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The role of auditory itch contagion in psoriasis: A link between susceptibility and symptom severity

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Abstract

Itch and associated scratching is a common and distressing symptom of psoriasis. Here, we tested whether people with psoriasis, relative to healthy controls, show an increased vulnerability to auditory itch contagion when presented with sounds of itch-associated actions of scratching and rubbing. We were also interested in whether manipulating the high frequency volume of these sounds alters itch perception. Results show that both groups rated scratching sounds as more itch-inducing than rubbing sounds, and the amount of induced itch increased as a function of high frequency volume. The amount of auditory itch contagion (i.e., difference of scratch – rub) was positively linked with psoriatic symptom severity. These findings demonstrate the role of auditory cues in eliciting sensations of itchiness in the absence of peripheral stimulation. Reducing the high frequency volume of itch-associated sounds may offer a novel approach for targeted multisensory itch interventions.

Introduction

Psoriasis is a chronic systemic inflammatory disease predominantly affecting the skin. Approximately 2% of the population are affected at any time with 85% of those experiencing itch (1, 2) which can have a detrimental effect on quality of life, sleep, mental wellbeing (3) and concentration. Treatment goals for psoriasis tend to focus on measurement of area and severity and assessment of quality of life (4, 5). Pruritus is a common symptom that is not always targeted although many treatments will have anti-pruritic effects. Although there are treatments specifically for pruritus, many have side-effects and limited impact in reducing psoriatic itch.

Itch is a multimodal experience. Scratching to alleviate an itch not only elicits a cutaneous perception, but also visual (e.g., sight of scratching, reddened skin), auditory (e.g., sound of scratching) and kinaesthetic (e.g., movement of the limbs) sensations. Each non-cutaneous sense contributes to subjective feelings of itchiness. For example, watching itch-related stimuli in the absence of peripheral stimulation (e.g., ants crawling on the ground) is sufficient to induce itch (6, 7). Since itch can be amplified by concurrent non-cutaneous sensory information (8), this type of sensory feedback might also provide a means to reduce itch intensity.

Here, we explore auditory modulation of itch in people with psoriasis and age-matched controls. Jousmäki and Hari (9) demonstrated that modulating the sound of hands being rubbed together changes the perception of skin roughness. When they increased the volume of high frequency feedback, the skin started to feel smoother and drier (hence the name ‘parchment skin illusion’). Conversely, when reducing the proportion of high frequencies, the skin started to feel rougher and more moist.

The present study investigates whether itch perception can be selectively increased or decreased in a similar way and whether people with psoriasis would show an increased susceptibility to auditory itch contagion. Addressing these questions may begin to offer novel solutions to the challenging issue of effectively treating psoriatic itch.

MATERIALS & METHODS

Aims

The aims of the study were two-fold. First, we wanted to establish whether auditory itch contagion is essentially a normative response (i.e., experienced by most people). Such a susceptibility of auditory itch conduction could either manifest itself in the form of higher itch ratings for scratching as comparing to rubbing sounds (which act as a high-level baseline), or in a linear increase of itch as a function high frequency amplitude in the sound recordings (decreased by 10 dB, original, increased by 10 dB). A second aim of the study was to investigate whether people with psoriasis, where itch and associated scratching are a common problem, show an increased vulnerability to auditory itch contagion.

Sample

Sixty four participants were recruited to each experimental group. This sample size was chosen because it is sufficient to detect an effect in a between-group design that is at least of medium size or greater (Cohen's $d \geq 0.5$) with a probability of 80%, as indicated by an a-priori power analysis (10). Experimental group inclusion criteria were: (i) self-reported history of psoriasis, (ii) age ≥ 18 years, (iii) normal or corrected-to-normal hearing and (iv) access to an internet-enabled computer, with the capability to play sound. Since this was an online study, we had no control over the volume setting or particular sound setup participants were using on their computer. However, the experimental manipulation was realized within subjects. Thus, the difference in sound intensity between experimental conditions remains stable, regardless of the particular sound setup of each computer. Inclusion criteria for the control group were identical except control participants had to be without any history of psoriasis and not currently experiencing itch. Mean age did not differ significantly between groups [psoriasis group: $M = 39.42$, $SD = 10.6$; control group: $M = 39.89$, $SD = 10.6$; $t(126) = 0.25$, $p = 0.80$], nor gender distribution (psoriasis group: females N=25, control group: N=31, $\chi2=$

1.14, p = 0.29). On average, participants in the psoriasis group had been living with the condition for 10.1 years (range 0 – 61 years, SD = 11.1).

Materials

Stimuli were recordings of scratching or rubbing. Different targets were scratched or rubbed for 20 seconds, including three body (beard, hand, leg) and three non-body (polyester, denim, leather) targets. High Frequencies (HF) above 1000 Hz were then either increased or decreased in amplitude by 10 dB using PRAAT (version 5.3.52, www.praat.org) resulting in 3 different versions of each sound file: Original, HF_increased and HF_decreased.

