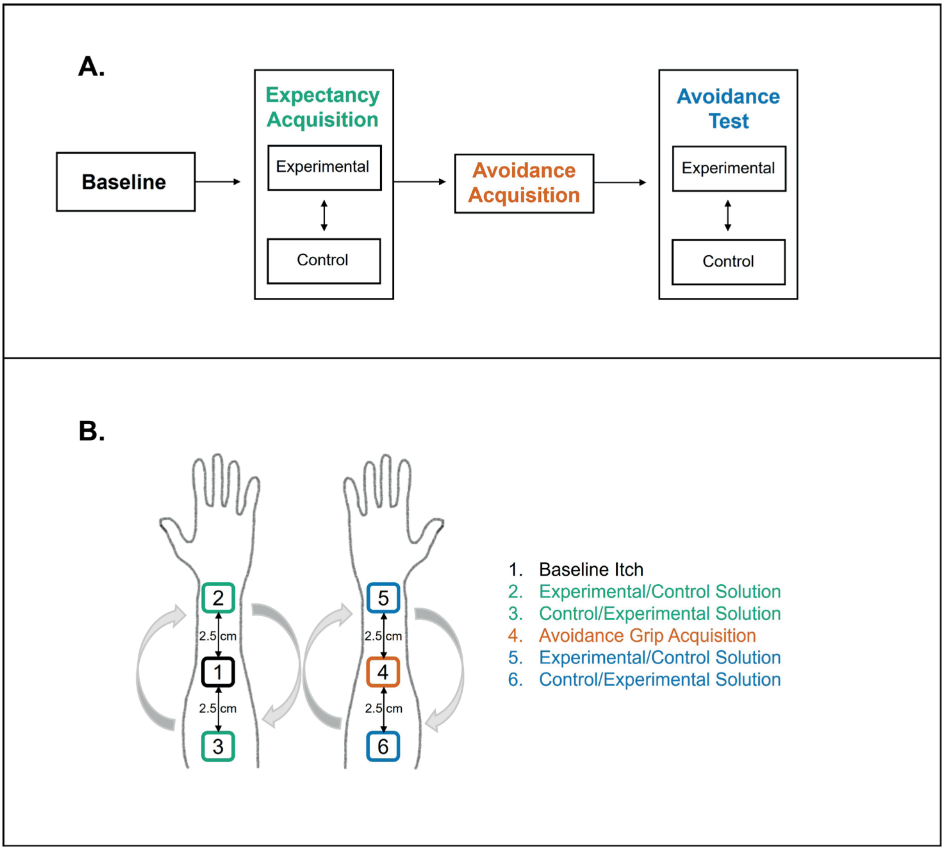
2.3 Design

The current study was conducted using a within subjects repeated measures design. Each participant underwent a total of four phases, namely the baseline phase (to measure itch and itch expectancy in response to the baseline itch stimuli), the expectancy acquisition phase (to induce negative itch expectancies), the avoidance acquisition phase (to learn the costly itch-avoidance behavior), and the avoidance test phase (to test whether negative expectancies led to more itch) (see *Figure 1A*). The expectancy acquisition phase and avoidance test phase both consisted of two trials, namely the experimental trial (to induce negative itch expectancies) and the control trial. Both the order of the trials and the location of the application were semi-randomized between participants to reduce bias (see *Figure 1B*). Randomization of the order and location of the trials was done by an independent researcher.

2.4 Procedure

Interested participants were invited to the research lab. Upon arrival, participants were briefed about the study verbally and given the information letter. All participants who agreed to participate in the study signed a consent form. Afterwards, participants were asked to complete a set of online baseline questionnaires (see *Materials and Measures* section and *Supplementary File 1* for a complete overview of questionnaires). Once the baseline questionnaires were completed, participants received a total of 6 applications of itch stimuli: 3 on the ventral side of each arm. Different sets of cowhage spicules (i.e., hairs of a tropical bean that can induce itch) were used to induce low (i.e., small set: 15±5 spicules), moderate (i.e., medium set: 25±5 spicules), and relatively high itching (i.e., large set: 45±5 spicules) throughout the experiment. The number of spicules for each set was determined based on pilot tests and previous studies (e.g., Andersen et al., 2017; Andersen et al., 2015; Blythe et al., 2021; Weng et al., 2022). Each set of cowhage spicules were counted under a microscope (Bresler, Rhede, Germany) and prepared using negative grip tweezers (Dumont Style N5 Inox 2) prior to the start of the study. Prior to receiving the itch stimuli, all six application areas were marked with a marker that was safe to use on skin. Then, four pieces of 3M Transpore White tape were attached around the 1.5cm x 1.5cm application areas before each trial.

