Universiteit Utrecht

Multisensory Perception of Itch-Related Stimuli: Effect on Perceived Itch Sensations

Name: Nassira Rifi

Email: n.rifi@students.uu.nl

Student number: 4226194

Supervisor(s)

Name: Chris Dijkerman

Contact details: c.dijkerman@uu.nl

Name: Anouk Keizer

Contact details: a.keizer@uu.nl

Abstract

Background: Itch sensations can be triggered in healthy individuals when watching someone else scratching. However, in our multisensory environment, itch-related stimuli can be processed differently as using multiple senses improves the perception of these stimuli. Studies investigating the top-down effect of itch-related stimuli in a multisensory context are lacking. Here we investigate experimentally whether multisensory perception of itch-related stimuli, compared to unisensory perception, induces stronger itch sensations in healthy individuals. Further, we examine which body parts and side of the body participants perceived as itchy.

Method: Thirty female volunteers were presented with video- and sound clips depicting someone scratching. Participants were then asked to rate their level of perceived itch, and to indicate which body parts they perceived as itchy. The experimenter obtained which exact side of the body was perceived as itchy.

Results: Participants did not only perceive a higher level of itch but they even engaged more in spontaneous scratching behavior when we presented itch-related stimuli, compared to non-itch related stimuli. However, compared to unisensory perception, multisensory perception of itch-related stimuli did not induce stronger itch sensations. Results further show that participants tended to perceive their face and both sides of their body as itchy.

Conclusions: Perceiving itch-related stimuli in their isolated modality seems effective enough to induce itch sensations that are strong as when those stimuli would be perceived with multiple senses. Our findings also suggest that instead of the actual scratching behavior, observed sensations are transmitted which can indicate that itch is not sensory mapped.

Keywords: multisensory perception, itch, scratch, contagious, body

Multisensory Perception of Itch-Related Stimuli: Effects on Perceived Itch Sensations

Everyone is familiar with experiencing itch: a sensation on the skin that, when strong enough, can provoke the urge to scratch (Savin, 1998). However, experiencing itch daily (i.e. chronic itching) can be highly debilitating (Bautista, Wilson, & Hoon, 2014; Ikoma, Steinhoff, Ständer, Yosipovitch, & Schmelz, 2006). Patients with medical skin conditions (e.g. eczema, atopic dermatitis) – for example – experience several difficulties apart from their common symptoms resulted from itching, such as sleep disruptions (Chrostowska-Plak, Reich, & Szepietowski, 2012; Prignano, Ricerri, Pescitelli, & Lotti, 2009; Zachariae, Zacharie, Lei, & Pedersen, 2008), distressed feelings (Chrostowska-Plak et al., 2012; Zachariae et al., 2008) and withdrawal from social activities (de Korte, Sprangers, Mombers, Bos, 2004). These factors can in turn significantly lower quality of life (Chrostowska-Plak et al., 2012; de Korte et al., 2004; Kini et al., 2011) and pose a greater risk for depression in those patients (Reich, Hrehorow, & Szepietowski, 2010; Zachariae et al., 2008). Effective treatment of itch is therefore highly needed.

To date, effective treatment options for itching are limited. Many treatments, such as emollients and corticosteroids (Dawn & Yosipovitch, 2006), have short-term effects (Dawn & Yosipovitch, 2006; Prignano et al., 2009) or do not alleviate itch at all (Dawn & Yosipovitch, 2006; Yosipovitch, Goon, Wee, Chan, & Goh, 2000). Other treatments can cause significant side-effects (Dawn & Yosipovitch, 2006), such as skin irritation and skin atrophy. These problems reveal the need for more effective and safer treatments targeting itch.

But before itch treatments can be improved, it is essential to deepen our understanding into the underlying mechanism of itch by – for example – investigating factors that can influence itch sensations in a way without causing side-effects. In the current study, we therefore aim to investigate factors influencing itch sensations in a harmless way.

In recent years, there has been an increasing amount of studies on factors influencing itch sensations. These studies have identified numerous factors influencing itch sensations in both healthy individuals and patients (Dalgard, Lien, & Dalen, 2007; Verhoeven, de Klerk, Kraaimaat, Van de Kerkhof, De Jong, & Evers, 2008), including psychosocial (e.g. low income) and psychological factors. An interesting psychological example is the influence of itch-related stimuli on itch sensations, such as visual and auditory stimuli depicting scratching behavior or medical skin conditions. This phenomenon is often referred to as *contagious itch*. Papoiu, Wang, Coghill, Chan and Yosipovitch (2011) have demonstrated this phenomenon by presenting atopic dermatitis patients and healthy volunteers with video clips showing a model scratching the left arm (itch-related) or sitting relaxed (control). These participants were also injected with either a histamine or a saline (control) solution. When participants were injected with a control solution, atopic dermatitis patients reported intensified itch symptoms after viewing the itch-related video clips, compared with the neutral video clips, whereas healthy participants' level of perceived itch was slightly increased. This finding suggests that individuals with medical skin conditions are more susceptible to the top-down effect of itch-related visual stimuli compared to healthy individuals (van Laarhoven et al., 2007).

In contrast to Papoui et al. (2011), other researchers successfully induced itch sensations in healthy individuals without using physiological triggers (Holle, Warne, Seth, Critchley, & Ward, 2012; Lloyd, Hall, Hall, & McGlone, 2013; Ogden & Zoukas, 2009). For example, Holle and colleagues (2012) induced itch sensations in healthy volunteers using video clips that show a model scratching or tapping different body parts (e.g. left arm, right arm or chest). After each video clip, participants were asked to rate their level of perceived itch. Results showed participants perceiving stronger itch sensations after viewing the itch-related video clips compared to the neutral (tapping) video clips. This finding suggests that not only patients with medical skin conditions (Papoui et al., 2011) but also healthy individuals are susceptible to the top-down effect of itch-related stimuli.

Holle et al. (2012) further recorded participants' spontaneous scratching behavior when they viewed the itch-related stimuli. They found that, in addition to an increased level of perceived itch, participants performed more scratch responses while viewing the itch-related stimuli compared to the non-itch related stimuli. This finding indicates that itch-related stimuli do not only induce itch sensations, but that itch-related stimuli are also effective enough to provoke spontaneous scratch responses in healthy individuals. Furthermore, Holle et al. (2012) identified a positive relationship between participant's perceived itch sensations and participant's scratching behavior. This relationship indicates that participant's scratching behavior can be used as an objective measure for their level of perceived itch.

To examine which body parts were scratched by participants in Holle and colleagues' study (2012), Ward et al. (2013) carried out an additional analysis on participants' scratching patterns. Their analysis revealed participants scratching themselves more often on their face and head compared to their other body parts, even when these locations were not scratched in the observed video clips. A similar pattern of results was found earlier by Papoiu et al. (2011): While viewing the itch-related video clip atopic dermatitis patients, compared to healthy participants, scratched body areas that extended from the body location that was induced with a histamine solution. Together, these findings suggest that despite itch being contagious, scratching patterns by observers do not reflect those of the observed individual.

The influence of itch-related stimuli on perceived itch sensations and scratching behavior is not limited to visual stimuli. Itch-related behavior can be perceived with multiple senses such as the visual and auditory sense. Yet, far too little attention has been paid (Niemeier, Kupfer, and Gieler, 2000) to the influence of itch-related stimuli perceived by other senses or a combination of them (e.g. visual and auditory sense combined). In an early study by Niemeier et al. (2000), both healthy volunteers and patients with skin conditions reported a higher level of perceived itch, and scratched themselves more often after attending a lecture about itch. This finding suggests that listening to someone else discuss itching, can trigger itch sensations and provoke scratching behavior in not only patients with skin diseases but also in healthy individuals. The study by Niemeier and colleagues (2000) further indicates that both healthy individuals and patients with medical skin conditions are susceptible to the top-down effect of not only visual, but also auditory itch-related stimuli.

In view of all that has been mentioned so far, one can infer that itch-related visual as well as auditory stimuli can trigger itch sensations and provoke scratching behavior in healthy individuals. However, there has been little research about the influence of other types of itch-related stimuli on itch sensations and scratching responses. For example, Niemeier and colleagues (2000) have focused more on inducing itch sensations by presenting participants itch-related semantic stimuli (i.e. listen to discussions about itch) instead of having participants listen to the actual sound of itch (i.e. scratching of the skin). Another crucial point is that other studies let participants either listen or visually observe itch-related stimuli, thereby focusing on the role of solely one sense in perception (i.e. only auditory or visual sense).

The fact that previous studies investigated only one sense in perception is particularly interesting because in daily life, people encounter many events that stimulate multiple senses at the same time (i.e. multisensory perception). This simultaneous stimulation can also be extended to itch-related contexts. Especially since we can see and hear someone else scratch themselves at the same time. Itch and scratching behavior could therefore be considered as multisensory events in daily life. Our multisensory environment suggests that the role of multiple senses should be considered when investigating the top-down effect of itch-related stimuli. To be more precise, investigating multisensory perception of itch-related behavior (i.e. scratching the skin) in an experimental way is needed to gain more insight into the mechanism underlying the top-down effect of itch-related stimuli. The present study therefore aims to investigate the perception of itch by using experimental stimuli to induce itch sensations in a multisensory context.

According to Stein & Stanford (2008), multisensory perception can lead to *multisensory integration*: the merging of information from multiple senses into one coherent event by the brain. To integrate multiple events, auditory and visual events need to occur close in space (*spatial rule*) and time (*temporal rule*) (Bolognini, Frassinetti, Serino, & Làdavas, 2005; Feng, Stormer, Martinez, McDonald, & Hillyard, 2014; Frassinetti, Bolognini, & Làdavas, 2002). When auditory and visual events occur simultaneously, the brain will be informed about the source of the stimuli and whether they should be integrated into one event or not (King, 2005; Stein & Stanford, 2008). In terms of itch-related behavior, multisensory integration will likely take place when we see and hear someone perform scratching behavior in synchrony.

Multisensory perception has, compared to unisensory perception, several benefits such as a more accurate perception (Koelewijn, Bronkhorst, & Theeuwes, 2010; Stein & Stanford, 2008), faster and better detection of events (Bell, Meredith, Van Postal, & Monaz, 2005; Noesselt, Bergmann, Hake, Heinze, & Fendrich, 2008; Stein & Stanford, 2008), and faster responses to events (Diederich & Colonius, 2004). These benefits are illustrated when we hear and visually see an approaching mosquito, allowing us to detect the mosquito fast and react upon it by removing the mosquito. In line with our reasoning, we propose that the perception of multisensory itch-related stimuli is fundamentally different from the perception of unisensory itch-related stimuli as the use of multiple senses enhances the perception of the environment, and could therefore trigger stronger itch sensations. Both processes might also provoke different itch-related reactions in observers. These assumptions have however not been experimentally tested yet.

The present study was therefore designed to investigate whether receiving itch-related multisensory input (multisensory perception of itch-related stimuli), compared to unisensory input (unisensory perception of itch-related stimuli), induces a significant higher level of perceived itch in healthy participants. To examine this research question, we presented participants individually with itch-related and non-itch related stimuli, such as video and sound clips. Following Holle et al. (2012), these stimuli depicted a female model scratching or tapping her left arm. Twenty-four stimuli were presented on separate slides in counter-balanced order using PowerPoint. After each stimulus, participants were asked to rate their level of perceived itch using a visual analogue scale (VAS), and to indicate which body locations were perceived as itchy. In a later step, the experimenter extracted from the data which side of participant’s body and which body parts were perceived as itchy. Participants’ scratching behavior was also recorded using a webcam, to obtain a more objective measure of participants’ level of perceived itch (Holle et al., 2012; Ward et al., 2013). Dalgard et al. (2007) and Holle et al. (2012) suggested that certain personality characteristics may influence the level of perceived itch. We took this into consideration by assessing empathy, neuroticism and itch sensitivity using several personality questionnaires.

Based on the previous discussed studies (e.g. Holle et al., 2012; Lloyd et al., 2012; Papoiu et al., 2011; Ward et al., 2013), we expected that the level of perceived itch in each participant would be higher when they were presented with itch-related multisensory input (i.e. itch-related visual and auditory stimuli), than when they were presented with unisensory input (i.e. only itch-related visual or auditory stimuli). We further expected that each participant would engage more in scratching behaviour when perceiving itch-related stimuli compared to non-itch related stimuli. We also hypothesized that participants perceived itch sensations more often on their face compared to their other body parts. Finally, we expected that body parts participants perceived as itchy differed between the multisensory and unisensory condition.

Method

Participants

Thirty healthy volunteers (all female; mean age 21.97 + 4.07 years) participated in the experiment (see Table 1 for demographic information). All participants were above 18 years of age. Participants were recruited through posters and flyers distributed on the campus of Utrecht University, and through two different websites: Proefbunny and 'proefpersoonuren'. Volunteers with present medical skin conditions, such as eczema and psoriasis, were not allowed to participate in the experiment. This choice was made for two reasons. First, individuals with medical skin conditions could have had already a higher level of perceived itch than healthy individuals before the stimuli were presented, because itching is a common symptom of skin conditions. Second, Van Laarhoven et al. (2007) found that individuals with medical skin conditions perceived somatosensory stimuli more easily compared to healthy individuals. Both discussed factors could confound participant's itch ratings; therefore, volunteers with medical skin conditions were not allowed to participate in the experiment.

We assessed participants' characteristics during the experiment (see section Self-report questionnaires for more information about the used questionnaires). Empathy was measured using the (short) Empathy Quotient Questionnaire (Baron-Cohen & Wheelwright, 2004), and neuroticism was measured using the Big Five Inventory (Denissen, Geenen, van Aken, Gosling, & Potter, 2008). The Edinburgh Handedness Inventory was used to assess handedness of all participants. Two left handed, 23 right handed, and five ambidextrous participants were in the sample. Participants were also asked to rate how frequently they experienced itch sensations compared to other individuals, (n = 29; mean 2.10 ± 0.56) using the question ‘*Do you think that you experience more or less often itch sensations compared to other individuals?*’. One participant was excluded because of a missing value. Three participants indicated perceiving less often itch sensations, while six participants indicated perceiving more often itch sensations compared to other individuals. Twenty participants reported perceiving itch sensations as often as other individuals did. We further asked each participant the highest education level they completed. Five participants completed HAVO, while 17 participants completed VWO. Only one participant reported completing MBO, while seven participants reported completing WO.

Each experiment lasted approximately 60 minutes. In return for participating, participants received monetary compensation (six euros) or one study credit. Signed written consent was obtained from all participants and none of the participants withdrew from the experiment. The current study was approved by the local ethics committee of Utrecht University.

Table 1

Demographic characteristics of participants

Measure	Participants
Age in years (mean ± *SD*)	21.97 ± 4.07
Highest education level (*n* , %)	
VMBO	0
HAVO	5 (16.7%)
VWO	17 (56.7%)
MBO	1 (3.3%)
HBO	0
WO	7 (23.3%)
Handedness[a] (*n*, %)	
Right	23 (76.67%)
Left	2 (6.67%)
Ambidexter	5 (16.67%)
Neuroticism[b] (mean ± *SD*)	3.26 ± 0.73
Empathy[c] (mean ± *SD*)	45.30 ± 11.52
Itch Sensitivity[d] (mean ± *SD*)	2.10 ± 0.56

a Handedness was assessed using the Edinburgh Handedness Inventory (Van Strien, 1992)

b *n* = 28; Neuroticism was measured using the Big Five Inventory (Denissen et al., 2008)

c Empathy was measured using the Empathy Quotient Questionnaire (Baron-Cohen & Wheelwright, 2004)

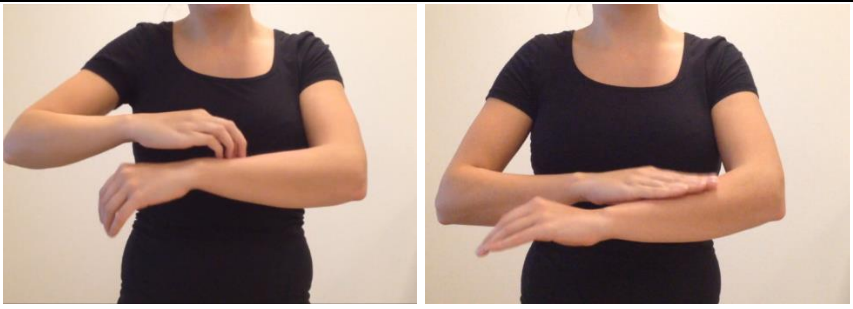
d *n* = 29.