To assess the amount of experienced itch within the last 14 days, all 128 participants completed the 5D itch scale (11) which provides estimates for 5 dimensions of itch (degree, duration, direction, disability, and distribution), as well as an overall score. The overall 5D score can vary between 5 (no itch) and 25 (most severe itch). Finally, participants in the psoriasis group assessed their symptom severity using the Self-assessed Psoriasis Area and Severity Index (SAPASI) (12). This instrument requires participants to indicate the body surface area affected by psoriasis, followed by a severity rating of a typical psoriatic lesion with respect to colour, thickness and scaliness. The resulting overall SAPASI index varies between 0 (no psoriasis on the body) and 72 (the most severe case of psoriasis).

Procedure

The experiment was conducted using a secure website. Healthy participants and people with psoriasis listened to sound recordings of either scratching or rubbing sounds. After each sound, participants were asked to rate the intensity of itchiness (if any) induced by the preceding sound. The rating scale ranged from 1 (not at all) to 7 (extremely), with 4 indicating moderate itchiness. The 36 sound stimuli were divided into 3 blocks, with the constraints that (a) each block contained an equal number of sounds from each condition, and (b) each block contained only one of the 3 variants of each particular sound (e.g., Block A would contain 'leg_rub_orig', Block B 'leg_rub_incr' and Block C ‘leg_rub_decr’). Sound order within each block was randomized. Participants completed all 3 blocks, with block order counterbalanced across participants. Participants had the opportunity to complete the study one block at a time, and could take a break if they wished. Most participants (60 out 64 in the psoriasis group, 58 out 64 in the control group) chose to complete the study on a single day.

Design and Data Analysis

The study used a 2 x 2 x 3 factorial design, using Movement Type (rub, scratch) and HF volume (original, HF_inc and HF_decr) as within-subject factors, as well as group (psoriasis, control) as a between-subject factor. Data were analysed using a mixed 2 x 2 x 3 ANOVA. For all main comparisons, Cohen’s d is given as an effect size measure, using the pooled variance between conditions as a standardizer(13).

RESULTS

Questionnaires

The overall 5D itch score was higher in the psoriasis group than in the control group (see Table 1). Similarly, the dimension scores for Degree, Duration, Disability and Distribution were significantly higher in the psoriasis group. The direction (i.e., amount of change in itch during the last 14 days, relative to the previous month) did not differ significantly between groups ($t(126) = 0.74$, $p = 0.46$). However, the lack of a group effect for the direction scale should be interpreted with caution. The relevant question “Over the past 2 weeks has your itching gotten better or worse compared to the previous month?” is difficult to answer for someone not currently experiencing itch (which was an inclusion criterion for the control group), and a response of ‘unchanged’ is scored with 4 points in the 5D questionnaire. This may also explain the relatively high overall 5D itch score of the control group, which is largely driven by the direction sub-scale.

The mean SAPASI score of the psoriasis group was 13.26 (range: 2.6 – 52.4, SD = 9.83) indicating that on average, symptom severity was moderate, although there were considerable differences between individuals.

Itch response in the control group

In the control group (Figure 1), there was a main effect of Movement Type ($F(1,63) = 42.78$, $p < 0.001$, $d = 0.61$), indicating that scratching sounds ($M = 2.94$, $SD = 0.92$) were perceived as more itch-inducing than rubbing sounds ($M = 2.40$, $SD = 0.82$). There was also a main effect of HF volume ($F(2,126) = 16.59$, $p < 0.001$, $\varepsilon = 0.80$). Two post-hoc t-tests indicated that relative to the unmodified original sounds ($M = 2.66$, $SD = 0.84$), accentuating the HF volume was associated with increased itch ($M = 2.90$, $SD = 1.02$; $t(63) = 3.10$, $p = 0.003$, $d = 0.25$). In contrast, dampening HF volume was associated with reduced itch ($M = 2.46$, $SD = 0.76$), relative to unmodified sounds ($t(63) = 3.54$, $p = 0.001$, $d = 0.25$). The interaction between Movement Type and HF Volume was not significant in the control group ($F(2,126) = 1.12$, $p = 0.33$).