Figure 1. Design overview, randomization, and location of trials.



2.4.1 Baseline Itch

Once the application areas had been marked, a baseline measurement of the induced itch stimulus was taken. To do so, the medium set of cowhage spicules were applied. The cowhage spicules were rubbed into the application area for 45 seconds and remained on the arm for three minutes (Blythe et al., 2021). This procedure of cowhage application was repeated for each trial using different sets of cowhage spicules. Within those three minutes, participants were asked to rate their itch and urge to scratch every 30 seconds using a 0 (no itch/urge to scratch) to 10 (worst itch/urge to scratch imaginable) numerical rating scale (NRS; see also section "*Self-report* *questionnaires*"). Participants were told to not scratch the application area, but if they really must scratch, then they may do so by rubbing outside of the application area. After three minutes, the spicules were removed using a 2.5cm wide 3M Transpore tape (see e.g., Blythe et al., 2021). Then the wait period began for the itch to subside to an itch level of 2 or lower on the NRS. During this five-minute wait period, participants were asked to rate their itch levels after every minute. If participants still felt high itch after 5 minutes, then the wait time was extended in one-minute increments until participants reached an itch level of NRS 2 or lower or until 10 minutes had passed since removal of the spicules, whichever came first. No participants exceeded 10 minutes during the wait period. At the end of this phase, participants who were not sensitive to the cowhage itch stimuli (i.e., those whose cowhage-induced itch mean rating at baseline was less than 0.5 on the NRS ranging from 0 indicating no itch to 10 indicating worst itch imaginable), and participants who were too sensitive to the cowhage itch stimuli (i.e., with a baseline cowhage-induced itch mean rating as 6 and above on the NRS) were excluded.

2.4.2 Expectancy Acquisition

After baseline itch application, the expectancy acquisition phase began. In this phase, participants were shown two bottles containing water-based solutions. Participants were told that a bottle with the label "Cyclosol" (the experimental solution that was applied during the experimental trial) would worsen their itch, while the "Hydro solution" (the control solution that was applied during the control trial) bottle would not affect the itch level. In truth, both solutions did not contain any itch inducing properties. In addition to the verbal explanation, participants watched a tailor made video based on the one used by Weng and colleagues (2022) that explained the science behind the itch inducing compound to increase the believability of the experimental solution. Subsequently, the solutions were applied to the participant's arm on two separate trials. For each separate trial, participants were asked how much itch they expected to feel, and how afraid they were of the itch stimuli after the solutions had been applied. After one minute, the large set of cowhage spicules was applied to the participant's arm on one location during the experimental trial to induce high itching, and the medium set of cowhage spicules was applied to the participant's arm on another location to induce medium itch. Itch and urge to scratch levels were again measured multiple times during cowhage application. Afterwards, the spicules were removed. Similar to the baseline itch phase, participant's itch had to reach an NRS of 2 or lower within 10 minutes before each new trial. All participants reached an itch rating of less than 2 on the NRS before 10 minutes.

