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INVESTIGATIVE REPORT

The Role of Auditory Itch Contagion in Psoriasis*

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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 (a deleterious influence) 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. Furthermore, the influence of high frequency volume on induced itch was more pronounced in the psoriasis group, relative to controls. 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. *Key words: itch; psoriasis; induction; vulnerability; susceptibility*.

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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 & 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 AND METHODS

A full description of the materials and methods of this study can be found in Appendix S1[1]. Briefly, the present study had 3 aims. First, we asked whether itch can be induced by auditory stimuli in the absence of peripheral stimulation, by comparing the amount of itch induced by listening to scratching sounds relative to rubbing sounds (which act as a high-level baseline). A second aim was to evaluate whether the amount of induced itch varies linearly as a function of high frequency volume in the sound recordings. Finally, we asked whether people with psoriasis show an altered response to these experimental manipulations, relative to healthy controls.

Sixty-four patients with psoriasis and an equivalent number of healthy controls took part in this online study. Stimuli consisted of audio recordings where different targets were scratched or rubbed for 20 s. High frequencies (HF) above 1,000 Hz were then either increased or decreased in volume by 10 *dB* resulting in 3 different versions of each sound file: HF volume –10 *dB*, HF volume unchanged and HF volume +10 *dB*. After logging into a secure website, participants rated the intensity of itchi-

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ness (if any) induced by each sound on a 1–7 rating scale. All participants additionally completed the 5D itch scale (10). Participants in the psoriasis group also completed the Self-assessed Psoriasis Area and Severity Index (SAPASI) (11).

For the statistical analysis, sound rating data were analysed using a Mixed 2 × 2 × 2 ANOVA, including the effect of High Frequency Volume modelled as a linear effect (linear effect present vs. absent), Movement Type (rub, scratch) as a categorical within-subject factor, as well as group (psoriasis, control) as a between-subject factor.

RESULTS

Questionnaires

The overall 5D itch score was higher in the psoriasis group than in the control group (Table I). 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 ± SD SAPASI score of the psoriasis group was 13.26 ± 9.83 (range 2.6 –52.4) indicating that on average, symptom severity was moderate, although there were considerable differences between individuals.

Auditory itch data

A summary of the auditory itch data can be seen in Fig. 1.The ANOVA yielded a significant main effect of Movement Type ($F(1,126)=49.67$, $p<0.001$, Cohen's $d=0.34$), indicating that across both groups, scratching sounds were perceived as more itch-inducing (mean ± SD 3.57 ± 1.34) than rubbing sounds (mean ± SD 3.11 ± 1.40). There was also a significant main effect of group ($F(1,126)=43.74$, $p<0.001$, $d=1.17$), indicating that participants in the psoriasis group (mean ± SD 4.01 ± 1.14) generally perceived the sounds as more itch-inducing than participants in the control group (mean ± SD 2.67 ± 1.14). Fig. 1 suggests a linear relationship between the amount of induced itch and HF volume. This was confirmed by the results of ANOVA, which revealed a significant linear main effect of HF volume ($F(1,126)=62.97$, $p<0.001$, mean ± SD slope of 0.29 ± 0.42). Thus, for every increase in HF volume by 10*dB*, the amount of induced itch increased by 0.29 points on the rating scale across both groups. The slope of this linear effect of HF volume was steeper in the psoriasis group (mean ± SD 0.37 ± 0.47) than in the control group (mean ± SD 0.22 ± 0.36), as indicated by a significant HF volume by Group interaction ($F(1,126)=4.12$, $p=0.04$, $d=0.36$). This suggests that the psoriasis group was more strongly affected by the manipulation of HF volume than the control group. Finally, the slope of the linear effect of HF volume was steeper for rubbing (mean ± SD 0.37 ± 0.47) than for scratching sounds (mean ± SD 0.22 ± 0.36), as indicated by a significant interaction of Movement Type and HF volume ($F(1,126)=14.29$, $p<0.001$, $d=0.36$). Thus, the itch-amplifying effect of increasing the HF volume is more pronounced for rubbing than for scratching sounds across both groups. The three-way interaction of Movement Type, HF volume and group was not significant ($F(1,126)=3.4$, $p=0.07$). All quadratic terms for the effect of HF volume in the ANOVA were also not significant [all $F(1,126) < 2.72$, all $p > 0.10$], suggesting that the relationship of HF volume and amount of induced itch is best captured by a linear model.