Itch response in the psoriasis group

The pattern across the six experimental conditions was similar in the psoriasis group. There was a main effect of Movement Type ($F(1,63) = 15.18$, $p < 0.001$, $d = 0.27$), indicating that scratching sounds ($M = 4.21$, $SD = 1.40$) were more itch-inducing than rubbing sounds ($M = 3.81$, $SD = 1.51$). There was also a main effect of HF volume ($F(2,126) = 29.68$, $p < 0.001$, $\varepsilon = 0.74$). Two post-hoc tests showed that accentuating HF volume ($M = 4.40$, $SD = 1.58$) increased itch ($t(63) = 5.19$, $p < 0.001$, $d = 0.31$), relative to unmodified sounds ($M = 3.94$, $SD = 1.37$), whereas dampening HF volume ($M = 3.68$, $SD = 1.44$) decreased itch ($t(63) = 3.68$, $p < 0.001$, $d = 0.19$). There was an interaction between Movement Type and HF Volume in the psoriasis group ($F(2,126) = 6.61$, $p = 0.002$, $\varepsilon = 0.82$) which was driven by the fact that the antipruritic effect of dampening the HF volume was significantly more pronounced for rubbing than scratching. That is, (rub_orig – rub_decr) was significantly greater than (scratch_orig – scratch_decr) in the psoriasis group, $t(63) = 2.31$, $p = 0.02$, $d = 0.30$. In contrast, (rub_orig – rub_incr) was not significantly different from (scratch_orig – scratch_incr), $t(63) = 1.67$, $p = 0.10$. However,

In an exploratory data analysis, we also looked at whether psoriatic symptom severity, as measured by the SAPASI, is linked with auditory itch contagion. These analyses indicated that the amount to which participants perceive the scratching sounds as more itch-inducing than the rubbing sounds (scratch – rub) was positively linked with the overall SAPASI score, $r(62) = 0.29$, $p = 0.02$. In contrast, the SAPASI score was not significantly correlated with the effect of HF accentuation (incr – original; $r(62) = -0.19$, $p = 0.13$), or the effect of HF dampening (decr – orig; $r(62) = -0.17$, $p = 0.19$).

Differences between groups in the itch response

Group comparisons indicated that the effect of accentuating HFs (HF incr. vs. unmodified sounds) tended to be more pronounced in the psoriasis group ($M = 0.46$, $SD = 0.71$) than in the control group ($M = 0.23$, $SD = 0.6$, $t(126) = 1.96$, $p = 0.05$, $d = 0.35$). Further analysis revealed that this group effect was primarily driven by the rubbing sounds. The effect of accentuating HFs of rubbing sounds was significantly more pronounced in the psoriasis group ($M = 0.57$, $SD = 0.89$) than in the Control group ($M = 0.25$, $SD = 0.80$, $t(126) = 2.16$, $p = 0.03$, $d = 0.38$). No such group difference was observed for scratching sounds ($t(126) = 0 .92$, $p = 0.36$). The effect of dampening HFs (HF decr – orig) was not significantly different between groups ($t(126) = 0.64$, $p = 0.52$), neither was the effect of Movement Type (scratch – rub; $t(126) = 1.05$, $p = 0.30$). Finally, there was a main effect of group ($F(1,126) = 43.74$, $p < 0.001$, $d = 1.17$), indicating that across all six experimental conditions, participants in the psoriasis group ($M = 4.01$, $SD = 1.14$) generally perceived the sounds as more itch-inducing than participants in the control group ($M = 2.67$, $SD = 1.14$).

DISCUSSION

The present study demonstrates, for the first time, that itch-associated sounds of scratching and rubbing can induce feelings of itchiness in the absence of peripheral stimulation. Both healthy volunteers and psoriatic patients were found to be susceptible to such auditory itch contagion. These findings further our understanding of the psychological factors involved in the induction of itch and could provide the basis for novel multimodal itch interventions.

A first important finding of our study is that auditory stimuli can be powerful inducers of itch. Scratching sounds were perceived as significantly more itch-inducing than rubbing sounds in both healthy controls and people with psoriasis. The magnitude of this effect was positively linked with psoriatic symptom severity suggesting it may play a role in perpetuating chronic itch in psoriasis.

Furthermore, our results suggest that manipulating the high frequency of action sounds typically associated with itching (i.e., rubbing and scratching) modulates itch perception. Dampening the high frequency was found to have an anti-pruritic effect in both groups. In contrast, accentuating high frequencies increased the amount of induced itch, with the psoriatic group showing an increased vulnerability to such auditory itch contagion. In our study, non-diseased skin was scratched during the recording of the sounds. However, psoriatic skin is particularly dry, which likely increases the high frequency volume of the scratching sound. Thus, the present study may be considered as a lower bound estimate of the amount of auditory itch amplification in psoriasis. These findings could have important clinical implications as pruritus is a common and troublesome symptom in many psoriatic patients, which may or may not be controlled by conventional therapies some of which will have unwanted side effects.

Looking ahead, the present study opens up a new perspective on the study of itch. While we used pre-recorded scratching and rubbing sounds, future studies could ask whether the *concurrent* physical perception of itch (e.g., after a histamine prick test) is also influenced by auditory feedback. Such studies could pave the way for targeted interventions designed to eliminate auditory amplification of chronic itch.