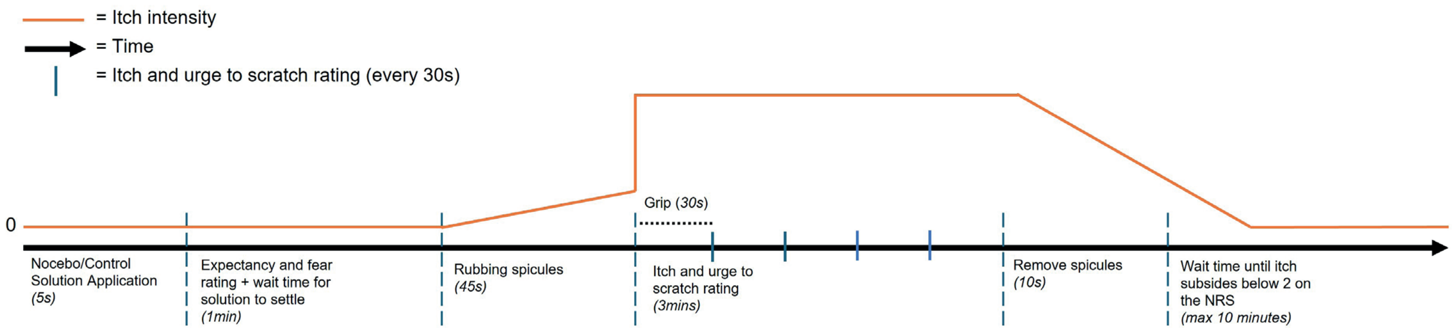
2.4.3 Avoidance Acquisition

During the avoidance learning phase, participants were told that clenching their fists above a certain threshold could decrease itch because it blocked certain itch inducing pathways, and that the stronger they gripped, the less itch they would feel. In other words, participants could avoid feeling medium-to-high levels of itch by gripping above a certain threshold. To determine the participants' individual thresholds, participants were given a dynamometer to hold and were told to grip the dynamometer as hard as possible for a duration of three seconds. Then, participants' individual thresholds were calculated (see *Avoidance Measure* section). Once the individual thresholds were calculated, participants' itch-expectancy and fear of itch were again measured before the cowhage spicules were applied. However, two types of expectancies were measured in this phase. Participants were asked how much itch they expected without gripping on a scale of 0 (no itch) to 10 (worst itch imaginable), and how much itch they expected while gripping, on the same scale. Subsequently, the small set of cowhage spicules were rubbed on to the participant's arm to induce low itch, therefore giving the impression that the gripping could reduce itch. As soon as the cowhage spicules were applied, participants were told to start gripping the dynamometer above their individual threshold for a period of 30 seconds. Participants were able to see their own threshold line on a computer monitor placed in front of them. Additionally, participant's itch and urge to scratch levels were measured multiple times during cowhage application. After participants performed the avoidance behavior, they were asked a question about how effective they thought the hand gripping was in reducing itch on a scale of 0 (not effective) to 10 (extremely effective).

2.4.4 Avoidance Test

During the avoidance test phase, the experimental and control solutions were applied again on the participant's dominant arm in two separate trials. Again, itch expectancy and fear of itch were measured prior to the application of cowage spicules. In this phase, participants only received the medium set of cowhage spicules and were given the dynamometer to hold. While the spicules were being rubbed onto the arm, participants were told that they may grip the dynamometer as hard as possible above their individual threshold for 30 seconds to reduce their itch after the spicules have been applied, however it was their decision whether they wanted to grip, how strongly they were gripping, and how long they wanted to grip. After 30 seconds, participants were told that they could stop gripping (see *Figure 2*). Itch and urge to scratch levels were again measured multiple times during cowhage applications. At the end of the experiment, participants were compensated through research credits or monetary payment and debriefed about the true aims of the study verbally and through a debriefing text that was displayed on a monitor.

Figure 2. Timeline of Trials in the Avoidance Test Phase.



Note. Participants underwent two trials with a similar procedure as above during the avoidance test phase, namely the experimental trial (in which the experimental solution was applied followed by a supposedly large set of cowhage spicules, which was in fact a medium set) and a control trial (in which the control solution was applied followed by a medium set of cowhage spicules).

2.5 Materials and Measures

2.5.1 Self-report questions

Baseline questionnaires. Baseline questionnaires consisted of demographic questions including the participant's age, gender, and education level. Additionally, participants completed a set of questionnaires for educational purposes in the context of a bachelor thesis project. Results from the questionnaires were not analyzed in this study. For the full list of questionnaires, see *Supplementary File 1*.

Expectancies and Fear. To measure itch expectancies, participants were asked to verbally rate how much itch they expected to feel on an NRS of 0 (no itch) to 10 (worst itch imaginable). Similarly, to measure fear of itch, participants were asked to verbally rate how afraid they were of the upcoming itch stimuli on an NRS of 0 (not at all afraid) to 10 (extremely afraid). The ratings were recorded using a Qualtrics survey (Qualtrics Inc., Provo, UT) by the experimenter. Both itch expectancies and fear of itch were measured during the expectancy acquisition phase, avoidance acquisition phase, and avoidance test phase once before the each separate cowhage application.

Itch and Urge to Scratch. Participants were asked to verbally rate how much itch they were experiencing on an NRS of 0 (no itch) to 10 (worst itch imaginable). Subsequently, participants were asked to rate how much they would like to scratch their itch on a scale of 0 (no urge to scratch) to 10 (worst urge to scratch imaginable). The itch and urge to scratch ratings were again recorded using a Qualtrics survey by the experimenter. Both itch and urge to scratch were measured every 30 seconds for a duration of three minutes after each set of cowhage spicules had been administered.

2.5.2 Expectancy stimuli

Two dropper bottles were filled with water-based solutions. Different labels were attached to each of the bottles. One bottle containing a supposedly itch inducing compound called "Cyclosol" was labeled as "Cyclosine solution" and was used as the experimental solution to induce high itch expectancies. This bottle contained a mix of water and a drop of water-based lotion. Another bottle labeled as "Hydro solution" was used as the control solution to induce no itch expectancies. This bottle only contained water.