Table I. *Means (standard deviation) values of the overall 5D Itch score and its 5 underlying dimensions for the control group and psoriasis group. The final two columns provide the t and associated* p *values of the corresponding two-tailed independent samples* t*-test, to identify significant group differences*

	Control group	Psoriasis group	*t*	*p*
5D Itch score	10.14 (3.21)	13.98 (3.43)	6.4	<0.001
Degree	2.16 (0.98)	2.81 (0.69)	4.4	<0.001
Duration	1.45 (0.73)	2.11 (1.10)	4.0	<0.001
Direction	3.13 (1.18)	3.27 (0.96)	0.74	0.46
Disability	1.89 (0.89)	3.20 (0.95)	8.1	<0.001
Distribution	1.58 (0.61)	2.58 (0.89)	7.4	<0.001

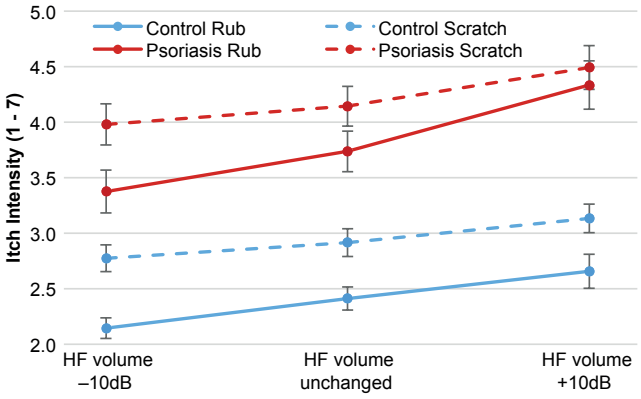

Fig. 1. Degree to which listening to sounds induced feelings of itchiness in the participants, as indicated by ratings. The scale ranges from 1 (not at all) to 7 (extremely), with 4 as moderate. n = 64 for each group. Error bars indicate 1 SEM. HF: high frequency.

Correlation analysis

To analyse the degree to which auditory itch contagion may be linked to psoriatic symptom severity,

the magnitude of the main experimental effects (i.e., magnitude of the linear effect of HF volume and categorical effect of Scratch – Rub) were correlated with the SAPASI score and the number of years patients had been living with the condition. This exploratory analysis indicated that the amount to which participants perceive the scratching sounds as more itch-inducing than the rubbing sounds (scratch – rub) was positively correlated with the overall SAPASI score, $r(62)=0.29$, $p=0.02$ (Table II). Furthermore, the number of years living with the condition was negatively correlated ($r(62)=-0.27$, $p=0.03$) with the effect of HF volume (i.e., the older the participants, the less pronounced the linear effect of HF volume). However, these correlation findings should be treated with caution, since correlation coefficients are rather small and are not statistically significant after correction for multiple comparisons.

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 correlated with psoriatic symptom severity suggesting it may play a role in perpetuating chronic itch in psoriasis. However, the correlation was rather small and requires replication in a larger sample.

A second main finding of the present study is that the amount of auditory induced itch varies as a function of the high frequency volume of the itch-inducing sounds. The present data set suggests that this relationship is of a linear nature, with an increase in high frequency volume by 10*dB* resulting in an increase of the amount of induced itch by about 0.3 points on the 7 point rating scale. Though relatively small in absolute terms, this effect was highly consistent across participants. Furthermore, the psoriatic group showed 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.

Table II. *Results of correlation analysis in the psoriasis group*

	Years living with condition	Effect of (Scratch – Rub)	Effect of HF volume
SAPASI score	**0.37**	**0.29**	–0.05
Years living with condition		0.09	**–0.27**
Effect of (Scratch – Rub)			–0.14

Table shows the magnitude of bivariate correlations (Pearson's r) between the following 4 variables: Overall SAPASI score, Years living with condition, Effect of Scratch – Rub (i.e., the main effect of Movement Type), Effect of high frequency (HF) volume (i.e., the slope of the linear effect of HF volume). Correlations that are statistically significant (at $p<0.05$, uncorrected for multiple comparisons) are marked in **bold**.

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. One possibility in this context would be to exploit the anti-pruritic effect of dampening high frequency volume via custom-made ear plugs with defined filter characteristics. Since the present study found that a manipulation of the high frequency volume is more effective for rubbing than for scratching sounds, such an intervention could be particularly promising for psoriatic patients who frequently rub their skin.

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, 12). 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 (13). 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 (14). 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 (15). Since auditory itch inducers lack a specific bodily target, they provide an interesting test case for future neuroimaging studies in the above-mentioned debate about the neural network underlying contagious itch.