Stimulus Materials

Each participant was individually presented with video- and sound clips using a PowerPoint presentation. Based on the study by Holle et al. (2012), two video clips were made of 20 seconds each. Video recording took place in the Langeveld-building at Utrecht

University using an iPhone 4s camera. The two video clips were extracted from the recordings using Windows Movie Maker. To create the sound clips, we extracted the sounds from the same video clips using Audacity.

Both video clips showed a female model wearing neutral black clothing who performed a specific behavior (i.e. tapping or scratching). Following Holle et al. (2012), these video clips were also cropped at the neck to avoid any influences of facial expressions of the female model. Still images from both video clips can be seen in Figure 1.



(A) Scratch **(B)** Control/Tapping

Figure 1. Still images from the itch-related (A) and non-itch related (B) video clip. The left image shows the female model scratching her left arm, while the right image shows the same model tapping herself on the same locations.

In video clip A (i.e. itch-related video clip), the female model was seen and heard performing scratching behavior on her left arm. In video clip B (i.e. neutral video clip), the same model was seen and heard tapping herself on the same locations on her left arm. As opposed to video clip A, video clip B was used to present non-itch related content. Participants were expected to perceive less/no itch sensations and to engage less in scratching behavior when they were presented with video clip B compared to video clip A.

The way in which video clips A and B were presented in this experiment varied between conditions. In other words, participants viewed the video clips with sound only in the multisensory conditions. In the visual conditions participants viewed the same video clips but without sound. Finally, in the auditory conditions participants only listened to the extracted sound clips.

Materials & Apparatus

PowerPoint presentation. All stimuli were presented on a laptop computer, *Packard-Bell Easynote TJ*-65, using PowerPoint. The PowerPoint presentation contained 24 stimuli in counterbalanced order to reduce order effects. Each participant was therefore presented with a different PowerPoint Presentation. There were in total six conditions: Visual itch-related, visual non-itch related, auditory itch-related, auditory non-itch related, multisensory itch-related (i.e. visual and auditory combined) and multisensory non-itch related condition (i.e. visual and auditory combined). Each condition was repeated four times. After each itch-related condition, a non-itch related condition was presented to collect a baseline measure of participant's level of perceived itch.

During the experiment, the experimenter recorded the time of each condition on an observation sheet. With this, the experimenter could examine the video recordings and extract the frequency of participant's scratch responses in each condition at a later stage. To inform the experimenter about which condition and trial were exactly presented to the participant, a code was shown in the right upper corner of each slide which consisted of two characters and one or two numbers, such as *CM1*. The participant was blind to the meaning of these codes, whereas the experimenter was not. For example, the characters '*CM*' were an abbreviation of the non-itch related (control) multisensory condition (*controle multisensorisch*), while the number '*1*' represented the first trial.

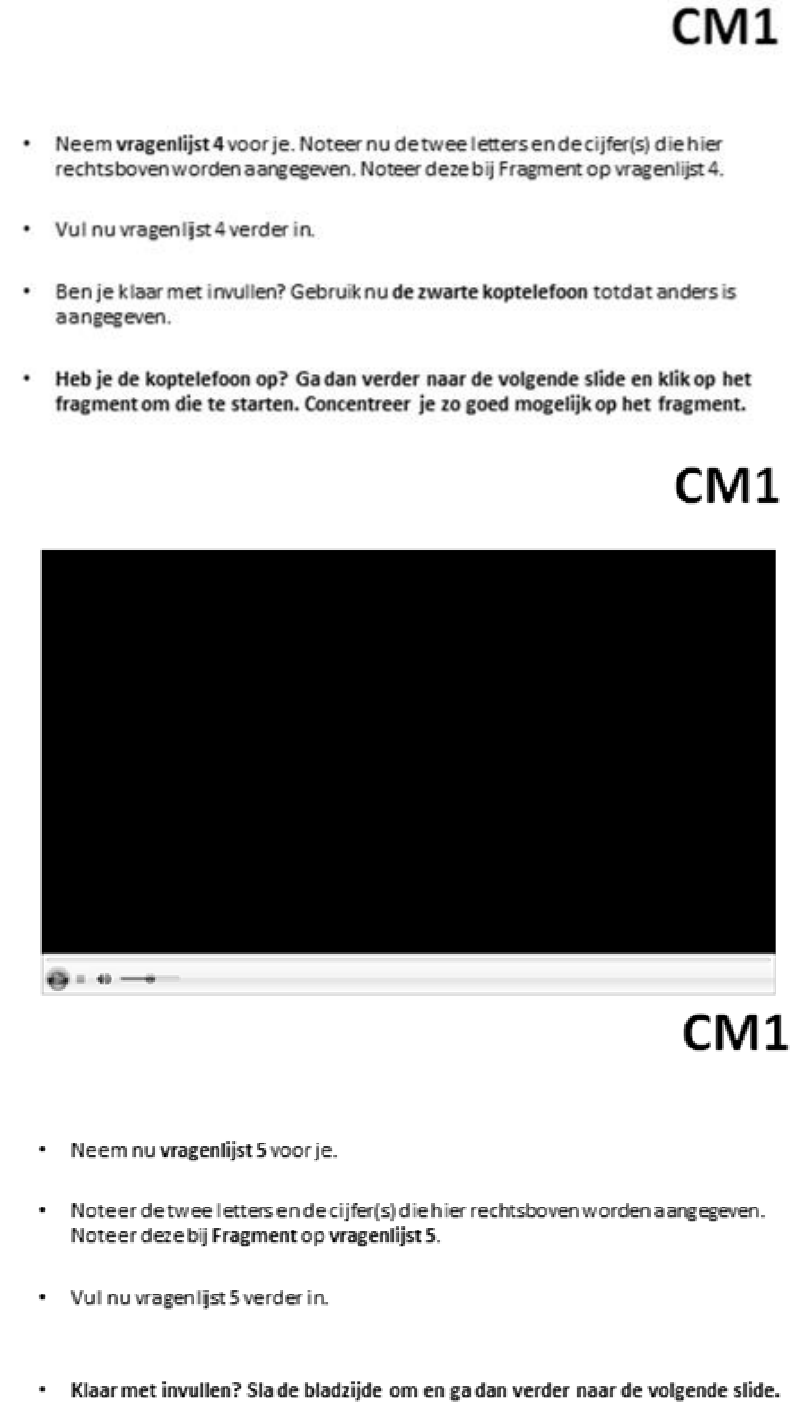


Figure 2. Still images from a PowerPoint Presentation. Each trial was represented by three slides: the first slide provided written instructions, the second slide presented the stimulus and the third slide provided instructions to fill in questionnaires on paper.

As can be seen in Figure 2, each trial consisted of three slides of which two provided written instructions and one presented the stimulus (i.e. video or sound clip). On the first slide of each trial, the participant received instructions to write the code on the questionnaire, and to use a headphone or an earmuff. Each participant also received written instructions to concentrate on the video- or sound clip. The earmuff was used to block external noises in the visual condition. On the second slide of each trial, the participant was presented with the stimulus. This stimulus could be the video clip (with or without sound) or the sound clip, depending on which condition was presented. On the third slide, each participant received instructions to fill in a questionnaire on paper assessing their itch sensations (see subsection 'Itch-ratings'). After completing this questionnaire, the participant moved to the next slide which presented a new trial.

The same procedure (use headphone/earmuff, stimulus, questionnaire) was repeated 24 times. However, at the first trial we also assessed participant's level of perceived itch before the first stimulus was presented to obtain a baseline measure for that trial.

Itch ratings. Based on the study by Lloyd et al. (2012), we made three questions to assess each participant's subjective experience of itch (see Figure 3). These questions were: '*How itchy do you feel*?', '*How itchy do you think the other person feels?*' and '*Please indicate, in the picture below, where you feel itchy on your body*'. Responses to the first two questions were given on a 10-cm VAS-ruler ranging from 0 (*not itchy at all*) to 10 (*worst imaginable itch with the desire to stop the experiment*). Higher values indicated a higher level of perceived itch, whereas lower values indicated a lower level of perceived itch.

The third question assessed which body parts participants perceived as itchy using a body diagram (see Figure 3). Each participant was allowed to indicate multiple locations on the body diagram. The frequency of each indicated body part was extracted by the experimenter at a later stage for analysis.

To obtain the baseline measure for the first trial, we asked each participant to respond only to the questions ‘*How itchy do you feel?*’ and ‘*Please indicate, in the picture below, where you feel itchy on your body?*’ before the first stimulus was presented

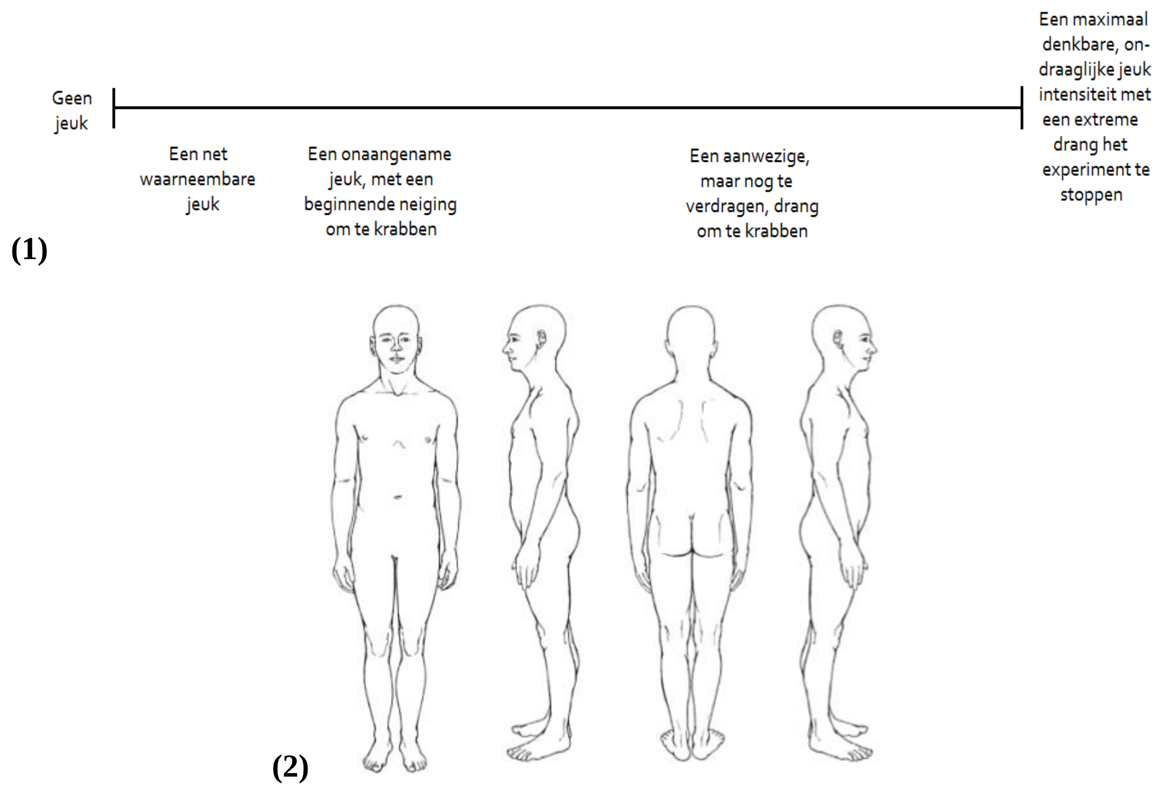


Figure 3. (1) The VAS-ruler (10 *cm*) was used to assess participants’ ratings on the questions ‘*How itchy do you feel?*’ and ‘*How itchy do you think the other person feels?*’. (2) Participants indicated on which body parts they perceived itch sensations using a body diagram.

Self-report questionnaires. Several personality questionnaires were administered to assess individual characteristics, specifically: neuroticism, empathy and itch sensitivity. These questionnaires were always administered after the participant completed all trials (i.e. after the PowerPoint presentation).

First, the Dutch translation of the Big Five Inventory (BFI) (by Denissen et al., 2008) was used to measure personality traits of each participant. This questionnaire is widely used and has a high internal consistency of 0.80 (*α*). Participants rated 40 self-report items (e.g. *worries a lot*) on a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Second, we used the Dutch translation of the Edinburgh Handedness Inventory (EHI) (Van Strien, 1992) to assess participants' hand preference by asking which hand they preferred when performing a specific behavior. This questionnaire has a Cronbach's *α* of 0.98, and contained 10 items (e.g. *With which hand do you draw?*). The total score for each participant was obtained by summing the scores of all items. Higher total scores (+8 or higher) indicated right-handedness, whereas lower total scores (-8 or lower) indicated left-handedness. Scores between -8 and +8 indicated ambidextrous.

Third, the Dutch version of the Empathy Quotient Questionnaire (Baron-Cohen & Wheelwright, 2004) was used to measure empathy in participants. This version is shorter compared to the original questionnaire as the control items were left out. Each participant rated therefore 40 self-report items (e.g. "*I often find it difficult to judge if something is rude or polite.*"). According to Baron-Cohen & Wheelwright (2004), this questionnaire is a reliable way to measure empathy in healthy individuals. Responses were given on a four-point Likert scale ranging from 1 (*strongly disagree*) to 4 (*strongly agree*). Total score of each participant was obtained by summing the scores of all items, with higher total scores indicating having more empathy whereas lower total scores indicated participants having less empathy. .

Finally, participants completed a questionnaire which assessed their demographic characteristics (e.g. gender, highest education level completed and sensitivity to itch) and which asked them to guess what the goal of our study was. We measured participants' sensitivity to itch by letting them rate the following item '*Do you think that you experience more or less often itch sensations compared to other individuals?*' with 'much less', 'less', 'just as much', 'more' and 'much more'. Participants were also asked what they thought the goal of our study was. Most participants reported that we investigated the influence of seeing or hearing a scratch on perceived itch sensation.

Webcam. Following Holle et al. (2012) and Papoiu et al. (2011), participant's scratching behavior was recorded during the experiment using a Logitech webcam. This recording was aimed at obtaining a more objective measure of participant's perceived itch sensations. A scratch was recorded when the participant moved her fingers across her body for more than one second. The webcam recording was started when the experimenter started the PowerPoint presentation, and the webcam recording was stopped when the participant completed all trials.

The webcam was attached with tape on a wall at the right side of the participant. In order to prevent participants from not scratching at all, they were blind to the purpose of the recording. They were told instead that the webcam recording allowed us to see whether the participant indeed viewed the video clips or not.

Procedure

The experiment took place in the Langeveld-building, which is located on the Uithof of Utrecht University. The participant was seated behind a desk on which the laptop computer was placed (see Figure 4). At the start of the experiment, the participant received verbal and written instructions in which the experimental set-up and the webcam recording were explained. After this introduction, we asked each participant permission for the webcam recording and we explicitly told them that the video recordings would be deleted when the study was completed. None of the participants refused to take part in the video recordings.

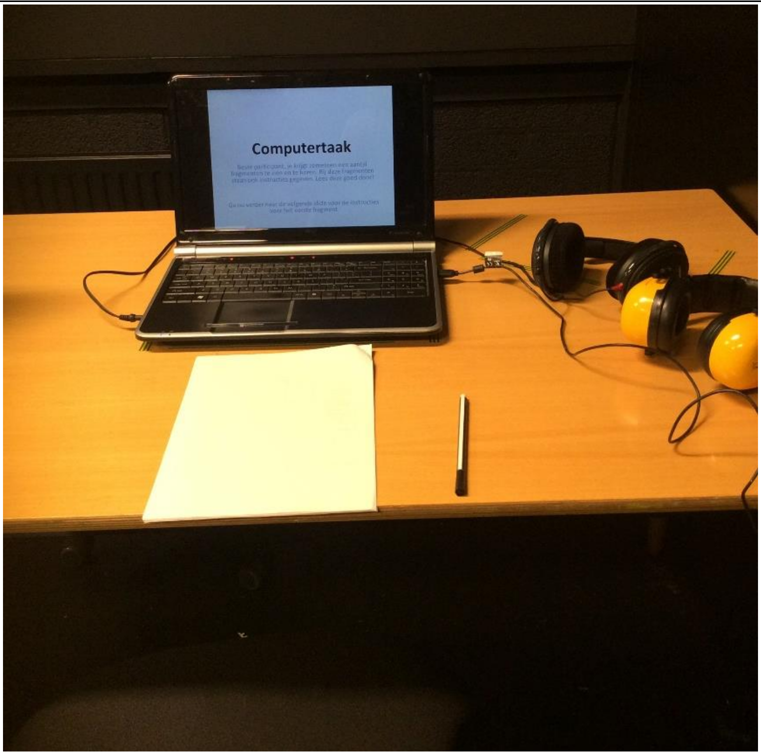


Figure 4. Experimental set-up. The participant was seated behind a desk on which the laptop computer, headphone, earmuff and questionnaires were placed.