2.5.3 Avoidance measure

Avoidance was defined as effortful gripping measured using an isometric hand dynamometer (BIOPAC Systems, Inc.). Individualized grip thresholds were calculated at 55% of participants' maximum grip strength while gripping the dynamometer as hard as possible for three seconds. This threshold was selected based on a pilot study which showed that this was the proportion of the maximum grip strength that is effortful to continuously maintain within a span of 30 seconds (see also Dahalan & Fernandez, 1993; West et al., 1995). It should be noted that for two participants, the participants' maximum grip value was displayed on the monitor as opposed to their individual threshold value. Therefore, these participants may have unintentionally had a more effortful grip as they may have tried to grip as hard as their maximum grip rather than their threshold grip within the 30-second window during the avoidance acquisition and test phases.

2.6 Statistical Analysis

Self-report and grip data were prepared using RStudio version 2022.07.0 and computed using SPSS version 29.0 for Windows (SPSS Inc. Chicago, USA). Normality of residuals for all data were assessed by calculating skewness and kurtosis z-scores, and sphericity was checked using Mauchley's test. Before testing the primary hypothesis, a manipulation check was performed to test whether negative expectancies were induced. For this, paired sample t-tests were conducted on the itch-expectancy ratings during experimental and control trials both in the expectancy acquisition phase and the avoidance test phase. We also performed additional paired sample t-tests on the itch and urge to scratch ratings during experimental and control trials in the acquisition phase to check whether the conditioning procedure generated the intended itch-related effect.

To test the primary hypothesis, a repeated measures ANOVA was conducted with average grip strength in both experimental and control trials during the avoidance test phase as the within-subjects variables. Participants' grip scores were logged as zero at any period that they did not grip within the 30 second window. Assumption checks indicated that the data violated the assumption of normality. As both log and square root transformations did not adjust for normality, a sensitivity analysis was conducted with the same variables using the Wilcoxon signed-rank test. Additionally, total grip strength (i.e., area under the curve) and peak grip strength within a 30 second window were also calculated as a measure of avoidance. Correlations using 1000 sample bootstrapping between the three avoidance measures were assessed. Due to high correlations between the average grip and total trip, and average grip and peak grip (all $r \geq 0.80$, $p < 0.001$), analyses were conducted with average grip strength as the only avoidance outcome.

To test the secondary hypothesis, a mediation analysis was performed using the MEMORE macro (Montoya & Hayes, 2017) on SPSS to assess whether itch expectancy mediated the relationship between condition and avoidance behavior. Model 1 and the percentile bootstrap confidence interval method was selected with 1000 samples. The within-subjects condition was dummy coded (experimental vs. control) and used as the predictor variable, average grip as the outcome variable, and itch expectancy as the mediator. Expectancy was specified as the itch-expectancy ratings after the application of the experimental vs. control solution during the avoidance test phase. It should be noted that the raw average grip scores per condition during the avoidance test phase were used instead of a difference score between conditions as stated in the preregistration. This decision was taken in consultation with a statistician, as the within-subjects conditions were already included as the predictor variable.

Furthermore, Pearson correlation coefficients were calculated to explore the correlation between avoidance (average grip) and itch-expectancy, and other itch-related measures (i.e., fear of itch, average itch, and average urge to scratch) in the avoidance test phase. For each of the variables included, difference scores were calculated by subtracting the scores of the control trial from the experimental trial during the avoidance test phase. Positive scores indicate an increased sensitivity to itch, while negative scores indicate a decreased sensitivity in itch. As the assumption of normality was not met for avoidance, correlations were performed with 1000 sample bootstrapping. Additionally, the assumptions of linearity between itch-expectancy and fear of itch were not met, therefore, Spearman's Rho was reported for this correlation.

Finally, as post-hoc exploratory analyses, we conducted paired sample t-tests on itch and urge to scratch ratings during both the experimental and control trials in the avoidance test phase to explore whether itch and urge to scratch ratings differed between the experimental and control trials. Additionally, we calculated descriptive statistics for each of the outcome measures in each phase to explore general patterns. For all analyses, two-sided tests were computed with the level of significance set at $p < 0.05$.

3. RESULTS

3.1 Participants

A total of 50 participants were recruited in the study. Of those participants, 16 were excluded after the baseline phase due to low or non-sensitivity to the itch stimuli (see also *Baseline Itch; Methods* section). Therefore, the final sample consisted of 34 participants ranging between the ages of 18 and 35 (M = 23, SD = 4.04), with the majority of participants (76%) identifying as female. Regarding education level, participants had recently completed either secondary education (17.6%) or tertiary education (82.4%). Due to an experimenter error, one participant unintentionally did not undergo the conditioning procedure during the avoidance acquisition phase but still received verbal suggestions regarding the grip behavior. Additionally, one participant participated in the study using a false identity which may have led to falsified data. These participants were included for all analyses but follow up sensitivity analyses were conducted with both participants removed.