More investigation is needed to discover what brain systems are involved when itch is induced by non-cutaneous sensory information. Most accounts of contagious itch assume that it involves some form of vicarious perception(6, 14). It is, however, currently unclear what specifically is being shared between the scratching person and the perceiver. The first possibility is that it is the motor act of scratching and associated somatosensory sensations of specific bodily locations that are being simulated in the perceiver's brain, recruiting the auditory mirror neuron system(15). The second possibility is that insular-mediated sharing of affect (in this case the unpleasantness of itch), rather than vicarious perception of motor act and bodily target, gives rise to contagious itch. This account is based on evidence from the related phenomenon of empathy for pain(16). In the present study, participants were not able to perceive the bodily target of scratching. Nonetheless, listening to these sounds induced itch. Furthermore, sounds where a non-body target was scratched/rubbed (denim, polyester, leather) were perceived as equally itch-inducing as sounds associated with a body target (beard, hand, leg). This is difficult to reconcile with a motor/somatosensory explanation, but in line with the idea that sharing of affect might give rise to contagious itching(17).

A limitation of the current study is that diagnosis of psoriasis was based on self-report data. Although 5D and SAPASI have been validated in clinical populations, it would be of interest to see if our findings are replicable when diagnoses of psoriasis are verified by a clinician. Another question for future research is whether auditory itch contagion affects only subjective itch, or whether it generalizes to behavioural (e.g., scratching frequency)(6, 14, 18) and brain-based markers of itch intensity (e.g., activity in itch-associated areas of the brain)(19).A final limitation is that we had no control over the volume settings of the computers of our participants, creating an additional source of variability compared to a lab-based experiment. However, the data pattern obtained from our control group was highly similar to that of previous group of healthy volunteers tested in a controlled lab setting (20) suggesting that the mode of data acquisition (online vs. lab-based) does not systematically influence the response.

In conclusion, the current study represents an important development in understanding auditory itch contagion. Further research is needed to meet the ultimate aim of identifying a new nonpharmacological approach to the management of itch, a frequent and distressing symptom of psoriasis.

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Table 1 Means (+ SD) of the 5D Itch score and its underlying dimensions for each experimental group. Columns 3 and 4 provide the t and associated p values of the corresponding two-tailed independent samples t-test.

	CONTROL GROUP	PSORIASIS GROUP	T	P
5D ITCH SCORE	10.14 (3.21)	13.98 (3.43)	6.4	< .001
DEGREE	2.16 (0.98)	2.81 (0.69)	4.4	< .001
DURATION	1.45 (0.73)	2.11 (1.10)	4.0	< .001
DIRECTION	3.13 (1.18)	3.27 (0.96)	0.74	.46
DISABILITY	1.89 (0.89)	3.20 (0.95)	8.1	< .001
DISTRIBUTION	1.58 (0.61)	2.58 (0.89)	7.4	< .001

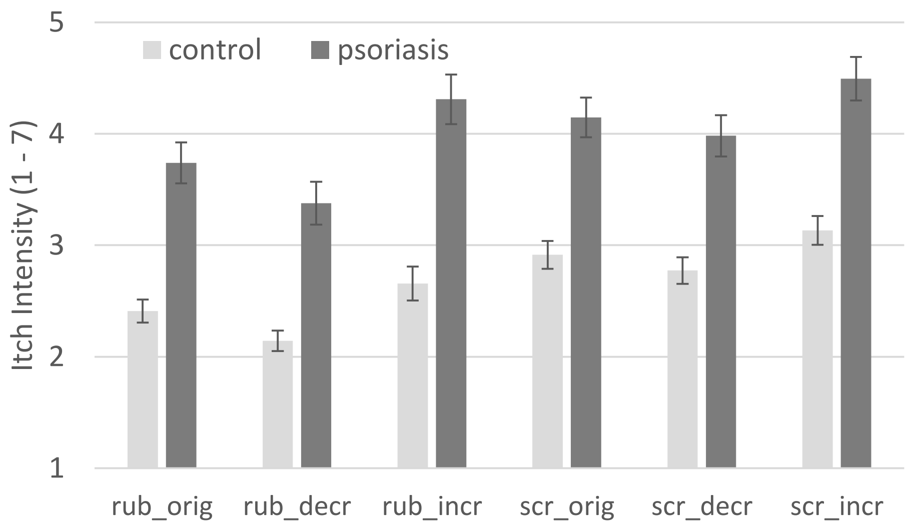

Figure 1 Degree to which listening to sounds induced feelings of itchiness in the participants, as indicated by ratings. The scale ranges from 1 (not at all) to 7 (extremely), with 4 as moderate. n = 64 for each group. Error bars indicate 1 SEM.