After signed consent was obtained we informed the participant about the PowerPoint presentation: '*In this PowerPoint presentation you will view video clips and listen to sound clips. After each video- or sound clip, you have to fill in a questionnaire on paper. There is only one exception: you have to fill in one questionnaire prior to the first fragment. This is also instructed on the next slide of this PowerPoint presentation. You can move to the next slide by pressing this button. Please read the instructions on the slides very carefully to prevent any confusion. Do you have any questions before I will start the presentation? I will be sitting behind you to observe whether everything proceeds as expected.*'

When the participant did not have any questions, the PowerPoint presentation and webcam recording were started by the experimenter. Then, the experimenter seated herself on a red chair behind the participant. The distance between the participant and experimenter was far enough to provide privacy, but at the same time close enough to be able to observe the

PowerPoint presentation (see Figure 5). During this observation, the experimenter recorded the time of each condition on an observation sheet by using the codes on the slides. Each participant was free to ask any questions during the experiment. Once the participant completed all trials, the webcam recording and PowerPoint presentation were stopped by the experimenter. Then, several personality questionnaires were administered to assess participant's characteristics (see section Materials & Apparatus).

Figure 5. Distance between the participant and the experimenter. After the experimenter started the PowerPoint presentation, she seated herself behind the participant to record the time of each condition. The participant sat on the black chair, while the experimenter sat on the red chair.

Statistical Analysis

All analyses on the collected data were performed using IBM SPSS Statistics, version 23. Statistical significance was set at $p < 0.05$. Bonferroni correction was applied when needed, and Bonferroni corrected comparisons were only performed when repeated measures ANOVA revealed statistically significant main or interaction effects. All assumptions for the repeated measures ANOVA were met, except for the normality of the mean difference scores.

Normality of mean difference scores was tested with the Shapiro-Wilk test. Assumptions for Friedman's non-parametric tests were met.

To verify whether the itch-related stimuli induced itch sensations in each participant, a repeated measures ANOVA was performed with a 2 (itch-related vs. control) x 3 (visual vs. auditory vs. multisensory) factorial design on the mean difference VAS-scores of '*How itchy do you feel?*'. The independent variables in this design were condition (itch vs. control) and modality (visual vs. auditory vs. multisensory). The dependent variable was the mean difference VAS-score.

Several steps were performed to obtain the mean difference scores. First, we calculated difference scores between trials by using the VAS-score from the previous trial as baseline. In other words, the VAS-score from e.g. trial 3 was subtracted from the VAS-score of trial 4. Then, we calculated the mean of the difference scores for each participant by condition, which resulted in a mean difference score for each condition (visual itch-related, visual non-itch related, auditory itch-related, auditory non-itch related, multisensory itch-related and multisensory non-itch related condition). Note here that positive values indicated participants perceiving a higher level of perceived itch, whereas negative values indicated lower level of perceived itch compared to baseline.

To determine whether participants perceived the itch-related stimuli as itch-related content, an additional repeated measures ANOVA was performed with a 2 (itch vs. control) x 3 (visual vs. auditory vs. multisensory) factorial design on the mean difference VAS-scores of '*How itchy do you think the other person feels?*'. The independent variables in this design were condition and modality, while the dependent variable was the mean difference VAS-score of '*How itchy do you think the other person feels?*'. We calculated the mean difference scores in the same way as we did for the previous question '*How itchy do you feel?*'.

To investigate which body parts participants perceived as itchy in each condition, multiple Friedman's nonparametric tests were applied on the frequency scores of each indicated body part. These frequency scores were calculated by counting how many times each participant indicated a body part in each condition, summing up all trials. Following Ward et al. (2013), body parts were coded as: *legs* (i.e. from the feet up to the hips and bottom), *arms* (i.e. from the wrists up to the upper arm), *hands*, *shoulders*, *chest* (i.e. upper part of the torso), *back*, *neck* (the neck also included the front side, i.e. throat), *face* (including the ears) and *hair*. Note here that Ward and colleagues (2013) did not include the back as a body part participants could perceive as itchy, whereas we did. If Friedman's test revealed a significant difference, Wilcoxon's signed rank tests were performed with Bonferroni correction applied. The independent variable was condition, while the dependent variable was frequency score. Level of confidence was divided by the number of comparisons (36), which resulted in a level of confidence of $p = 0.001$.

We also investigated whether body sides participants perceived as itchy differed between the body sides in each condition. Multiple Friedman's non-parametrical tests were therefore performed on the frequency of each indicated body side. Again, we counted how many times a particular body side was indicated as itchy in each condition by summing up all trials. Sides of the body were coded as: *only left*, *only right* and *both sides*. When participants did not perceive itch sensations, we coded this as '*no perceived itch*'. Wilcoxon's signed rank tests were performed when Friedman's test identified a significant difference. Independent variable in this design was condition/modality, and dependent variable was frequency score of each body part. Bonferroni correction was applied by dividing the level of confidence by the number of comparisons, in this case 6 comparisons, resulting in a level of confidence of $p = 0.008$.

Finally, we examined participant's scratching behavior in the experimental conditions (itch-related vs. non-itch related) using Friedman's test on frequency scores. The independent variable was condition. To obtain the frequency scores of scratch responses, the experimenter counted how many times a participant scratched herself in each condition. Each time the participant moved her finger stroke-wise, a scratch was recorded.

Results

'How itchy do you feel?'

The question '*How itchy do you feel?*' assessed participant's level of perceived itch by letting participants rate their sensations on a 10-*cm* VAS-scale ranging from 0 (*not itchy at all*) to 10 (*worst imaginable itch with the desire to stop the experiment*). Mean difference scores were then calculated for each condition.

A repeated measures ANOVA was performed with Condition (itch vs. control) and Modality (visual vs. auditory vs. multisensory) as within-subjects factors. The dependent variable in this analysis was the mean difference VAS-score. It is important to note that positive values indicated stronger itch sensations in participants, whereas negative values indicated weaker itch sensations compared to baseline. We did not include demographic characteristics (i.e. age, handedness, empathy, neuroticism and education level) as covariates, because these characteristics did not correlate with the mean difference VAS-scores, all p*'s* $\geq$ 0.08.

First, we wanted to verify whether participants rated their level of perceived itch higher when we presented the itch-related stimuli, compared to the non-itch related stimuli (see Table 2 for the means and standard deviations of repeated measures ANOVA). Results of the repeated measures ANOVA revealed a significant main effect of Condition, $F(1,29) = 15.88$, $p < 0.001$, with participants perceiving stronger itch sensations in the itch-related condition (*M* = 5.05, *SD* = 1.24) compared to non-itch related condition (*M* = -4.23, *SD* = 1.12).

Second, we were particularly interested in whether participants rated their level of perceived itch higher in the multisensory condition (i.e. auditory and visual combined) compared to the visual and auditory condition. However, the repeated measures ANOVA showed no significant main effect for Modality $F(2.58) = 0.60$, $p = 0.550$. This finding shows that participants' level of perceived itch did not differ between the visual, auditory and multisensory condition; therefore, our primary hypothesis was not confirmed. We also did not find an interaction effect between Condition and Modality, $F(2,58) = 0.94$, $p = 0.400$.

To summarize the results, participants perceived stronger itch sensations after being presented with itch-related stimuli (i.e. seeing or hearing the model scratching her left arm) compared to non-itch related stimuli (i.e. seeing or hearing the same model tapping her left arm). However, participants' level of perceived itch did not differ between the modality conditions, showing that participants did not perceive stronger itch sensations in the multisensory condition compared to the visual or auditory condition.

'How itchy do you think the other person feels?'

The question '*How itchy do you think the other person feels?*' measured the extent to which participants rated how itchy the female model in the video- or sound clip felt. Participants' responses were again recorded on a 10-*cm* VAS-scale ranging from 0 (*no itch*) to 10 (*worst imaginable itch with the desire to stop the experiment*). Prior to analysis, difference scores between trials were calculated in the same way as we did for the question '*How itchy do you feel?*'. Positive values indicated that participants rated the female model in the clips as feeling more itchy, whereas negative values indicated participants rating the female model as feeling less compared to baseline measure.

Then, a repeated measures ANOVA was performed on the mean difference scores with two within-subjects factors: Condition (itch vs. control) and Modality (visual vs. auditory vs. multisensory). The dependent variable in this design was the mean difference score of the question '*How itchy do you think the other person feels?*'. Pearson Correlation analysis did not reveal any correlations between participants' characteristics (i.e. age, handedness, empathy, neuroticism and highest education level completed) and mean difference scores, all *p's* $\geq$ 0.057 Therefore, we did not control for those variables in the repeated measures ANOVA analysis.

First, we wanted to verify whether participants rated the female model as feeling more itchy in the itch-related condition compared to the non-itch related condition. Whether participants rated the model as itchy in the itch-related condition compared to the non-itch related condition, could inform us that the itch-related stimuli were perceived as itch-related content. Results showed a significant main effect of Condition, $F(1,29) = 102.09$, $p < 0.001$, with participants rating the model as having stronger itch sensations in the itch-related condition ($M = 34.52$, $SD = 3.21$) compared to the non-itch related condition ($M = -31.37$, $SD = 3.33$). This finding shows that the itch-related stimuli in our experiment indeed provided participants with itch-related content.

Second, we compared participants' ratings of the model across the multisensory, visual and auditory condition. Results revealed a significant main effect of Modality Hyuhn-Feldt corrected, $F(1.75; 50.59) = 4.09$, $p = 0.027$. Bonferroni corrected pairwise comparisons showed participants rating the female model as feeling more itchy in the multisensory condition ($M = 4.40$, $SD = 1.22$) compared to the visual condition ($M = -0.57$, $SD = 0.81$) , $t(29) = 2.72$, $p = 0.033$. However, no significant difference was found between the multisensory and auditory condition ($M = 0.91$, $SD = 1.10$), $t(29) = 1.67$, $p = 0.316$. We also found no significant difference between the visual and auditory condition, $t(29) = 1.74$, $p =$

0.854. Further, no interaction effect was found between Condition and Modality, $F(2,58) = 1.27$, $p = 0.290$.

Taken together, the above results showed participants rating the model as feeling more itchy when perceiving itch-related stimuli compared to non-itch related stimuli. Participants also rated the model as feeling more itchy in the multisensory condition compared to the visual condition. However, participants' rating of the model did not differ between the auditory and visual condition, nor between the auditory and multisensory condition.

Table 2

Results of the ANOVA repeated measures for the rating of ‘self’ and ‘other’.

Question	Effect	*F*	*P*	Condition	*M (SD)*	Modality	*M (SD)*
How itchy do you feel?	Main effect Condition	15.88	< 0.001	Itch-related	5.05 (1.24)	Visual	-0.35 (0.70)
	Main effect Modality	0.60	0.550	Non-itch related	-4.23 (1.12)	Auditory	1.05 (0.71)
	Condition * Modality	0.94	0.400			Multisensory	0.53 (0.88)
How itchy do you think the other person feels?	Main effect Condition	102.09	< 0.001	Itch-related	34.52 (3.21)	Visual	-0.57 (0.81)
	Main effect Modality	4.09	0.027	Non-itch related	-31.37 (3.33)	Auditory	0.91 (1.10)
	Condition * Modality	1.27	0.290			Multisensory	4.40 (1.22)

Itch Sensations Perceived On The Body

Side of the body. We wanted to examine whether there was a significant difference between body sides in how often participants perceived these sides as itchy. In other words, which body side was more often perceived as itchy in each condition? Note here that the female model in the stimuli scratched only the left side of her body.

Sides of the body were coded as: *both sides*, *only left*, *only right* or, when participants did not perceive any itch sensations at all, *no perceived itch*. As each condition consisted of four trials, frequency scores were calculated by summing up how many times each body side was indicated as itchy and how many times participants perceived no itch sensations on their body in each condition. Multiple Friedman's tests were then performed on the frequency scores, with condition and modality as independent variables. If a significant difference was revealed, Bonferroni corrected Wilcoxon signed rank test was performed.

In the non-itch related condition (visual, auditory and multisensory combined), we found no significant difference between how often participants perceived their right, left and both sides as itchy, and how often participants perceived no itch, $X^2(3) = 4.16$, $p = 0.245$. Frequency scores can be seen in Figure 6. In the itch-related condition (visual, auditory and multisensory combined) however, a significant difference was revealed between body sides in how often these were perceived as itchy, using Friedman's non-parametrical test $X^2(3) = 9.40$, $p = 0.024$. Wilcoxon signed rank test showed participants perceiving *both* sides of their body significantly more often as itchy compared to only their *left* ($Z = -2.76$, $p = 0.006$) or *right* side ($Z = -2.77$, $p = 0.006$). No significant difference was found when we compared *both* body sides with *no perceived itch* ($Z = -1.40$, $p = 0.161$). We also found no significant differences between the *left* and *right* side ($Z = -0.21$, $p = 0.834$), nor between the *left* side and how often participants perceived *no itch* at all ($Z = -0.09$, $p = 0.925$). Frequency scores for *right* body side and *no perceived itch* also did not differ significantly ($Z = -0.41$, $p = 0.681$).

Frequencies for the itch-related modality conditions can be seen in Figure 7. In the itch-related visual condition, Friedman's test did not show a significant difference between frequency scores for the *left*, *right*, *both* or *no* body side, $X^2(3) = 4.16$, $p = 0.202$. In the itch-related multisensory condition – however – results revealed a significant difference between the body sides (*left*, *righ*t, *both* or *no perceived itch*), $X^2(3) = 12.28$, $p = 0.006$. Wilcoxon signed rank test showed that participants perceived *both sides* of their body more often as itchy compared to only their *right side* ($Z = -2.80$, $p = 0.005$). No significant differences was found when we compared *left* and *both* body sides ($Z = -2.56$, $p = 0.010$) nor when we compared the *right* and *left side* ($Z = -0.680$, $p = 0.497$) in how often participants perceived these sides as itchy. We also did not find significant differences between the frequency scores for *no perceived itch* and *both sides* ($Z = -1.67$, $p = 0.095$) nor between frequency scores for *no perceived itch* and the *left side* of the body ($Z = -0.52$, $p = 0.606$). Finally, no significant difference was identified between *no perceived itch* and *right side* of the body ($Z = -0.55$, $p = 0.580$).

In the itch-related auditory condition, results revealed again a significant difference between body sides, $X^2(3) = 9.51$, $p = 0.023$. Post-hoc analysis with Wilcoxon signed rank test showed however no significant differences. Therefore, no significant differences were found between frequency scores for *left* side vs. *both* sides ($Z = -2.13$, $p = 0.033$), *right* side vs. *both* sides ($Z = -2.29$, $p = 0.022$), *no perceived itch* vs. *both* sides ($Z = -1.54$, $p = 0.125$), *right* side vs. *left* side ($Z = -0.06$, $p = 0.955$), *no perceived itch* vs. *left* side ($Z = -0.51$, $p = 0.610$), nor between only the *right* side and *no perceived itch* ($Z = -0.59$, $p = 0.552$).

Figure 8 shows frequencies for the non-itch related modality conditions. In the non-itch related multisensory condition, no significant difference was found between the frequency scores for the *right* side, *left* side, *both* sides and *no perceived itch*, $X^2(3) = 4.01$, $p = 0.260$. Also in the non-itch related auditory condition ($X^2(3) = 1.84$, $p = 0.605$) and in the non-itch related visual condition ($X^2(3) = 6.57$, $p = 0.087$) we found no significant differences between how often participants perceived *both* sides, only the *left*, only the *right* as itchy, and perceived *no itch* at all.

To summarize the results, participants perceived only in the itch-related multisensory condition more often both sides of their body as itchy compared to only their right side. No significant differences were found in the other experimental conditions (i.e. itch-related visual, non-itch related visual, non-itch related auditory and the non-itch related multisensory condition). Even when a significant difference was revealed in the itch-related auditory condition, post hoc analysis did not reveal significant comparisons.