3.2 Manipulation check

3.2.1 Itch expectancy during expectancy acquisition phase

A paired sample t-test indicated that participants expected more itch after the application of the experimental solution compared to the control solution during the expectancy acquisition phase (*Table 1*, $t(33) = 9.33$, $p < 0.001$, $d = 1.60$). Similarly, a paired sample t-test also indicated that participants expected more itch after the application of the experimental solution compared to the control solution during the avoidance test phase ($t(33) = 6.74$, $p < 0.001$, $d = 1.16$). The results indicated that negative expectations were successfully induced during the expectancy acquisition phase and still present during the avoidance test phase (see also *Table 1*).

3.2.2 Itch level during expectancy acquisition phase

A paired sample t-test also indicated that participants reported more itch ($t(33) = 4.05$, $p < 0.001$, $d = 0.70$), and a greater urge to scratch ($t(33) = 3.96$, $p < 0.001$, $d = 0.68$), after the application of the experimental solution compared to the control solution during the expectancy acquisition phase, indicating that different itch and urge to scratch levels were successfully induced between the two conditions.

3.2.3 Effortful gripping during avoidance test phase

To explore whether participants engaged in effortful gripping, the proportion of gripping during the experimental and control trials in the avoidance test phase relative to maximum grip was calculated across participants by calculating a percentage. Indeed, on average, participants engaged in effortful gripping as their average grip was around 50% of their maximum grip strength (see *Table 1* and *Supplementary Figure 1*).

3.3 Primary outcomes

Based on the repeated measures ANOVA, there was no significant effect of condition on avoidance behavior ($F(1, 33) = 0.12$, $p = 0.74$, $\eta_p^2 = 0.003$), which indicated, in contrast to our hypothesis, that participants did not grip harder after the application of the experimental solution compared to after the application of the control solution in the avoidance test phase. Results of the non-parametric Wilcoxon signed-rank test also confirmed a non-significant relationship ($z = -0.42$, $p = 0.68$). Additionally, we conducted sensitivity analyses without the participant who unintentionally only received verbal suggestions during the avoidance acquisition trial, and without the person who used a false identity. These results confirmed the results of the full dataset and can be found in *Supplementary File 1*.

3.4 Secondary and post-hoc outcomes

As there was no significant effect of condition on avoidance behavior, mediation analyses were not conducted to assess whether there was an indirect effect of condition on avoidance through expectancies. Additionally, in line with our preregistration, due to low variability in fear ratings (see *Supplementary Table 1*), no mediation analyses were conducted to assess whether fear mediated the relationship between condition and avoidance behavior. Furthermore, we found no significant correlation between avoidance and expectancies, and fear, itch and urge to scratch during the experimental trial in the avoidance test phase (see *Supplementary Table 2*). A paired sample t-test also indicated that participants did not report significantly more itch after the application of the experimental solution compared to the control solution during the avoidance test phase ($t(33) = 1.28$, $p = 0.21$, $d = 0.22$), indicating no significant itch difference between the two conditions. Similar findings were also found for urge to scratch ratings ($t(33) = 0.98$, $p = 0.34$, $d = 0.17$). Full descriptive statistics of expectancy, itch, urge to scratch and average grip can be found in *Table 1*. Additional descriptive statistics of fear, peak grip, and total grip can be found in *Supplementary Table 1*.

Table 1. Descriptive statistics of outcome measures.