The major limitation of the current study is that diagnosis of psoriasis and symptom severity relied on participants' accurate self-reporting without subsequent verification by a physician. However, advertisement for the experimental group was restricted to psoriasis-specific forums, which increases the likelihood of accurate self-reporting of psoriasis (see also 16). Another limitation is that the present study relies on self-report data which are susceptible to response bias. For example, completing the 5D scale at the beginning of the experiment (and additionally the SAPASI in the case of the psoriasis group) may have biased the participant's responses in the subsequent auditory task. Such a bias could explain the overall higher ratings in the auditory itch experiment obtained from the psoriasis group. However, it is difficult to explain the specific pattern of experimental results, especially the observed group by condition interactions, on the basis of a general bias towards itch. Since the present study relied on self-report data, it is crucial for future research to determine whether auditory itch contagion affects only subjective itch, or whether it generalizes to behavioural (e.g., scratching frequency) (6, 12, 17) and brain-based markers of itch intensity (e.g., activity in itch-associated areas of the brain) (18). 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 (19) 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 non-pharmacological approach to the management of itch, a frequent and distressing symptom of psoriasis.

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The authors declare no conflicts of interest.

REFERENCES

1. Prignano F, Ricceri F, Pescitelli L, Lotti T. Itch in psoriasis: epidemiology, clinical aspects and treatment options. Clin Cosmet Investig Dermatol 2009; 2: 9–13.
2. Yosipovitch G, Goon A, Wee J, Chan YH, Goh CL. The prevalence and clinical characteristics of pruritus among patients with extensive psoriasis. Br J Dermatol 2000; 143: 969–973.
3. Zachariae R, Zachariae CO, Lei U, Pedersen AF. Affective and sensory dimensions of pruritus severity: associations with psychological symptoms and quality of life in psoriasis patients. Acta Derm Venereol 2008; 88: 121–127.
4. Mrowietz U, Kragballe K, Nast A, Reich K. Strategies for improving the quality of care in psoriasis with the use of treatment goals – a report on an implementation meeting. J Eur Acad Dermatol Venereol 2011; Suppl 3: 1–13.
5. Radtke MA, Reich K, Spehr C, Augustin M. Treatment goals in psoriasis routine care. Arch Dermatol Res 2015; 307: 445–449.
6. Lloyd DM, Hall E, Hall S, McGlone FP. Can itch-related visual stimuli alone provoke a scratch response in healthy individuals? Br J Dermatol 2013; 168: 106–111.
7. Niemeier V, Gieler U. Observations during an Itch-Inducing Lecture. Dermatology and Psychosomatics/Dermatologie und Psychosomatik 2000; 1 (Suppl. 1): 15–18.
8. Papoiu ADP, Wang H, Coghill RC, Chan YH, Yosipovitch G. Contagious itch in humans: a study of visual 'transmission' of itch in atopic dermatitis and healthy subjects. Br J Dermatol 2011; 164: 1299–1303.
9. Jousmaki V, Hari R. Parchment-skin illusion: sound-biased touch. Curr Biol 1998; 8: R190.
10. Elman S, Hynan LS, Gabriel V, Mayo MJ. The 5-D itch scale: a new measure of pruritus. Br J Dermatol 2010; 162: 587–593.
11. Feldman SR, Fleischer AB, Jr., Reboussin DM, Rapp SR, Exum ML, Clark AR, et al. The self-administered psoriasis area and severity index is valid and reliable. J Invest Dermatol 1996; 106: 183–186.
12. Holle H, Warne K, Seth AK, Critchley HD, Ward J. Neural basis of contagious itch and why some people are more prone to it. Proc Natl Acad Sci U S A 2012; 109: 19816–19821.
13. Gazzola V, Aziz-Zadeh L, Keysers C. Empathy and the somatotopic auditory mirror system in humans. Curr Biol 2006; 16: 1824–1829.
14. Lamm C, Decety J, Singer T. Meta-analytic evidence for common and distinct neural networks associated with directly experienced pain and empathy for pain. Neuroimage 2011; 54: 2492–2502.
15. Ward J, Burckhardt V, Holle H. Contagious scratching: shared feelings but not shared body locations. Front Hum Neurosci 2013; 7: 122.
16. O'Neill JL, Chan YH, Rapp SR, Yosipovitch G. Differences in itch characteristics between psoriasis and atopic dermatitis patients: results of a web-based questionnaire. Acta Derm Venereol 2011; 91: 537–540.
17. Schut C, Bosbach S, Gieler U, Kupfer J. Personality traits, depression and itch in patients with atopic dermatitis in an experimental setting: a regression analysis. Acta Derm Venereol 2014; 94: 20–25.
18. Ikoma A, Steinhoff M, Stander S, Yosipovitch G, Schmelz M. The neurobiology of itch. Nat Rev Neurosci 2006; 7: 535–547.
19. Holle H, Swithenbank S, Ward J, editors. Auditory modulation of Itch. 7th World Congress on Itch 2013; World Trade Centre, Boston, MA, USA. Acta Derm Venereol 2013; 93: 497–640.