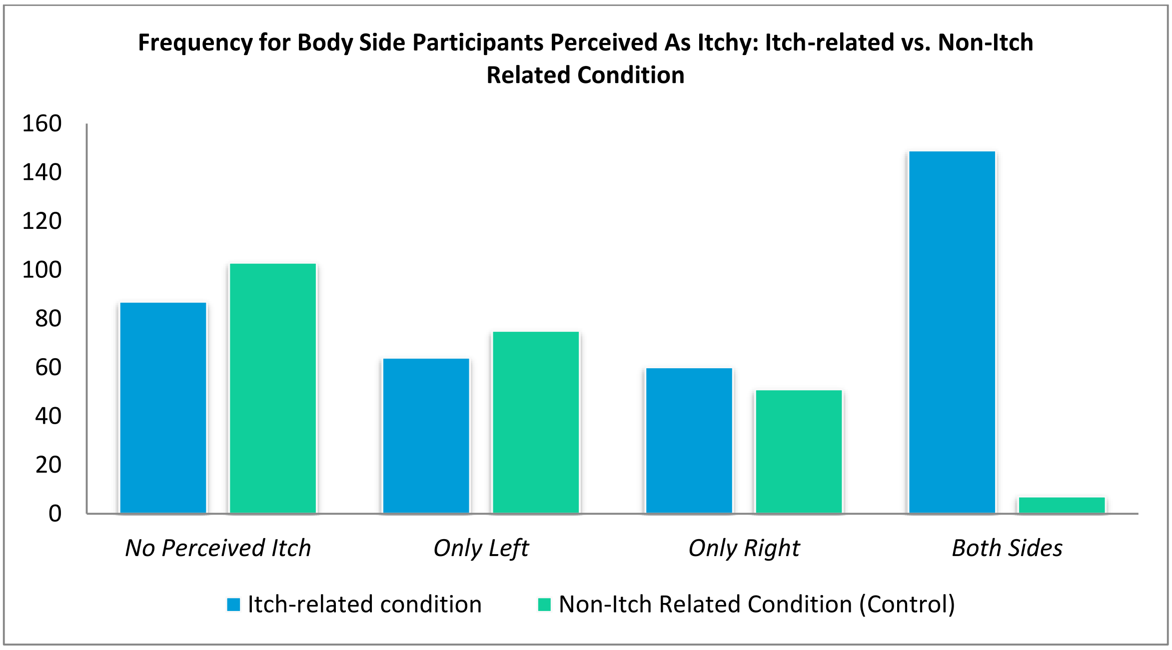


Figure 6. Frequency scores for how often participants perceived their body side as itchy in the experimental conditions (itch related- and non-itch related condition). Sides of the body were coded as: only *left*, only *right*, *both* sides, or when participants did not perceive any itch sensations '*no perceived itch*'.

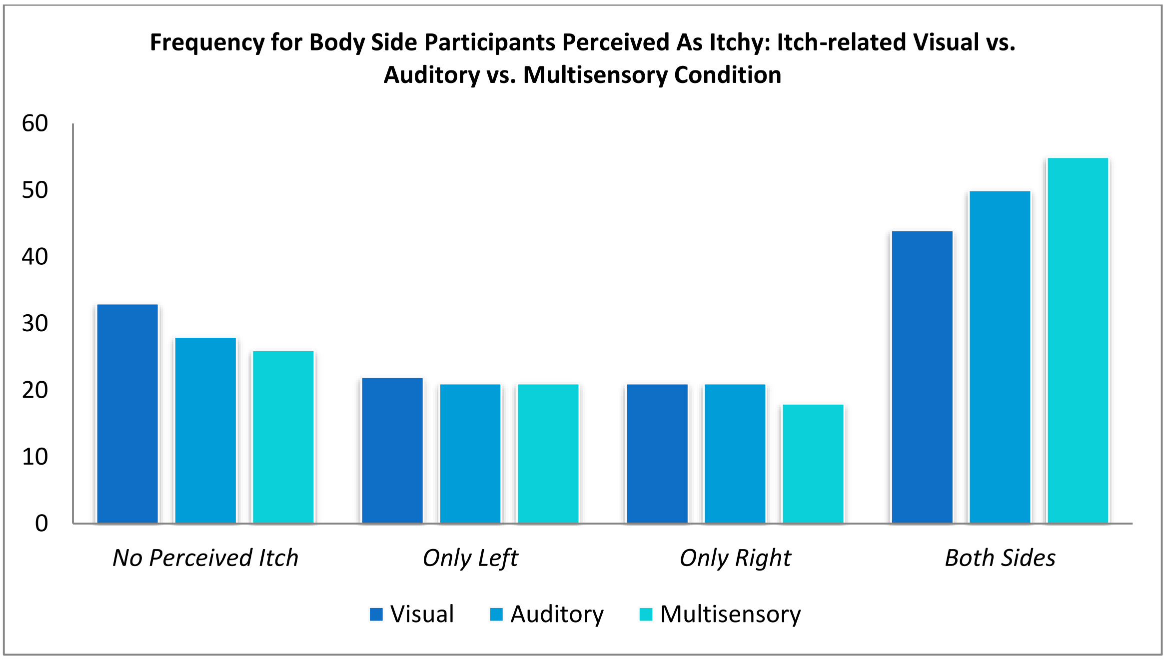


Figure 7. Frequency scores for how often participants perceived their body side as itchy across modalities in the itch-related condition (i.e. only visual, only auditory, multisensory). We coded the sides of the body as: *both* sides, *only left*, *only right* or ‘*no perceived itch*’ when participants did not feel itchy.

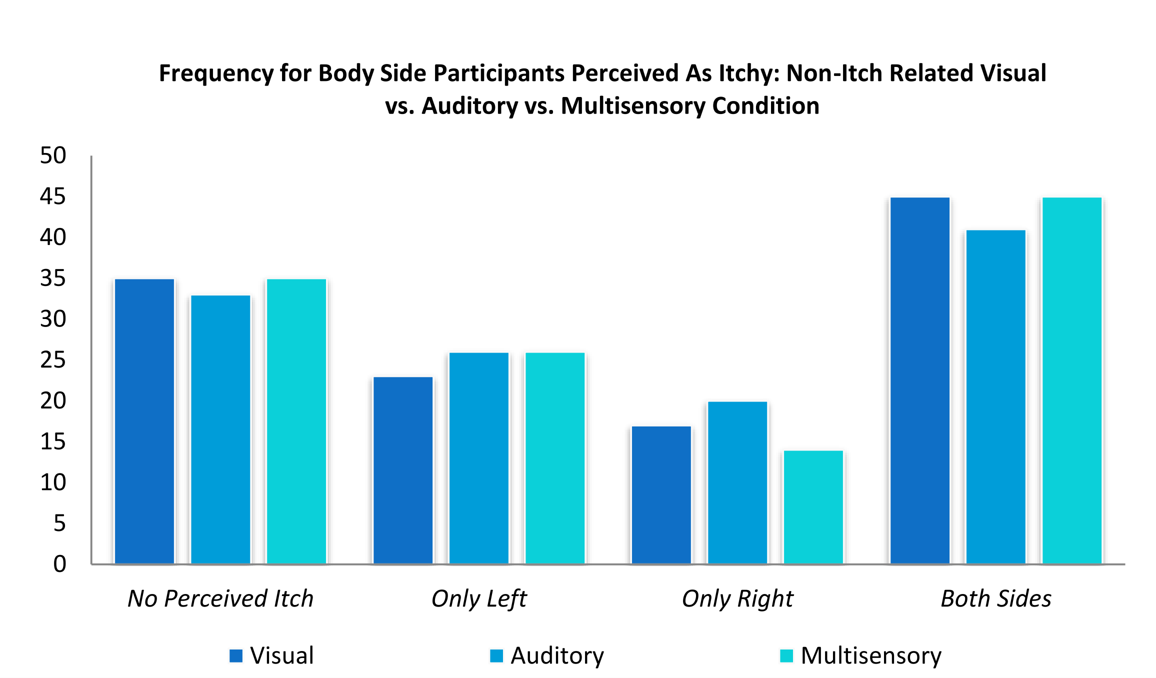


Figure 8. Frequency scores for how often participants perceived their body side as itchy across modalities in the non-itch-related condition (i.e. only visual, only auditory, multisensory). Sides of the body were coded as: *only left*, *only right*, *both sides*, or when participants did not perceive itch sensations at all '*no perceived itch*'.

Body locations. We also wanted to investigate whether body parts perceived as itchy differed in each of the six conditions. It is important to highlight here that the female model in the stimuli scratched or tapped her left arm.

Based on the study by Ward et al. (2013), we coded body locations as: *chest* (i.e. upper part of torso), *face* (including the ears), *arms* (i.e. from the wrist up to the upper arm), *hands*, *neck (*also included was the front side, i.e. throat), *back*, *legs* (i.e. from the feet up to the bottom and hips), *hair* and *shoulders*. Frequency scores were then calculated by summing up how often each body part was perceived as itchy in each condition. Friedman's non-parametrical tests were conducted on the frequency scores and post-hoc analysis with Wilcoxon signed rank test was performed when a significant difference was revealed. Level of confidence was corrected for multiple comparisons which resulted in a *p*-value of 0.001.

In the itch-related condition (i.e. visual, auditory and multisensory combined), a significant difference was found between the various body parts participants perceived as itchy, $X^2(8) = 60.86$, $p < 0.001$. Figure 9 shows frequency scores from the itch-related condition. Wilcoxon signed rank test was conducted, showing participants perceiving more often their face as itchy compared to their *chest* ($Z = -3.96$, $p < 0.001$), *neck* ($Z = -3.89$, $p < 0.001$), *hands* ($Z = -3.38$, $p = 0.001$) and *shoulders* ($Z = -4.08$, $p < 0.001$), but not when the face was compared to the *arms* ($Z = -1.12$, $p = 0.263$), *back* ($Z = -3.10$, $p = 0.002$), *legs* ($Z = -1.44$, $p = 0.150$) and *hair* ($Z = -3.13$, $p = 0.002$). *Chest* was significantly more often perceived as itchy only compared to *legs* ($Z = -3.21$, $p = 0.001$), but the chest was not more often perceived as itchy when compared to the *arms* ($Z = -2.91$, $p = 0.004$), *hands* ($Z = -0.14$, $p = 0.887$), *neck* ($Z = -1.18$, $p = 0.237$), *back* ($Z = -1.36$, $p = 0.175$), *hair* ($Z = -2.63$, $p = 0.008$) nor the *shoulders* ($Z = -0.57$, $p = 0.568$). Participants did perceive their *arms* more often as itchy only when compared to their *shoulders* ($Z = -3.46$, $p = 0.001$), but not when we compared *arms* to *hands* ($Z = -2.75$, $p = 0.006$), *neck* ($Z = -2.20$, $p = 0.028$), *back* ($Z = -2.52$, $p = 0.012$), *legs* ($Z = -1.83$, $p = 0.855$) and *hair* ($Z = -1.14$, $p = 0.254$). *Hands* were not significantly more often perceived as itchy compared to the *neck* ($Z = -0.61$ $p = 0.540$), *back* ($Z = -0.90$, $p = 0.369$), *legs* ($Z = -2.77$, $p = 0.006$), *hair* ($Z = -1.95$, $p = 0.052$) and the *shoulders* ($Z = -0.81$, $p = 0.421$). Also, participants did not perceive their *neck* significantly more often as itchy compared to their *back* ($Z = -0.13$, $p = 0.896$), *legs* ($Z = -3.07$, $p = 0.002$), *hair* ($Z = -1.34$, $p = 0.181$) and *shoulders* ($Z = -1.73$, $p = 0.084$). *Back* was not significantly more often perceived as itchy compared to *legs* ($Z = -2.66$, $p = 0.008$), *hair* ($Z = -1.11$, $p = 0.267$), and *shoulders* ($Z = -1.87$, $p = 0.062$). Furthermore, participants did not perceive their *legs* significantly more often as itchy compared to their *hair* ($Z = -2.38$, $p = 0.018$). However, we did found a significant difference between the *legs* and *shoulders* in how often participants perceived those as itchy ($Z = -3.31$, $p = 0.001$). Finally, no significant difference was found between *shoulders* and *hair*, $Z = -2.35$, $p = 0.019$.

In the non-itch related condition (i.e. visual, auditory and multisensory combined), body parts perceived as itchy differed significantly between all body parts, $X^2(8) = 58.66$, $p < 0.001$ (see Figure 9 for frequency scores). Wilcoxon signed rank test showed participants perceiving more often their *face* as itchy only compared to their *chest* ($Z = -3.86$, $p < 0.001$), *shoulders* ($Z = -4.04$, $p < 0.001$), *hands* ($Z = -3.38$, $p = 0.001$), *back* ($Z = -3.37$, $p = 0.001$), *neck* ($Z = -3.97$, $p < 0.001$) and *hair* ($Z = -3.32$, $p = 0.001$), but not when the face was compared to the *arms* ($Z = -1.26$, $p = 0.208$) or *legs* ($Z = -1.84$, $p = 0.066$). No significant differences were found in frequency scores when we compared *chest* to *arms* ($Z = -2.44$, $p = 0.015$), *hands* ($Z = -0.48$, $p = 0.631$), *neck* ($Z = -0.89$, $p = 0.376$), *back* ($Z = -0.52$, $p = 0.604$), *legs* ($Z = -2.60$, $p = 0.009$), *hair* ($Z = -2.11$, $p = 0.035$) and *shoulders* ($Z = -1.45$, $p = 0.147$). Participants perceived their *arms* significantly more often as itchy only when compared to *shoulders* ($Z = -3.43$, $p = 0.001$), but not when *arms* were compared to *hands* ($Z = -2.66$, $p = 0.008$), *neck* ($Z = -1.80$, $p = 0.072$), *back* ($Z = -2.64$, $p = 0.008$), *legs* ($Z = -0.11$, $p = 0.909$) and *hair* ($Z = -1.16$, $p = 0.246$). No other significant differences were further found between other body parts. *Hands* were not more often perceived as itchy compared to the *neck* ($Z = -1.11$, $p = 0.267$), *back* ($Z = -0.77$, $p = 0.439$), *legs* ($Z = -2.91$, $p = 0.004$), *hair* ($Z = -2.51$, $p = 0.012$) and *shoulders* ($Z = -0.90$, $p = 0.370$). *Neck* was not more often perceived as itchy by participants compared to the *back* ($Z = -0.26$, $p = 0.793$), *legs* ($Z = -2.56$, $p = 0.011$), *hair* ($Z = -1.07$, $p = 0.285$) and *shoulders* ($Z = -2.10$, $p = 0.036$). Participants did not perceive their *back* more often as itchy compared to *legs* ($Z = -2.30$, $p = 0.021$), *hair* ($Z = -1.27$, $p = 0.203$) and *shoulders* ($Z = -2.13$, $p = 0.033$). No significant differences were further identified between *legs* and *hair* ($Z = -1.72$, $p = 0.085$), nor between *legs* and *shoulders* ($Z = -3.08$, $p = 0.002$).

Finally, we found no significant difference between *hair* and *shoulders* in how often participants perceived these body parts as itchy, $Z = -2.68$, $p = 0.007$.

We also compared differences between body parts in how often these were perceived as itchy in each modality condition (see Figure 10 and Figure 11 for frequency scores in the modality conditions). In the itch-related multisensory condition, Friedman's test revealed a significant difference between body parts in how often participants perceived these body parts as itchy, $X^2(8) = 50.40$, $p < 0.001$. To compare which body parts significantly differed from each other, Wilcoxon signed rank test was conducted. Participants perceived their *face* more often as itchy compared to their *chest* ($Z = -3.89$, $p < 0.001$), *neck* ($Z = -3.53$, $p < 0.001$) and *shoulders* ($Z = -3.67$, $p < 0.001$), but not when *face* was compared to the *arms* ($Z = -0.78$, $p = 0.436$), *hands* ($Z = -2.90$, $p = 0.004$), *back* ($Z = -2.77$, $p = 0.006$), *legs* ($Z = -1.56$, $p = 0.118$) and *hair* ($Z = -2.67$, $p = 0.008$). *Chest* was significantly more often perceived only when compared to *arms* ($Z = -3.21$, $p = 0.001$) and *legs* ($Z = -3.22$, $p = 0.001$) but not when compared to *hands* ($Z = -0.96$, $p = 0.336$), *neck* ($Z = -1.43$ $p = 0.153$), *back* ($Z = -1.81$, $p = 0.070$), *hair* ($Z = -2.72$, $p = 0.007$) or *shoulders* ($Z = -0.33$, $p = 0.739$). We found no other significant differences between frequency scores when we compared *arms* to *hands* ($Z = -2.61$, $p = 0.009$), *neck* ($Z = -2.36$, $p = 0.018$), *back* ($Z = -2.35$, $p = 0.019$), *legs* ($Z = -0.37$, $p = 0.712$), *hair* ($Z = -1.25$, $p = 0.210$) and *shoulders* ($Z = -3.06$, $p = 0.002$). Again, no significant differences were found when *hands* were compared to *neck* ($Z = -0.37$, $p = 0.714$), *back* ($Z = -0.61$, $p = 0.541$), *legs* ($Z = -2.22$, $p = 0.026$), *hair* ($Z = -1.52$, $p = 0.129$) and *shoulders* ($Z = -0.55$, $p = 0.582$). *Neck* was also not significantly more often perceived as itchy compared to *back* ($Z = -0.47$, $p = 0.642$), *legs* ($Z = -2.12$, $p = 0.034$), *hair* ($Z = -1.62$, $p = 0.106$) and *shoulders* ($Z = -0.95$, $p = 0.340$). Furthermore, participants did not perceive their *back* significantly more often as itchy than their *legs* ($Z = -2.08$, $p = 0.037$), *hair* ($Z = -1.03$, $p = 0.305$) nor *shoulders* ($Z = -1.28$, $p = 0.199$). *Legs* were also not more often perceived as itchy compared to *hair* ($Z = -1.37$, $p = 0.171$) and *shoulders* ($Z = -2.60$, $p = 0.009$). Finally, we found no significant difference between *hair* and *shoulders* ($Z = -2.15$, $p = 0.032$) in how often participants perceived these body parts as itchy.