Variables *(Number of Cowhage Spicules)*	**Mean**	**SD**	**Min.**	**Max.**
Baseline cowhage induction *(25 Cowhage Spicules)*				
Average Itch	3.4	1.5	1.0	5.8
Average Urge to Scratch	3.1	1.7	0.0	6.3
Expectancy Acquisition – Experimental *(45 Cowhage Spicules)*				
Expectancy	7.1	1.9	0.0	9.0
Average Itch	4.7	1.9	0.3	8.2
Average Urge to Scratch	4.3	2.0	0.0	7.5
Expectancy Acquisition – Control *(25 Cowhage Spicules)*				
Expectancy	2.8	2.4	0.0	8.0
Average Itch	3.0	2.3	0.0	7.0
Average Urge to Scratch	2.8	2.3	0.0	7.2
Avoidance Acquisition *(15 Cowhage Spicules)*				
Grip Threshold (in kg)	8.8	3.7	5.0	23.3
Expectancy (while gripping)	2.8	1.9	0.0	6.0
Expectancy (without gripping)	4.1	2.2	0.0	7.0
Average Itch	1.5	1.7	0.0	6.5
Average Urge to Scratch	1.2	1.7	0.0	6.7
Average Grip (in kg)	9.7	3.7	3.8	18.6
Effectiveness of Grip	7.2	3.4	0.0	10.0
Proportion of Average Grip Relative to Maximum Grip (%)	64.6	14.3	34.8	111.4
Avoidance Test – Experimental *(25 Cowhage Spicules)*				
Expectancy	5.1	2.3	0.0	9.0
Average Itch	2.8	1.9	0.0	6.8
Average Urge to Scratch	2.3	2.1	0.0	7.0
Average Grip (in kg)	7.4	4.1	0.0	20.3
Proportion of Average Grip Relative to Maximum Grip (%)	49.9	22.4	0.1	86.8
Avoidance Test – Control *(25 Cowhage Spicules)*				
Expectancy	3.2	1.8	0.0	7.0
Average Itch	2.4	2.0	0.0	7.7
Average Urge to Scratch	2.0	2.0	0.0	7.8
Average Grip (in kg)	7.2	4.4	0.0	21.9
Proportion of Average Grip Relative to Maximum Grip (%)	47.9	22.3	0.2	93.9

Note. SD: standard deviation. Units for itch, urge to scratch, and expectancy are on a scale of 0 – 10 with higher numbers indicating more itch, urge to scratch, and expectancy. Average grip was calculated based on participant's grip strength within a 30 second window for each trial.

4. DISCUSSION

The impact of itch in daily life is often underestimated, despite studies reporting that the psychological and behavioral impact of chronic itch is comparable to that of chronic pain (Cole et al., 2021; Kini et al., 2011). The results of the current study demonstrate that acute itch can trigger avoidance behavior. However, avoidance behavior was not influenced by the magnitude of itch expectancies. Additionally, fear of itch, itch, and urge to scratch were neither associated with avoidance behaviors nor with expectancies.

4.1 The Role of Expectancies and Other Factors in Itch-Related Avoidance

Negative expectancies were successfully induced via instructional learning and Pavlovian conditioning. This was in line with previous studies evaluating the influence of experimentally induced expectancies on itch (Blythe et al., 2019; Thomaidou et al., 2023). However, despite having significantly different levels of itch expectations and experienced itch, participants not only reported moderate levels of itch for the medium set of spicules, but also for the large set of spicules. In other words, the conditioning procedure only induced on average medium itch for both medium and high sets of spicules, which, albeit significantly different, did not match their high itch expectations prior to the conditioning procedure. This may explain why participants performed an equal amount of avoidance behavior across the experimental and control trial. It could be the case that participants may have learned that the itch caused by the experimental solution was not aversive nor harmful enough to warrant extra gripping.

Furthermore, there were two types of expectations at play during the avoidance test phase: the expectation of how much itch participants would feel after the application of the two solutions, and the expectation of how much gripping could reduce their itch. Therefore, having a lower itch experience coupled with two competing expectations, may have led participants to engage in a "better safe than sorry" strategy (Van den Bergh et al., 2021) because participants knew that gripping was effective at reducing itch. That is to say, participants may have wanted to ultimately prevent any itch regardless of expected intensity. Relatedly, it was also observed that the level of itch for both experimental and control trials were overall lower in the avoidance test phase than the level of itch during the expectancy acquisition phase. This may indicate that the gripping behavior may have caused a decrease in sensitivity to itch.

Nevertheless, it is important to note that, while participants gripped equally hard in the two trials of the avoidance test phase, they did not grip harder than their threshold level.

This may suggest that although participants tried to avoid itch, the threshold level, assessed based on three seconds of maximum gripping, may have been too difficult to sustain for the participants despite their best efforts at maintaining it during the 30 second trials. Regardless, most participants did perform some effortful gripping compared to their maximum grip, which further indicates that itch is a somatic sensation that people do not want to experience even when expecting a moderate intensity.

Considering that negative expectations was not the main driver of costly avoidance, other psychological mechanisms may be involved in itch avoidance. For example, in line with the fear avoidance model, higher levels of fear may have been needed to drive more avoidance (Vlaeyen et al., 2016; Vlaeyen & Linton, 2000, 2012). In the current sample, most participants showed low levels of fear towards the itch stimuli. This may be due to participants believing that there is no risk of harm with the induced itch. Studies from other fields, such as pain, have shown that fear is highly related to risk of harm, therefore motivating avoidance behavior (Martinez-Calderon et al., 2019; Vlaeyen & Linton, 2000; Zale & Ditre, 2015). Perhaps also in itch, participants would have avoided more if they would have higher levels of fear or if they believed that they are at risk of harm. However, to date, studies investigating the role of fear and perception of harm in itch are still scarce.

4.2 Strengths, limitations, and future directions

To our knowledge this was the first study to examine costly avoidance behavior in the context of itch. The avoidance measure that we used also bears some ecological value as many individuals tend to clench their firsts, or tense their muscles, to prevent scratching (Melin et al., 1986; Norén et al., 2018). Additionally, as the trials within participants were semi-randomized, an order effect can likely be eliminated. However, our study is also not without limitations. First, as participants could grip multiple consecutive times at a level that could cause arm fatigue, participants may not have been able to grip as strongly during the second trial compared to the first trial in the avoidance test phase. Although, this was partly counteracted by counterbalancing the trials, the level of energy in the participants' arm may have interfered with their grip strength. If this study were to be replicated, longer intervals before and between avoidance trials would be beneficial to ensure an unbiased grip rating. Second, although different levels of expectancies were induced, the high set of spicules did not induce the high level of itch as intended. Having higher levels of itch in future studies may lead to higher levels of expectancies and different levels of avoidance. Finally, the current sample consisted of young adults without chronic itch with high levels of higher education, therefore our results may not be generalizable to the general population nor the clinical population. Future research could investigate how established itch expectancies due to long-term itch could impact costly avoidance behaviors in the general population and in individuals with chronic itch due to chronic skin conditions. In fact, some studies have also shown that individuals with chronic itch may try different strategies to avoid itch (Silverberg et al., 2018; Verhoeven et al., 2006), yet, it is still unclear to what extent these avoidance behaviors are influenced by expectancies and to what extent it can be costly. Extending this research line and exploring the costs to itch-related avoidance behaviors in the clinical population may shed some light on how itch persists.

4.3 Conclusion

Negative itch expectations can be acquired through verbal suggestions and conditioning, but these negative expectations may not be the main driver of costly avoidance behavior in itch. Healthy participants seem to perform an equal amount of effortful avoidance behavior regardless of itch expectancy and previous itch intensity. However, as this was the first study to investigate costly itch avoidance behavior, more studies are needed to evaluate the different factors that might influence avoidance behavior. If we can establish that individuals do engage in costly avoidance behavior, it could potentially change how we approach treatments for chronic itch. For example, by incorporating more cognitive-behavioral based therapy such as exposure therapy (Hedman-Lagerlöf et al., 2019) and habit reversal (Schut et al., 2016). However, despite evidence that a biopsychosocial approach is needed to understand (chronic) itch, there is currently a lack of an empirically supported theoretical model that can explain how psychological, somatic, and behavioral mechanisms in itch influence one another. Further studies are needed to fully understand the impact of both expectancies and avoidance, and their potential interaction on itch.

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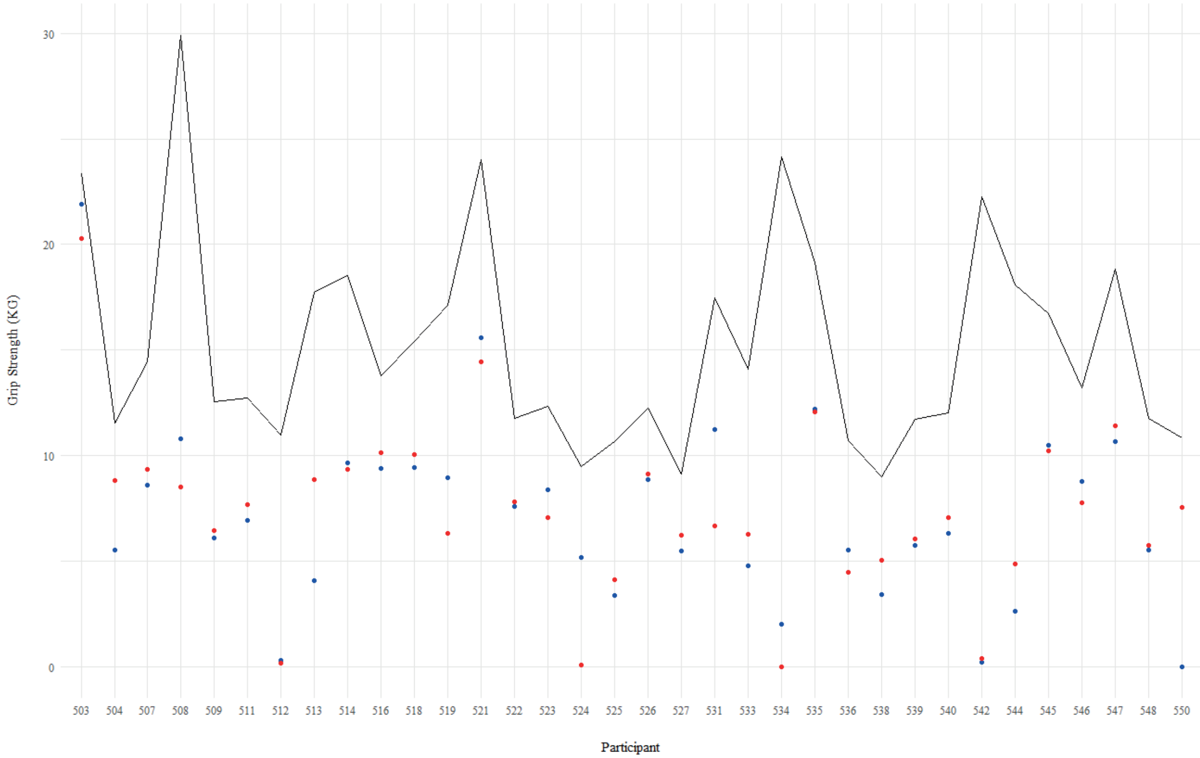
SUPPLEMENTARY MATERIALS