In the itch-related visual condition, a significant difference was revealed between body parts in how often these were perceived as itchy using Friedman's test, $X^2(8) = 46.81$, $p <$ 0.001. Post-hoc analysis using Wilcoxon signed rank test revealed participants perceiving their *face* significantly more often as itchy compared to their *neck* ($Z = -3.32$, $p = 0.001$) and *shoulders* ($Z = -3.59$, $p < 0.001$), but not when frequency score for *face* was compared to *arms* ($Z = -0.83$, $p = 0.404$), *hands* ($Z = -3.00$, $p = 0.003$), *back* ($Z = -2.94$, $p = 0.003$), *leg*s ($Z = -1.18$, $p = 0.238$) and *hair* ($Z = -2.22$, $p = 0.026$). No significant differences were found when we compared *chest* to *arms* ($Z = -2.28$, $p = 0.023$), *hands* ($Z = -0.43$, $p = 0.666$), *neck* ($Z = -0.62$, $p = 0.537$), *back* ($Z = -0.71$, $p = 0.476$), *legs* ($Z = -2.54$, $p = 0.011$), *hair* ($Z = -1.68$, $p = 0.094$) or *shoulders* ($Z = -1.10$, $p = 0.272$). Again, no significant differences were found when *arms* were compared to *hands* ($Z = -2.75$, $p = 0.006$), *neck* ($Z = -2.00$, $p = 0.046$), *back* ($Z = -2.12$, $p = 0.034$), *legs* ($Z = -0.12$, $p = 0.904$), *hair* ($Z = -0.86$, $p = 0.388$) and *shoulders* ($Z = -3.09$, $p = 0.002$). *Hands* also were not more often perceived as itchy when compared to *neck* ($Z = -1.23$, $p = 0.219$), *back* ($Z = -1.22$, $p = 0.221$), *legs* ($Z = -2.52$, $p = 0.012$), *hair* ($Z = -2.01$, $p = 0.044$) and *shoulders* ($Z = -0.74$, $p = 0.461$). We found no significant differences between the frequency scores for *neck* and *back* ($Z = -0.04$, $p = 0.971$), *legs* ($Z = -2.76$, $p = 0.006$), *hair* ($Z = -1.36$, $p = 0.175$) or *shoulders* ($Z = -1.65$, $p = 0.098$). *Back* was not significantly more often perceived as itchy than the *legs* ($Z = -2.13$, $p = 0.033$), *hair* ($Z = -0.97$, $p = 0.334$) and *shoulders* ($Z = -1.78$, $p = 0.075$). No significant differences were found between the *legs* and *hair* ($Z = -1.32$, $p = 0.188$), nor between the *legs* and *shoulders* ($Z = -2.91$, $p = 0.004$) in how often participants perceived these body parts as itchy. Finally, we found no significant difference in how often participants perceived their *hair* and *shoulders* as itchy (Z = -2.49, p = 0.013).

In the itch-related auditory condition, Friedman's non-parametrical test again identified a significant difference between body parts in how often participants perceived these parts as itchy, $X^2(8) = 46.81$, $p < 0.001$. We therefore performed Wilcoxon signed rank test to examine which exact body parts significantly differed. Participants perceived their *face* significantly more often as itchy only when compared to their *shoulders* (Z = -3.42, p = 0.001), but not when compared to *chest* (Z = -2.62, p = 0.009), *arms* (Z = -0.68, p = 0.495), *hands* (Z = -2.54, p = 0.011), *neck* (Z = -3.10, p = 0.002), *back* (Z = -2.43, p = 0.015), *legs* (Z = -0.84, p = 0.401) and *hair* (Z = -2.70, p = 0.007). However, *chest* was not significantly more often perceived as itchy compared to *arms* (Z = -1.94, p = 0.052), *hands* (Z = -0.45, p = 0.652), *neck* (Z = -0.72, p = 0.786), *back* (Z = -0.48, p = 0.631), *legs* (Z = -2.10, p = 0.036), *hair* (Z = -1.02, p = 0.310) and *shoulders* (Z = -0.63, p = 0.531). We also found no significant differences in frequency scores when we compared *arms* to *hands* (Z = -162, p = 0.106), *neck* (Z = -1.90, p = 0.057), *back* (Z = -2.33, p = 0.020), *legs* (Z = -0.16, p = 0.876), *hair* (Z = -1.57, p = 0.117) and *shoulders* (Z = -2.66, p = 0.008). Again, *hands* were not significantly more often perceived as itchy compared to the *neck* (Z = -0.36, p = 0.719), *back* (Z = -0.30, p = 0.977), *legs* (Z = -1.77, p = 0.077), *hair* (Z = -0.55, p = 0.581) and *shoulders* (Z = -1.31, p = 0.191). Furthermore, no significant differences were found when we compared frequency scores for *neck* to *back* (Z = -0.31, p = 0.755), *legs* (Z = -2.24, p = 0.025), *hair* (Z = -0.62, p = 0.537) and *shoulders* (Z = -0.98, p = 0.327). Participants did not perceive their *back* significantly more often as itchy than their *legs* (Z = -1.81, p = 0.070), *hair* (Z = -0.36, p = 0.719) and *shoulders* (Z = -1.43, p = 0.154). No significant differences were found between frequency scores for *legs* and *hair* (Z = -2.36, p = 0.018), nor between *legs* and *shoulders* (Z =

-3.01, *p* = 0.003). We also found no significant between how often participants perceived their *hair* and *shoulders* as itchy (*Z* = -1.63, *p* = 0.103).

In the non-itch related multisensory condition, we found a significant difference between body parts perceived as itchy using Friedman's test, $X^2(8) = 44.70$, $p < 0.001$. Wilcoxon signed rank test showed that participants perceived their *face* significantly more often as itchy compared to *chest* (*Z* = -3.22, *p* = 0.001), *neck* (*Z* = -3.29, *p* = 0.001), *hair* (*Z* = -3.18, *p* = 0.001) and *shoulders* (*Z* = -3.80, $p < 0.001$), but the *face* was not more often perceived as itchy compared to the *arms* (*Z* = -1.59, *p* = 0.111), *hands* (*Z* = -3.07, *p* = 0.002), *back* (*Z* = -2.82, *p* = 0.005) and *legs* (*Z* = -1.64, *p* = 0.102). No significant differences were found when we compared frequency scores for *chest* to frequency scores for *arms* (*Z* = -1.67, *p* = 0.095), *hands* (*Z* = -0.50, *p* = 0.615), *neck* (*Z* = -0.40, *p* = 0.968), *back* (*Z* = -0.18, *p* = 0.856), *legs* (*Z* = -1.93, *p* = 0.053), *hair* (*Z* = -0.68, *p* = 0.499) and *shoulders* (*Z* = -1.66, *p* = 0.098). We also found no significant differences when we compared frequency scores for *arms* to *hands* (*Z* = -2.19, *p* = 0.028), *neck* (*Z* = -1.39, *p* = 0.164), *back* (*Z* = -1.80, *p* = 0.072), *legs* (*Z* = -0.20, *p* = 0.838), *hair* (*Z* = -1.08, *p* = 0.281) and *shoulders* (*Z* = -2.69, *p* = 0.007). Participants did not perceive their *hands* significantly more often as itchy compared to their *neck* (*Z* = -1.08, *p* = 0.279), *back* (*Z* = -0.65, *p* = 0.518), *legs* (*Z* = -2.60, *p* = 0.009), *hair* (*Z* = -1.65, *p* = 0.099) and *shoulders* (*Z* = -0.68, *p* = 0.496). Again, no significant differences were found in how often participants perceived their *neck* as itchy compared to their *back* (*Z* = -0.43, *p* = 0.666), *legs* (*Z* = -2.91, *p* = 0.004), *hair* (*Z* = -0.73, *p* = 0.465) and *shoulders* (*Z* = -1.41, *p* = 0.159). *Back* was also not significantly more often perceived as itchy when compared to *legs* (*Z* = -2.23, *p* = 0.025), *hair* (*Z* = -0.91, *p* = 0.365) and *shoulders* (*Z* = -1.28, *p* = 0.202). No significant differences were found between frequency scores for *legs* and *hair* (*Z* = -1.71, *p* = 0.087), nor between frequency scores for *legs* and *shoulders* (*Z* = -2.77, *p* =

0.006). Finally, we found no significant difference in how often participants perceived their *hair* and *shoulders* as itchy, $Z = -2.04$, $p = 0.041$.

Friedman's test also revealed a significant difference between body parts participants perceived as itchy in the non-itch related visual condition, $X^2(8) = 51.90$, $p < 0.001$. *Face* was significantly more often perceived as itchy when compared to *chest* ($Z = -3.65$, $p < 0.001$), *hands* ($Z = -3.28$, $p = 0.001$), *neck* ($Z = -3.32$, $p = 0.001$), *back* ($Z = -3.27$, $p = 0.001$), *hair* ($Z = -3.89$, $p < 0.001$) and *shoulders* ($Z = -4.11$, $p < 0.001$). However, the *face* was not more often perceived as itchy compared to *arms* ($Z = -1.30$, $p = 0.193$) and *legs* ($Z = -2.39$, $p = 0.017$). We found no significant differences when we compared frequency scores for *chest* to frequency scores for *arms* ($Z = -2.07$, $p = 0.039$), *hands* ($Z = -0.06$, $p = 0.952$), *neck* ($Z = -1.05$, $p = 0.296$), *back* ($Z = -0.32$, $p = 0.751$), *legs* ($Z = -2.12$, $p = 0.034$), *hair* ($Z = -0.06$, $p = 0.951$) and *shoulders* ($Z = -0.95$, $p = 0.340$). Again, no significant differences were found when we compared frequency scores for *arms* to *hands* ($Z = -2.36$, $p = 0.019$), *neck* ($Z = -1.30$, $p = 0.193$), *back* ($Z = -2.20$, $p = 0.027$), *legs* ($Z = -0.39$, $p = 0.694$), *hair* ($Z = -1.90$, $p = 0.057$) and *shoulders* ($Z = -2.62$, $p = 0.009$). *Hands* were also not significantly more often perceived as itchy compared to *neck* ($Z = -1.28$, $p = 0.200$), *back* ($Z = -0.31$, $p = 0.754$), *legs* ($Z = -2.09$, $p = 0.037$), *hair* ($Z = -0.16$, $p = 0.874$) and *shoulders* ($Z = -0.85$, $p = 0.395$). Participants did not perceive their *neck* significantly more often as itchy compared to their *back* ($Z = -0.82$, $p = 0.413$), *legs* ($Z = -1.24$, $p = 0.214$), *hair* ($Z = -0.93$, $p = 0.351$) and *shoulders* ($Z = -2.07$, $p = 0.039$). We found again no significant differences in body parts perceived as itchy when comparing *back* to *legs* ($Z = -1.66$, $p = 0.096$), *hair* ($Z = -0.21$, $p = 0.837$) and *shoulders* ($Z = -1.90$, $p = 0.058$). Furthermore, no significant differences were found between frequency scores for *legs* and *hair* ($Z = -2.54$, $p = 0.011$), nor between frequency scores for *legs* and *shoulders* ($Z = -2.80$, $p = 0.005$). Finally, *hair* and *shoulders* did not significantly differ in how often participants perceived these body parts as itchy, $Z = -1.10$, $p = 0.272$.

Friedman's non-parametrical test showed a significant difference between body parts perceived as itchy in the non-itch related auditory condition, $X^2(8) = 40.25$, $p < 0.001$. Wilcoxon signed rank test showed participants perceiving their *face* significantly more often as itchy only when compared to the *chest* ($Z = -3.24$, $p = 0.001$) and *shoulders* ($Z = -3.25$, $p = 0.001$), but not when compared to *arms* ($Z = -0.23$, $p = 0.005$), *hands* ($Z = -2.49$, $p = 0.013$), *neck* ($Z = -3.10$, $p = 0.002$), *back* ($Z = -2.12$, $p = 0.034$), *legs* ($Z = -0.89$, $p = 0.374$) or *hair* ($Z = -0.98$, $p = 0.328$). No significant differences were found when comparing how often participants perceived their *chest* as itchy to their *arms* ($Z = -2.62$, $p = 0.009$), *hands* ($Z = -0.72$, $p = 0.473$), *neck* ($Z = -0.65$, $p = 0.518$), *back* ($Z = -1.29$, $p = 0.199$), *legs* ($Z = -2.41$, $p = 0.016$), *hair* ($Z = -2.46$, $p = 0.014$) and *shoulders* ($Z = -0.41$, $p = 0.068$). *Arms* were significantly more often perceived as itchy only when compared to *shoulders* ($Z = -3.23$, $p = 0.001$), but not when *arms* were compared to *hands* ($Z = -2.35$, $p = 0.019$), *neck* ($Z = -2.24$, $p = 0.025$), *back* ($Z = -1.95$, $p = 0.051$), *legs* ($Z = -0.23$, $p = 0.820$) and *hair* ($Z = -0.49$, $p = 0.626$). Participants did not perceive their *hands* significantly more often as itchy compared to *neck* ($Z = -0.05$, $p = 0.958$), *back* ($Z = -0.47$, $p = 0.641$), *legs* ($Z = -2.03$, $p = 0.042$), *hair* ($Z = -2.33$, $p = 0.020$) and *shoulders* ($Z = -1.04$, $p = 0.301$). No significant differences were further found when we compared how often participants perceived their *neck* as itchy to their *back* ($Z = -0.54$, $p = 0.587$), *legs* ($Z = -2.37$, $p = 0.018$), *hair* ($Z = -1.88$, $p = 0.061$) and *shoulders* ($Z = -1.19$, $p = 0.236$). Again, no significant differences were found when frequency scores for *back* were compared to frequency scores for *legs* ($Z = -1.70$, $p = 0.089$), *hair* ($Z = -1.71$, $p = 0.087$) and *shoulders* ($Z = -1.73$, $p = 0.084$). No significant differences were found between *legs* and *hair* in how often participants perceived these body parts as itchy ($Z = -0.32$, $p =$

0.750), nor between *legs* and *shoulders* (Z = -2.68, p = 0.007). Finally, *hair* and *shoulders* did not significantly differ in how often these were perceived as itchy, Z = -2.83, p = 0.005.

Taken together, these results suggest that participants perceived itch sensations more often on their face compared to other body parts (i.e. shoulders and neck). This effect was found independent of experimental condition (itch vs. non-itch related stimuli) and modality (visual vs. auditory vs. multisensory condition).

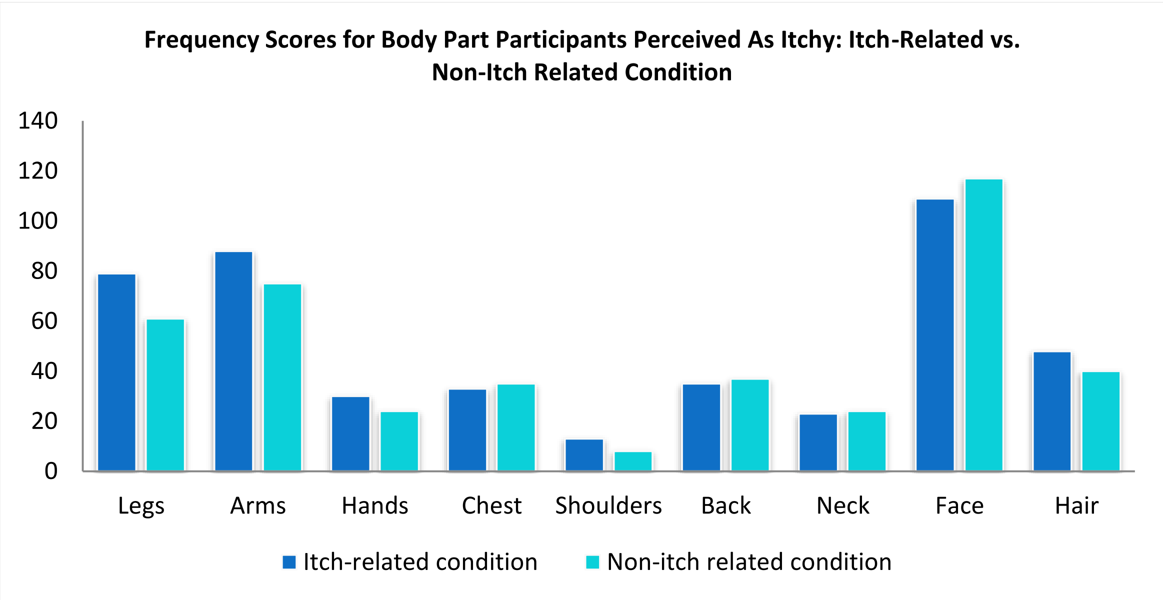


Figure 9. Frequency scores for how often participants perceived a body part as itchy in the experimental conditions (i.e. itch-related vs. non-itch related condition). Following Ward et al. (2013), we coded body parts as: *legs*, *arms*, *hands*, *chest*, *shoulders*, *back*, *neck*, *face* and *hair*.