Supplementary Figure 1. Participants' average grip during the avoidance test phase relative to their maximum grip.



Note. The black line indicates the participants' maximum grip within three seconds. The blue dots depict each participant's average grip in the control trial (when having medium itch-expectations) whereas the red dots depict participant's average grip in the experimental trial (when having high itch-expectations).

SUPPLEMENTARY FILE 1

Questionnaires

The list of questionnaires administered for educational purposes in the context of a bachelor thesis project include the 21-item Depression and Anxiety Stress Scale (Lovibond & Lovibond, 1995), the itch version of the Pain Vigilance and Awareness Questionnaire (van Laarhoven et al., 2018), the itch version of the Pain Catastrophizing Scale (Andersen et al., 2017), and the Five Facet Mindfulness Questionnaire (Baer et al., 2006). Baseline questionnaires were administered through a Qualtrics (Qualtrics Inc., Provo, UT) survey that was completed on a computer inside the university laboratory.

Sensitivity Analysis

Results of the repeated measures ANOVA without the participant who only received verbal suggestions and without the participant who participated with a false identity were consistent with the analyses of the full dataset showing no significant effect of negative itch-expectancies on avoidance behavior ($F(1,31) = 0.45$, $p = 0.51$, $\eta_p^2 = 0.02$). These findings were also replicated after conducting a non-parametric Wilcoxon signed rank test ($z = -0.60$, $p = 0.55$).

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Supplementary Table 1. Descriptive statistics of additional outcome measures.

Variables *(Number of Cowhage Spicules)*	**Mean**	**SD**	**Min.**	**Max.**
Expectancy Acquisition – Experimental *(45 Cowhage Spicules)*				
Fear	3.1	2.5	0.0	8.0
Expectancy Acquisition – Control *(25 Cowhage Spicules)*				
Fear	2.1	2.0	0.0	7.0
Avoidance Acquisition *(15 Cowhage Spicules)*				
Fear (while gripping)	0.7	1.2	0.0	4.0
Fear (without gripping)	1.1	1.5	0.0	6.0
Total Grip (AUC)	288.5	109.5	112.2	548.0
Peak Grip (in kg)	13.3	5.2	5.8	29.6
Avoidance Test – Experimental *(25 Cowhage Spicules)*				
Fear	1.2	1.6	0.0	5.0
Total Grip	219.1	120.3	0.4	600.7
Peak Grip (in kg)	11.3	5.9	0.3	29.4
Avoidance Test – Control *(25 Cowhage Spicules)*				
Fear	0.6	0.9	0.0	3.0
Total Grip	214.1	131.2	0.5	643.4
Peak Grip (in kg)	11.4	6.7	0.1	30.9

Note. SD: standard deviation; AUC: Area Under the Curve. Fear was measured on a scale of 0 – 10 with higher numbers indicating more fear. Total grip (AUC) and peak grip were calculated based on participant's grip strength within a 30-second window for each trial

Supplementary Table 2. Correlation between itch-related measures, expectancies, and avoidance.

	Itch Expectations		Fear of Itch		Itch		Urge to Scratch		Avoidance	
Correlation Coefficient										
	r	*p*	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*
Avoidance	0.04	0.84	0.21	0.24	0.03	0.85	0.07	0.71	-	-
Itch Expectations	-	-	0.20[1]	0.26[1]	-0.16	0.37	-0.14	0.42	0.04	0.84

Note. [1]Spearman's Rho was reported as the assumption of linearity was not met. All other correlation coefficients reported indicated Pearson's correlation coefficient. No correlations were significant.

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