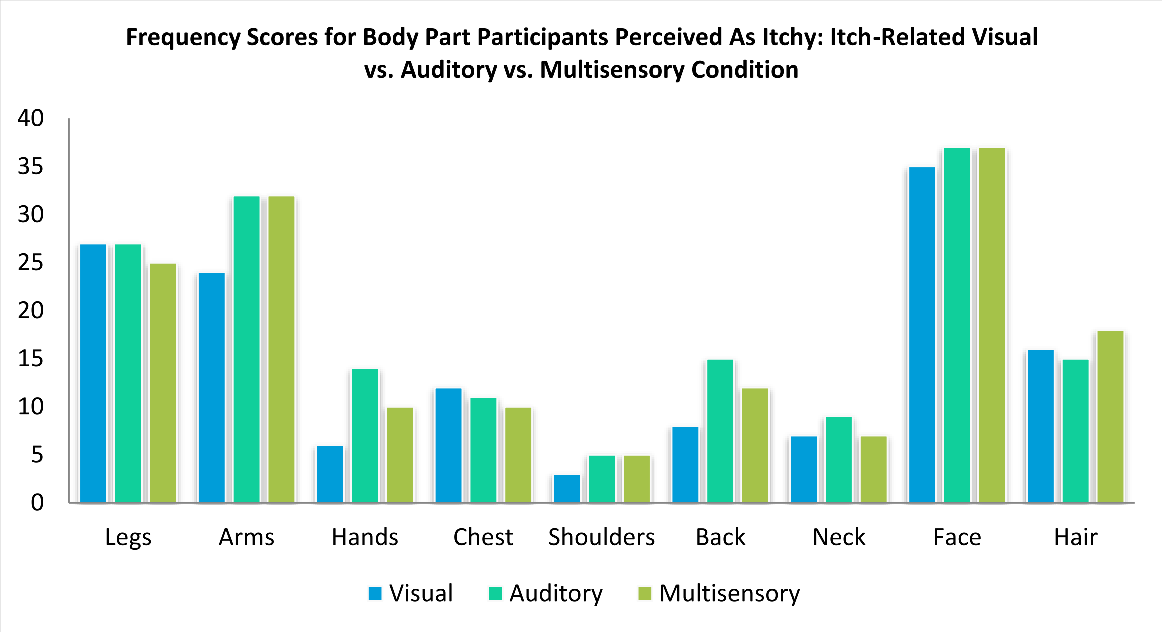


Figure 10. Frequency scores for body parts perceived as itchy across modalities in the itch-related condition (i.e. only visual, only auditory, multisensory condition). Following Ward et al. (2013), body parts were coded as: *shoulders*, *hair*, *neck*, *chest*, *legs*, *back*, *hands*, *face* and *arms*.

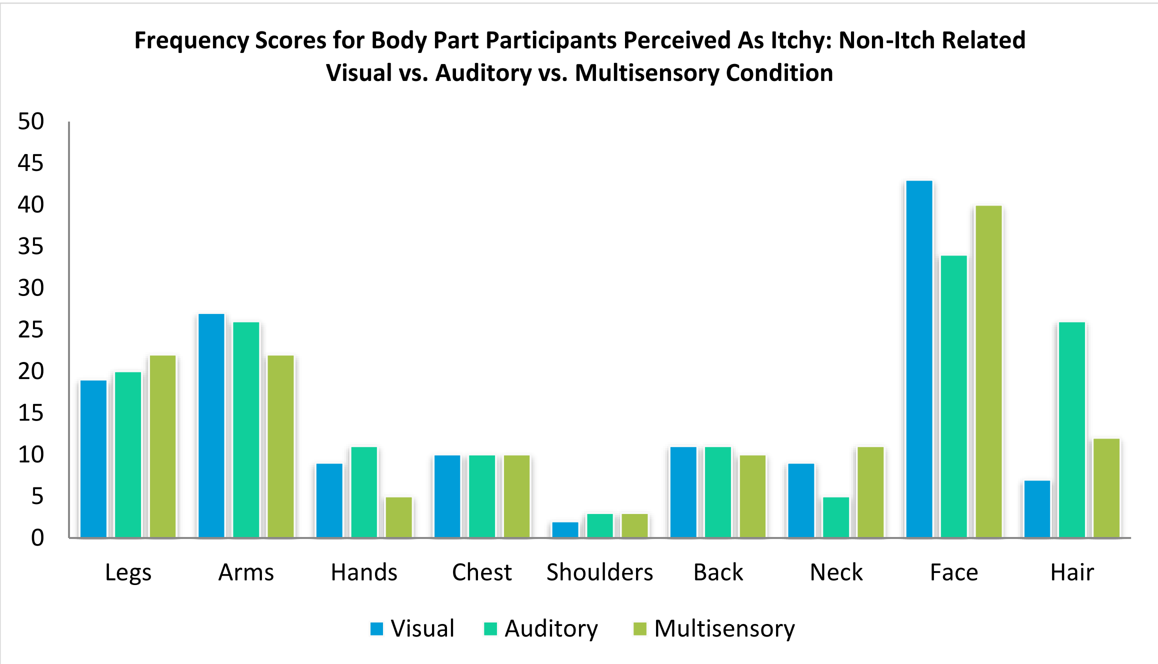


Figure 11. Frequency scores for body parts perceived as itchy by modality in the non-itch-related condition (i.e. only visual, only auditory, multisensory condition). Following Ward et

al. (2013), we coded body parts as: *face*, *hair*, *back*, *neck*, *shoulders*, *legs*, *hands*, *arms* and *chest*.

Spontaneous scratching movements

Participants' scratching behavior was recorded during the experiment to obtain an objective measure of participants' perceived itch sensations (Holle et al., 2012; Papoiu et al., 2011). We recorded a scratch when the participant moved her finger in a stroke-like movement across her body for more than one second. Frequency scores were then calculated for each participant by extracting how many times scratching movements were made in each condition.

To investigate whether participants' scratching responses differed between the itch-related and the non-itch related condition, Friedman's test was performed on the frequency scores. Results revealed that the amount of scratching movements participants made differed between the two experimental conditions (itch-related vs. non-itch related condition): Scratching movements were more often made in the itch-related condition (220 scratch responses) compared to the non-itch related condition (171 scratch responses), $X^2 = 6.14$, $p = 0.013$.

To summarize the results, participants engaged more often in scratching behavior when they saw/heard the female model scratching herself compared to when participants saw/heard her tapping her arm.

Discussion

Itch sensations can be contagious for healthy individuals in absence of any physiological triggers (Holle et al., 2012; Lloyd et al., 2012; Ward et al., 2013). In other words, itch sensations can be transmitted to the observer when observing someone else scratching themselves. With the daily environment containing multiple stimuli, we however do not only see but also hear someone engage in scratching behaviour at the same time. Using multiple senses at the same time is also known as *multisensory perception*.

Interestingly, multisensory perception has certain benefits compared to unisensory perception (i.e. perceiving stimuli using only one sense) such as better detection and faster responses to events (Bell et al., 2005; Noesselt et al., 2008; Stein & Stanford, 2008). It is therefore essential when investigating the influence of itch-related stimuli on perceived itch sensations, to do this in a multisensory context. This in turn could allow us to deepen our understanding of itch and improve treatments targeting (chronic) itching which are – to date – ineffective (Prignano et al., 2009). For example, can itch-related stimuli induce stronger itch sensations when multiple senses are used at the same time compared to when we use only one sense?

In the current study, we therefore investigated whether multisensory perception of itch-related stimuli induced a higher level of perceived itch (i.e. stronger itch sensations) compared to unisensory perception. We also examined which body parts and side of the body participants perceived as itchy, and whether this differed between multisensory and unisensory perception. In order to do so, thirty female volunteers were presented with short video- and sound clips depicting a female model scratching or tapping her left arm. Participants then rated their perceived itch sensations on a scale, and participants indicated which body parts they perceived as itchy. To obtain a more objective measure of participants' perceived itch sensations, participant's scratching behaviour was filmed also during the experiment.

In line with previous studies (Holle et al., 2012; Lloyd et al., 2012; Ogden & Zoukas, 2009; Ward et al., 2013), our results identified stronger perceived itch sensations and more scratching responses in participants when they perceived the model engage in scratching behaviour (i.e. itch-related stimuli) compared to when they perceived the model tapping herself (i.e. non-itch related stimuli). Triggering itch sensations in healthy individuals using harmless itch-related stimuli (i.e. using pictures or video clips) has earlier been demonstrated (Ogden & Zoukas, 2009; Holle et al., 2012; Lloyd et al., 2012; Ward et al., 2013). However, the mechanism behind this top-down effect is still unclear. A possible explanation can be related to the mirror-neuron system, as argued in earlier studies by Holle et al. (2012), Lloyd et al. (2012) and Papoiu et al. (2011).

Initially found in monkeys (Rizzolatti, 2005), mirror neurons are neurons in including the premotor cortex and the inferior parietal lobule that fire when seeing another person perform a specific movement as well as when that same movement is executed (Cattaneo & Rizzolatti, 2009). The mirror-neuron system may not be related only to motoric movements, but it can be related also to understanding behaviour, imitation, learning and even empathy (Gallese, Keysers, & Rizzolatti, 2004). While the mirror-neuron system has not been investigated in *contagious itch* yet, it has however been proposed to be involved in *contagious yawning*: a phenomenon similar to contagious itch in which an individual yawns when observing someone else yawning (Haker, Kawohl, Herwig, & Rössler, 2013; Schürmann et al., 2005). Whether the mirror-neuron system is indeed activated while perceiving itch has not been experimentally tested yet and is an area recommended for future research.

Although our results did reveal a top-down effect of itch-related stimuli, this effect was independent of modality condition. In other words, participants did not perceive stronger itch sensations when visually observing and hearing the model scratching herself at the same time than when they only heard or only visually observed the model. This finding therefore did not support our primary hypothesis. Because we did find a stronger effect of itch-related stimuli in the itch-related condition compared to the non-itch related condition, the lack of effect in the modality conditions could not be accounted for by our study’s design. Then, how could our results be explained? One explanation for this finding could be that studies investigating the benefits of multisensory perception focused more on small effects such as better detection (Bell et al., 2005; Noesselt et al., 2008; Stein & Stanford, 2008) or faster responses to events (Diederich & Colonius, 2004), whereas we examined the benefits on a more higher level (e.g. thinking and rating one's own itch sensations).

Another and more likely explanation for our finding could be the following: Gillmeister and Eilmer (2007) – for example – showed in an earlier study that multisensory perception is indeed beneficial compared to unisensory perception, but only when sensory information from one modality was in itself weak. In their study, they presented participants with tactile and auditory stimuli to investigate whether multisensory integration improved detection of auditory events and auditory intensity. Their results revealed that auditory stimuli were perceived as louder when they were accompanied with tactile stimuli at the same time. However, this effect was found only when the stimuli were weaker when presented in isolation compared to when the auditory stimuli were accompanied with tactile stimuli.

Thus, multisensory integration seems beneficial only when the sensory information is weak when presented in isolation. The fact that participants in our study perceived no increase in itch sensations in the multisensory condition, compared to the unisensory condition (only visual and only auditory), suggests that the itch-related stimuli were effective enough in their isolated modality to induce the necessary increase of perceived itch. In other words, when the auditory stimulus is accompanied by the visual stimulus (i.e. multisensory input), participants would not perceive stronger itch sensations compared to when the stimulus was presented in its isolated modality (i.e. only visual or only auditory). Our results do confirm this explanation because participants' level of perceived itch did not differ between the visual, auditory and multisensory condition.

Not only did we investigate how strong itch sensations were perceived in each condition, but we also investigated which exact locations on the body were perceived as itchy.

While the female model in our stimuli scratched her arm on the left side of her body, participants perceived itch sensations on different locations. For instance, participants perceived itch sensations on both sides of their body in the itch-related condition instead of perceiving itch sensations only on their left side. No significant differences were found in the non-itch related condition. These results suggest that when observing someone scratch themselves only itch sensations are transmitted, whereas the spatial location of the observed behaviour (i.e. scratching) is not.

Transmission of sensations to the same spatial location has earlier been investigated in not contagious itch, but *shared pain (*Avenanti, Bueti, Galati, & Aglioti, 2005; Fitzgibbon, Giummarra, Georgiou-Karistianis, Enticott, & Bradshaw, 2010; Osborn & Derbyshire, 2010). For example, observing pain in other individuals can evoke the same pain experience on the same location in the observer (Avenanti et al., 2005). A study by Avenanti et al. (2005) demonstrated that when an individual observed a needle prick in another person's finger, the observer also would feel pain sensations in the same finger. Their findings suggest that pain is somatotopically organized. In other words, the location of pain sensations could be mapped in the cortex and therefore observing pain in other individuals induces pain on the same location as was observed. Itch however seems not to be somatosensory localized because participants in our study perceived itch sensations on different sides of their body compared to the scratched location they observed. This explanation has however not been investigated yet and can be recommended for future research.

When examining which body parts participants perceived as itchy, a similar pattern of results was found in both experimental (i.e. itch-related and non-itch related condition) and modality conditions (i.e. visual, auditory and multisensory condition). Participants tended to perceive their face as itchy, even when the female model scratched or tapped her am. Why participants tended to perceive their face as itchy compared to other body parts in all conditions, can be explained by a tendency to touch the face (Ekman & Friesen, 1969; Kwok, Gralton, & McLaws, 2015); an explanation that has also been proposed by Ward et al. (2012). In Ward and colleagues' study (2012) participants scratched their face and head more often compared to their other body parts. However, note here that Ward and colleagues (2012) observed participants' scratching behaviour while we asked participants themselves to indicate which body parts felt itchy, ruling out the possibility that participants could have not scratched other body parts on purpose. This is important to highlight, especially since participants in the study by Ward et al. (2012) could have deliberately not scratched other body parts perceived as itchy.

Taken together, perceiving itch-related stimuli in a multisensory context does not induce higher itch sensations compared to perceiving these same stimuli in an unisensory context. Furthermore, scratching behaviour participants observed in the video clips (i.e. left arm on the left side of the body) did not transmit itch sensations to only the same body part or to only the same body side of the observer. This suggests that the sensory experience is shared rather than the spatial location of the scratching behaviour itself, which could be explained by that the location of itching is not mapped in the sensory cortex.

However, some limitations need to be taken into account. First, after each itch-related trial, a non-itch related trial would be presented to the participant. The time between these conditions was not fixed and started immediately after participants completed the questionnaires on paper. As the time between conditions may have been too short, the effect of the itch-related condition could have influenced ratings in the non-itch related condition. In our study, participants did report itch sensations also in the non-itch related condition. Instead of a within-subjects design, future studies could use a between-subjects design in which separate groups are formed for each condition.

Second, the webcam recordings did not allow us to observe participant's scratching behaviour on their whole body. As we placed the webcam on the right side of each participant, only the upper body and lower half of participant's face were filmed. It was therefore not possible to observe whether participants scratched themselves more often compared to the amount of scratching movements we observed in the current video recordings. Future research filming participant's whole body using a 360° webcam is highly recommended. These recordings could also be used to observe on which locations scratching behaviour is performed which in turn could be used as an objective measure for body parts participants perceive as itchy.

Third, when we asked participants what the goal of our study was, most participants knew that we investigated the influence of itch-related stimuli on perceived itch sensations. Before the start of the experiment, participants also knew they participated in an experiment about itch. Some participants even complained about feeling itchy before the experiment even started. Future work investigating itch sensations could use a blind design in which participants focus on – for example – a memory task.

The findings of this study have an important implication for clinical practice that could improve future treatment options for (chronic) itching. Because itch sensations can be evoked in observers by only observing itch-related stimuli, gaining insight in which specific factors induce these itch sensations allows us to reverse this process of transmission. For instance, factors known to influence itch sensations can be manipulated in patients with chronic itch which could in turn relieve their debilitating symptoms. Investigating how somatosensory sensations are transmitted and also whether this differs between senses could provide more insight into the role of multisensory perception of itch-related stimuli. To our knowledge, multisensory perception of itch-related stimuli has not been investigated yet in an experimental way. The current study provides additional support for transmission of itch sensations in healthy individuals. We also extended the knowledge on contagious itch by showing that itch sensations are not transmitted to the same body part and not even the same body side of the observer.

The present study has demonstrated in an experimental way that observing someone else engage in scratching behaviour – whether with one or multiple senses – can induce itch sensations in healthy individuals. However perceiving itch sensations with multiple senses does not necessarily provoke stronger itch sensations, even when multisensory perception can be beneficial in our environment. Our study also indicated for the first time that observing someone else scratching themselves evokes itch sensations that are not perceived on the same side of the body and not on the same body part. Scratching behaviour seems therefore to transmit only the somatosensory experience but not the movement itself. This suggests that location of itching is not organized in the brain. Future research should further investigate which locations on the body are perceived as itchy when observing scratching behaviour, and which specific brain regions are involved in this transmission. Also, more research is needed to investigate the role of multiple senses in the top-down effect of itch related stimuli. Itch-related stimuli can aggravate itch symptoms in patients with chronic itching and could in turn significantly lower their quality of life. Knowing which exact factors could influence patients' itch symptoms, treatments targeting itching could be made more effective which in turn may prevent patients from developing depression .

References

Avenanti, A., Bueti, D., Galati, G., & Aglioti, S. M. (2005). Transcranial magnetic stimulation highlights the sensorimotor side of empathy for pain. *Nature Neuroscience, 8,* 955-960. doi:10.1038/nn1481

Baron-Cohen, S., & Wheelwright, S. (2004). The Empathy Quotient (eq). An investigation of adults with Asperger Syndrome or High Functioning Autism, and normal sex differences. *Journal of Autism and Developmental Disorders, 34,* 163–75.

Bautista, D. M., Wilson, S. R., & Hoon, M. A. (2014). Why we scratch an itch: the molecules, cells and circuits of itch. *Nature Neuroscience, 17,* 175-182. doi:10.1038/nn.3619

Bell, A. H., Meredith, A., Van Opstal, A. J., & Munoz, D. P. (2005). Crossmodal integration in the primate superior colliculus underlying the preparation and initiation of saccadic eye movements. *Journal of Neurophysiology, 93,* 3659-3673. doi:10.1152/jn.01214.2004

Bolognini, N., Frassinetti, F., Serino, A., & Làdavas, E. (2005). Acoustical vision of below threshold stimuli: interaction among spatially converging audiovisual inputs. *Experimental Brain Research, 160,* 273-282. doi:10.1007/s00221-004-2005-z

Cattaneo, L., & Rizzolatti, G. (2009). The mirror neuron system. *Archives of neurology, 66,* 557-560. doi:10.1001/archneurol.2009.41.

Chrostowska-Plak, D., Reich, A., & Szepietowski, J. C. (2013). Relationship between itch and psychological status of patients with atopic dermatitis. *Journal of the European of Dermatology and Venereology, 27,* 239-242. doi:10.1111/j.1468-3083.2012.04578.x

Dalgard, F., Lien, L., & Dalen, I. (2007). Itch in the community: associations with psychosocial factors among adults. *Journal of the European Academy of Dermotology and Venereology, 21,* 1215-1219. doi:10.1111/j.1468-3083.2007.02234.x

Dawn, A., & Yosipovitch, G. (2006). Treating itch in psoriasis. *Dermatology Nursing, 18,* 227-233.

De Korte, J., Sprangers, M. A. G., Mombers, F. M. C., & Bos, J. D. (2004). Quality of life in patients with psoriasis: a systematic literature review. *Journal of Investigative Dermatology, 9,* 140-147. doi: 10.1186/1477-7525-4-35

Denissen, J.J.A., Geenen, R., Van Aken, M.A.G., Gosling, S.D. & Potter, J. (2008). Development and validation of a Dutch translation of the Big Five Inventory (BFI). *Journal of Personality Assessment*, *90*, 152-157.

Diederich, A., & Colonius, H. (2004). Bimodal and trimodal multisensory enhancement: Effects of stimulus onset and intensity on reaction time. *Perception & Psychophysics*, *66*, 1388-1404. doi:10.3758/BF03195006

Ekman, P., and Friesen, W. V. (1969). The repertoire of nonverbal behavior: categories, origins, usage, and coding. *Semiotica, 1,* 49–98. doi:10.1515/semi.1969.1.1.49

Feng, W., Stormer, V. S., Martinez, A., McDonald, J. J., & Hillyard, S. A. (2014). Sounds activate visual cortex and improve visual discrimination. *The Journal of Neuroscience, 29*, 9817-9824. doi:10.1523/JNEUROSCI.4869-13.2014

Fitzgibbon, B. M., Giummarra, M. J., Georgiou-Karistianis, N., Enticott, P. G., & Bradshaw, J. L. (2010). Shared pain: From empathy to synaesthesia. *Neuroscience and Biobehavioral Reviews, 34,* 500-512. doi:10.1016/j.neubiorev.2009.10.007

Frassinetti, F., Bodognini, N., Ladavas, E. (2002). Enhancement of visual perception by crossmodal visuo-auditory interaction. *Experimental Brain Research, 147*, 332-343. doi: 10.1007/s00221-002-1262-y

Gallese, V., Keyser, C., & Rizzolatti, G. (2004). A unifying view of the basis of social cognition. *Trends in Cognitive Sciences, 8,* 396-403. doi:10.1016/j.tics.2004.07.002

Gillmeister, H., & Eimer, M. (2007). Tactical enhancement of auditory detection and perceived loudness. *Brain Research, 1160,* 58-56. doi:10.1016/j.brainres.2007.03.041

Haker, H., Kawohl, W., Herwig, U., & Rössler, N. (2013). Mirror neuron activity during contagious yawning – an fmri study. *Brain Imaging and Behavior, 7,* 28-34. doi: 10.1007/s11682-012-9189-9

Holle, H., Warne, K., Seth, A. K., Critchley, H. D., & Ward, J. (2012). Neural basis of contagious itch and why some people are more prone to it. *Proceedings of the National Academy of Sciences, 109,* 19816-19821. doi: 10.1073/pnas.1216160109

Ikoma, A., Steinhoff, M., Ständer, S., Yosipovitch, G., & Schmelz, M. (2006). The neurobiology of itch. *Nature Reviews, 7,* 535-547. doi:10.1038/nrn1950

King, A. J. (2005). Multisensory integration: strategies for synchronization. *Current Biology, 15,* 339-341. doi:10.1016/j.cub.2005.04.022

Kini, S. P., DeLong, L. K., Veledar, E., McKenzie-Brown, A. M., Schaufele, M., & Chen, S. C. (2011). The impact of pruritus on quality of life. *Archives of Dermatology, 147,* 1153-1156. doi:10.1001/archdermatol.2011.178

Koelewijn, T., Bronkhorst, A., & Theeuwes, J. (2010). Attention and the multiple stages of multisensory integration: A review of audiovisual studies. *Acta Psychologica, 134,* 372-384. doi:10.1016/j.actpsy.2010.03.010

Kwok, Y. L. A., Gralton, J., & McLaws, M. L. (2015). Face touching: A frequent habit that has implications for hand hygiene. *American Journal of Infection Control, 43,* 112-114. doi: 10.1016/j.ajic.2014.10.015

Lloyd, D. M., Hall, E., Hall, S., & McGlone, F. P. (2013). Can itch-related visual stimuli alone provoke a scratch response in healthy individuals? *British Journal of Dermatology, 168,* 106-111. doi:10.1111/bjd.12132

Noesselt, T., Bergmann, D., Hake, M., Heinze, H. J., & Fendrich, R. (2008). Sound increases the saliency of visual events. *Brain Research, 1220,* 157-163. doi:10.1016/j.brainres.2007.12.060

Niemeier, V., Kupfer, J., & Gieler, U. (2000). Observations during an itch-inducing lecture. *Dermatology Psychosomatics, 1,* 15-18. doi:0.1159/000057993

Ogden, J., & Zoukas, S. (2009). Generating physical symptoms from visual cues: An experimental study. *Psychology, Health & Medicine, 14,* 695-704. doi:10.1080/13548500903311547

Osborn, J. & Derbyshire, S. W. G. (2010). Pain sensation evoked by observing injury in others. *Pain, 148,* 268-274. doi:10.1016/j.pain.2009.11.007

Papoiu, A. D. P., Wang, H., Coghill, R. C., Chan, Y-H., & Yosipovitch, G. (2011). Contagious itch in humans: a study of visual 'transmission' of itch in atopic dermatitis and healthy subjects. *British Journal of Dermatology, 164,* 1299-1303. doi:10.1111/j.1365-2133.2011.10318.x

Prignano, F., Ricceri, F., Pescitelli, L., & Lotti, T. (2009). Itch in psoriasis: epidemiology, clinical aspects and treatment options. *Clinical, Cosmetic and Investigational Dermatology, 2,* 9-13. doi:10.2147/CCID.S4465

Reich, A., Hrehorow, E., & Szepietowski, J. C. (2010). Pruritus is an important factor negatively influencing the well-being of psoriatic patients. *Acta Dermato-Venereologica, 90,* 257-263. doi:10.2340/00015555-0851

Rizzolatti, G., & Craighero, L. (2004). The mirror-neuron system. *Annual review of Neuroscience, 27,* 169-192. doi:10.1146/annurev.neuro.27.070203.144230

Rizzolatti, G. (2005). The mirror neuron system and its function in humans. *Anatomy and Embryology, 210,* 419-421. doi: 10.1007/s00429-005-0039-z

Savin, J.W. (1998). How should we define itching? *Journal of the American Academy of Dermatology, 39,* 268-269. doi:10.1016/S0190-9622(98)70087-8

Stein, B. E., & Stanford, T. R. (2008). Multisensory integration: current issues from the perspective of the single neuron. *Nature Reviews, 9,* 255-266. doi:10.1038/nrn2331

Schürmann, M., Hesse, M. D., Stephan, K. E., Saarera, M., Zilles, K., Hari, R., & Fink, G. R. (2005). Yearning to yawn: the neural basis of contagious yawning. *NeuroImage, 24,* 1260-1264. doi:10.1016/j.neuroimage.2004.10.022

Van Laarhoven, A. I. M., Kraaimaat, F. W., Wilder-Smith, O. H., van de Kerkhof, P. C. M., Cats, H., van Riel, P. L. C. M., & Evers, A. W. M. (2007). Generalized and symptom-specific sensitization of chronic itch and pain. *Journal of European Academy of Dermatology and Venereology, 21,* 1187-1192. doi: 10.1111/j.1468-3083.2007.02215.x

Van Strien, J. W. (1992). Classificatie van links- en rechtshandige proefpersonen. *Nederlands Tijdschrift voor de Psychologie, 47,* 88-92.

Verhoeven, E. W. M., De Klerk, S., Kraaimaat, F. W., Van De Kerkhof, P. C. M., De Jong, E. M. G. J., & Evers, A. W. M. (2008). Biopsychosocial mechanisms of chronic itch in patients with skin diseases: a review. *Acta Dermato-Venereologica, 88,* 211-218. doi: 10.2340/00015555-0452

Wang, H., & Yosipovitch, G. (2010). New insights into the pathophysiology and treatment of chronic itch in patients with end-stage renal disease, chronic liver disease, and lymphoma. *International Journal of Dermatology, 49,* 1-11. doi:10.1111/j.1365-4632.2009.04249.x

Ward, J., Burckhardt, V., & Holle, H. (2013). Contagious scratching: shared feelings but not shared body locations. *Frontiers in Human Neuroscience, 7,* 1-2. doi:10.3389/fnhum.2013.00122

Yosipovitch, G., Goon, A., Wee, J., Chan, Y. H., & Goh, C. L. (2000). Prevalence and clinical characteristics of pruritus among patients with extensive psoriasis. *British Journal of Dermatology, 143,* 969-973.

Zachariae, R., Zachariae, C. O. C., Lei, U., & Pedersen, A. F. (2008). Affective and sensory dimensions of pruritus severity: Associations with psychological symptoms and quality of life in psoriasis patients. *Acta Dermato-Venereologica, 88*, 121-127. doi: 10.2340/00015555-0371

Datum: __________ Proefpersoonnr.: ____

Naam proefleider: ___________________________

Universiteit Utrecht

Beste deelnemer,

Allereerst hartelijk dank voor uw deelname aan dit onderzoek van de Universiteit Utrecht. Dit onderzoek gaat over jeuk. Hierbij zult u naar videofragmenten kijken en naar audiofragmenten luisteren. Daarna krijgt u hier vragen over om te beantwoorden. Het is hierbij belangrijk om op uw eigen gevoel af te gaan. Uw gegevens zullen anoniem verwerkt worden.

Tijdens het bekijken van de fragmenten wordt er door middel van een webcam video-opnames van u gemaakt. Er worden met de opnames verder niks gedaan en zullen later weer verwijderd worden.

Het onderzoek zal ongeveer 60 minuten gaan duren. In het belang van het onderzoek wil ik u vragen om de komende maand niet met anderen te spreken over dit onderzoek.

Door de informed consent formulier te tekenen, stemt u in met deelname aan dit onderzoek.

Vragenlijst 1

De volgende stellingen hebben betrekking op uw opvatting over uzelf in verschillende situaties. Het is aan u om aan te geven in hoeverre u het eens bent met elke stelling, waarbij u gebruik maakt van een schaal waarop 1 'helemaal oneens' betekent, 5 'helemaal eens', en 2, 3 en 4 beoordelingen daartussenin zijn. Omcirkel achter elke stelling een getal op de ernaast staande schaal

1	Helemaal oneens
2	Oneens
3	Eens noch oneens
4	Eens
5	Helemaal eens

Er zijn geen goede of foute antwoorden. Selecteer dus bij elke stelling het getal dat zo goed mogelijk bij u past. Neem de tijd en denk goed na over elk antwoord.

	IK ZIE MEZELF ALS IEMAND DIE,	**Helemaal oneens**				**Helemaal eens**
1.	... Spraakzaam is.	1	2	3	4	5
2.	... Geneigd is kritiek te hebben op anderen.	1	2	3	4	5
3.	... Grondig te werk gaat.	1	2	3	4	5
4.	... Somber is.	1	2	3	4	5
5.	... Origineel is, met nieuwe ideeën komt.	1	2	3	4	5
6.	... Terughoudend is.	1	2	3	4	5
7.	... Behulpzaam en onzelfzuchtig ten opzichte van anderen is.	1	2	3	4	5
8.	... Een beetje nonchalant kan zijn.	1	2	3	4	5
9.	... Ontspannen is, goed met stress kan omgaan.	1	2	3	4	5
10.	... Benieuwd is naar veel verschillende dingen.	1	2	3	4	5
11.	... Vol energie is.	1	2	3	4	5
12.	... Snel ruzie maakt.	1	2	3	4	5
13.	... Een werker is waar men van op aan kan.	1	2	3	4	5
14.	... Gespannen kan zijn.	1	2	3	4	5
15.	... Scherpzinnig, een denker is.	1	2	3	4	5
16.	... Veel enthousiasme opwekt.	1	2	3	4	5
17.	... Vergevingsgezind is.	1	2	3	4	5
18.	... Doorgaans geneigd is tot slordigheid.	1	2	3	4	5
19.	... Zich veel zorgen maakt.	1	2	3	4	5
20.	... Een levendige fantasie heeft.	1	2	3	4	5
21.	... Doorgaans stil is.	1	2	3	4	5
22.	... Mensen over het algemeen vertrouwt.	1	2	3	4	5
23.	... Geneigd is lui te zijn.	1	2	3	4	5
24.	... Emotioneel stabiel is, niet gemakkelijk overstuur raakt.	1	2	3	4	5
25.	... Vindingrijk is.	1	2	3	4	5

(vervolg vragenlijst 1)

	IK ZIE MEZELF ALS IEMAND DIE,	Helemaal oneens				Helemaal eens
26.	... Voor zichzelf opkomt.	1	2	3	4	5
27.	... Koud en afstandelijk kan zijn.	1	2	3	4	5
28.	... Volhoudt tot de taak af is.	1	2	3	4	5
29.	... Humeurig kan zijn.	1	2	3	4	5
30.	... Waarde hecht aan kunstzinnige ervaringen.	1	2	3	4	5
31.	... Soms verlegen, geremd is.	1	2	3	4	5
32.	... Attent en aardig is voor bijna iedereen.	1	2	3	4	5
33.	... Dingen efficiënt doet.	1	2	3	4	5
34.	... Kalm blijft in gespannen situaties.	1	2	3	4	5
35.	... Een voorkeur heeft voor werk dat routine is.	1	2	3	4	5
36.	... Hartelijk, een gezelschapsmens is.	1	2	3	4	5
37.	... Soms grof tegen anderen is.	1	2	3	4	5
38.	... Plannen maakt en deze doorzet.	1	2	3	4	5
39.	... Gemakkelijk zenuwachtig wordt.	1	2	3	4	5
40.	... Graag nadenkt, met ideeën speelt.	1	2	3	4	5
41.	... Weinig interesse voor kunst heeft.	1	2	3	4	5
42.	... Graag samenwerkt met anderen.	1	2	3	4	5
43.	... Gemakkelijk afgeleid is.	1	2	3	4	5
44.	... Het fijne weet van kunst, muziek, of literatuur.	1	2	3	4	5

----------- Ga verder naar de volgende bladzijde om de volgende vragenlijst in te vullen -----------

Vragenlijst 2

Deze lijst bestaat uit één vraag over de hand waarmee u bij voorkeur schrijft en tien vragen met betrekking tot uw voorkeurshand voor andere handelingen. Geef voor elke vraag aan met welke hand u de betreffende handeling gewoonlijk uitvoert.

Schrijfhand
Omcirkel met welke hand u schrijft:
Links rechts op school gedwongen rechts te schrijven

Handvoorkeur
Hieronder staan een aantal activiteiten die u met uw linker of rechterhand kunt uitvoeren. Omcirkel welke kant u gewoonlijk gebruikt voor elk van deze activiteiten. Indien u het antwoord niet meteen weet, voer dan de betreffende handeling in gedachten uit. Heeft u geen duidelijke voorkeur, omcirkel in dat geval ‘beide’.

1. Met welke hand tekent u?	linker rechter beide
2. Welke hand gebruikt u om met een tandenborstel te poetsen?	linker rechter beide
3. In welke hand houdt u een flesopener vast?	linker rechter beide
4. Met welke hand gooit u een bal ver weg?	linker rechter beide
5. In welke hand heeft u een hamer vast als u ermee op een spijker moet slaan?	linker rechter beide
6. Met welke hand houdt u een (tennis)-racket vast?	linker rechter beide
7. Welke hand gebruikt u om met een mes een touw door te snijden?	linker rechter beide
8. Welke hand gebruikt u om met een lepel te roeren?	linker rechter beide
9. Welke hand gebruikt u om met een gummetje iets uit te vlakken?	linker rechter beide
10. Met welke hand strijkt u een lucifer aan?	linker rechter beide

----------- Ga verder naar de volgende bladzijde om de volgende vragenlijst in te vullen -----------

Vragenlijst 3

In deze vragenlijst staan een aantal stellingen opgesomd. Lees elke stelling aandachtig door en geef aan in welke mate je het met de stelling eens bent door het passende antwoord te omcirkelen. Er zijn geen juiste of foute antwoorden. Er zijn geen strikvragen.

	Helemaal mee oneens	Tamelijk mee oneens	Tamelijk mee eens	Helemaal mee eens
1. Ik voel heel goed aan wanneer iemand aan een conversatie wenst deel te nemen.	1	2	3	4
2. Ik vind het moeilijk om dingen die ik moeiteloos begrijp aan anderen uit te leggen, als zij het niet de eerste keer begrepen hebben.	1	2	3	4
3. Ik heb er echt plezier in om voor andere mensen te zorgen.	1	2	3	4
4. Ik vind het moeilijk te weten wat te doen in sociale situatie.	1	2	3	4
5. Mensen zeggen mij vaak dat ik te ver ben gegaan in het doordrijven van mijn standpunt in een discussie.	1	2	3	4
6. Het maakt me niet zoveel uit als ik te laat ben op een afspraak met een vriend.	1	2	3	4
7. Vriendschappen en relaties zijn gewoon te moeilijk, daarom houd ik mij er niet mee bezig.	1	2	3	4
8. Ik vind het vaak moeilijk om te oordelen of iets grof of beleefd is.	1	2	3	4

(vervolg vragenlijst 3)

	Helemaal mee oneens	Tamelijk mee oneens	Tamelijk mee eens	Helemaal mee eens
9. Tijdens een gesprek richt ik mij eerder op mijn eigen gedachten dan op wat mijn gesprekspartner zou kunnen denken.	1	2	3	4
10. Als kind vond ik het leuk om wormen door te snijden en te kijken wat er dan gebeurde.	1	2	3	4
11. Ik heb het snel door wanneer iemand iets zegt, maar iets anders bedoelt.	1	2	3	4
12. Ik vind het moeilijk om te begrijpen waarom bepaalde dingen mensen zo erg van streek maken.	1	2	3	4
13. Ik vind het gemakkelijk om me in de positie van een ander te verplaatsen.	1	2	3	4
14. Ik kan goed voorspellen hoe iemand zich zal voelen.	1	2	3	4
15. Ik merk snel wanneer iemand zich niet op zijn plaats of oncomfortabel voelt in een groep.	1	2	3	4
16. Indien ik iets zeg waardoor iemand anders zich beledigd voelt, dan is dat zijn probleem, niet het mijne.	1	2	3	4

(vervolg vragenlijst 3)

	Helemaal mee oneens	Tamelijk mee oneens	Tamelijk mee eens	Helemaal mee eens
17. Wanneer iemand zou vragen of ik zijn kapsel mooi vind, zou ik eerlijk antwoorden, ook als ik het niet mooi vind.	1	2	3	4
18. Ik zie niet altijd in waarom iemand zich beledigd zou voelen door een opmerking.	1	2	3	4
19. Anderen zien huilen raakt me niet echt.	1	2	3	4
20. Ik ben erg rechtuit, wat sommigen als grof beschouwen, hoewel dit niet zo bedoeld is.	1	2	3	4
21. Ik ben niet geneigd om sociale situaties verwarrend te vinden.	1	2	3	4
22. Andere mensen zeggen tegen mij dat ik goed ben in het begrijpen hoe zij zich voelen en wat zij denken.	1	2	3	4
23. Wanneer ik met mensen praat, ben ik geneigd om over hun ervaringen te praten in plaats van over die van mij.	1	2	3	4
24. Het maakt me van streek om een dier pijn te zien lijden.	1	2	3	4
25. Ik kan beslissingen nemen zonder beïnvloed te worden door andermans gevoelens.	1	2	3	4
26. Ik kan gemakkelijk zien of iemand anders geïnteresseerd of verveeld is over wat ik zeg.	1	2	3	4
27. Ik raak van streek als ik mensen zie lijden in nieuwsuitzendingen.	1	2	3	4

(vervolg vragenlijst 3)

	Helemaal mee oneens	Tamelijk mee oneens	Tamelijk mee eens	Helemaal mee eens
28. Vrienden vertellen mij gewoonlijk over hun problemen, omdat zij vinden dat ik zeer begrijpend ben.	1	2	3	4
29. Ik voel aan wanneer ik stoor, zelfs wanneer de andere persoon het mij niet vertelt.	1	2	3	4
30. Mensen zeggen me soms dat ik te ver ben gegaan met plagerijen.	1	2	3	4
31. Andere mensen zeggen vaak dat ik ongevoelig ben, hoewel ik niet altijd inzie waarom.	1	2	3	4
32. Wanneer ik een vreemde in een groep zie, vind ik dat het aan hen is om moeite te doen om zich bij de groep te voegen.	1	2	3	4
33. Ik blijf meestal emotioneel afstandelijk wanneer ik naar een film kijk.	1	2	3	4
34. Ik kan mij snel en intuïtief afstemmen op hoe iemand anders zich voelt.	1	2	3	4
35. Ik kan gemakkelijk opmaken waar de andere persoon over zou willen praten.	1	2	3	4
36. Ik kan zien of iemand zijn ware gevoelens aan het verbergen is.	1	2	3	4
37. Ik probeer niet bewust de regels van sociale situaties te begrijpen	1	2	3	4

(vervolg vragenlijst 3)

	Helemaal mee oneens	Tamelijk mee oneens	Tamelijk mee eens	Helemaal mee eens
38. Ik kan goed voorspellen wat iemand zal doen.	1	2	3	4
39. Ik ben geneigd om emotioneel betrokken te raken bij de problemen van een vriend.	1	2	3	4
40. Ik kan meestal iemand anders standpunt appreciëren, zelfs wanneer ik er niet mee akkoord ga.	1	2	3	4

--- Einde Vragenlijst 3 ---

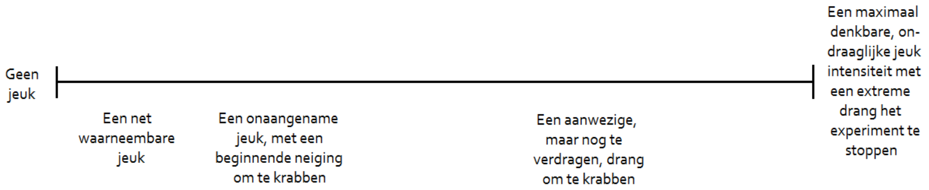
U kunt nu bij de proefleider melden dat u klaar bent met het eerste gedeelte van de vragenlijsten.

Vragenlijst 4

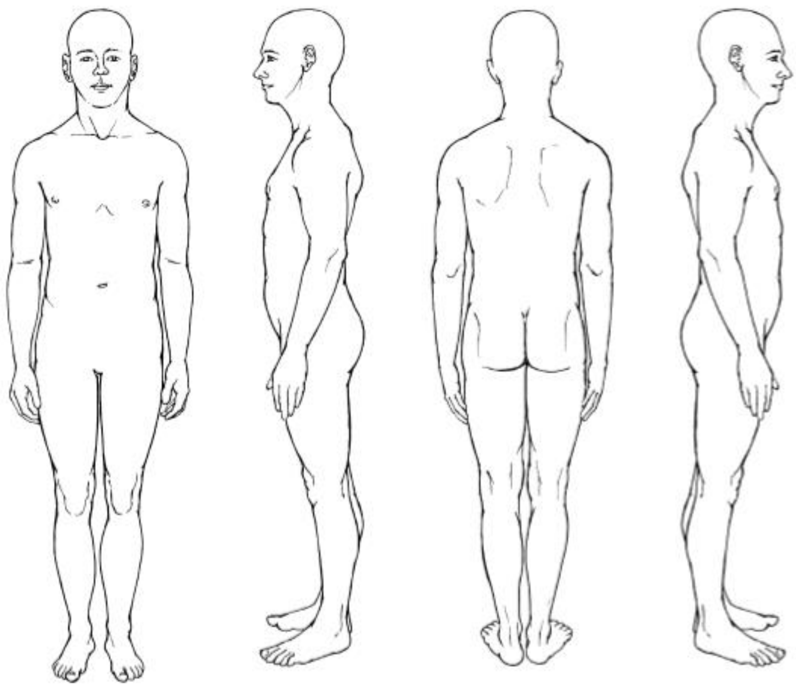
Fragment: _____ **(in te vullen door de participant)**

Vul alstublieft de volgende vraag in. Doe dit door op de lijn een streep te zetten dat het beste overeenkomt met uw gevoel. Vul dit zo goed mogelijk in.

1. Hoeveel jeuk ervaart **u** op dit moment?



2. Geef aan, op de afbeelding hieronder, waar **u** op **uw lichaam** jeuk ervaart. Kleur de locaties in.



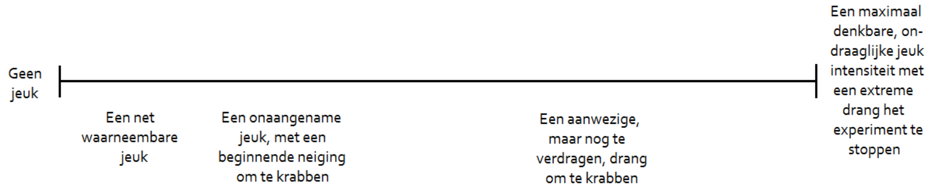
--- Einde Vragenlijst 4 ---

Vragenlijst 5

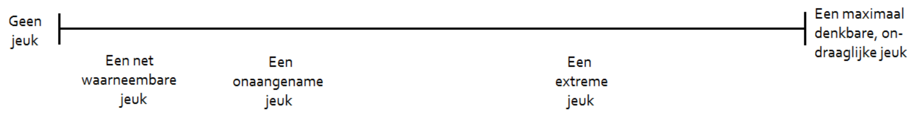
Fragment: _____ **(in te vullen door de participant)**

Hieronder volgen een aantal vragen over u en de persoon die u zonet heeft gezien of gehoord. Vul alle vragen zo goed mogelijk in.

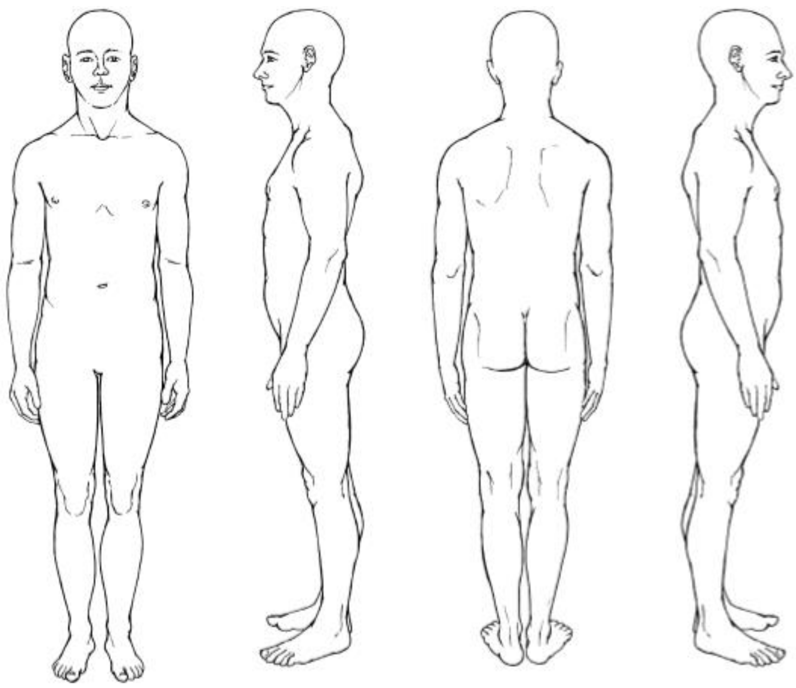
1. Hoeveel jeuk ervaart **u** op dit moment? Zet een streep op de plaats dat het beste overeenkomt met uw beoordeling.



2. Hoeveel jeuk ervaart **de andere persoon** volgens u? Zet een streep op de plaats dat het beste overeenkomt met uw beoordeling.



3. Geef aan, op de afbeelding hieronder, waar **u** op **uw lichaam** jeuk ervaart. Kleur de locaties in.



------- Ben je klaar met invullen? Sla dan deze bladzijde om. -------

Vragenlijst 6

De volgende vragen hebben betrekking op algemene gegevens over uzelf . Vul alstublieft de volgende vragen in:

1. Wat is uw geslacht? (Kruis aan wat op u van toepassing is)

   Man ○ Vrouw ○

2. Wat is uw leeftijd?

   Ik ben …… jaar

3. Wat is uw hoogst afgeronde opleiding?

   VMBO ○ MBO ○ Anders, namelijk: ………………………….
   HAVO ○ HBO ○
   VWO ○ WO ○

------------ Ga verder naar de volgende bladzijde om de volgende vragenlijst in te vullen -----------

Vragenlijst 7

Hieronder volgen nog een aantal vragen. Vul deze alstublieft zo goed mogelijk in.

1. Ervaart u meer of minder jeuk dan anderen, volgens u? Omcirkel wat op u van toepassing is.

veel minder / minder / evenveel / meer / veel meer

2. Waar op uw lichaam ervaart u over het algemeen het meest jeuk?

____

____

____

------------ Ga verder naar de volgende bladzijde om de volgende vragenlijst in te vullen -----------

Vragenlijst 8

1. Wat is volgens u het doel geweest van dit onderzoek?

____

____

____

Einde Onderzoek

Hartelijk dank voor uw deelname!