Characteristics of vicarious touch reports in a general population

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Abstract

Vicarious touch refers to the phenomenon where individuals experience tactile sensations when observing another person being touched. This study explored vicarious touch reports in 422 undergraduate students using videos from the Validated Touch-Video Database (VTD), rated for hedonic qualities, arousal, and perceived threat levels. A surprisingly large majority (84%) of participants reported vicarious sensations such as touch, tingling, pressure, and pain, predominantly matching the location of touch to the hands observed in the videos. Contrary to previous studies, we found that vicarious touch was more prevalent in women than men. Additionally, while earlier research suggested a correlation between vicarious sensations and emotional empathy, our data did not support this relationship. The nature and intensity of reported sensations varied strongly with the emotional content of the videos: pleasant touches evoked ticklish or warm sensations, while unpleasant touches often resulted in pain or pressure. Participants often described their sensations as either pleasant or unpleasant, indicating that the affective qualities of observed touch were mirrored in their experiences. Arousal and threat ratings taken from the VTD for each video strongly correlated with the prevalence and intensity of vicarious touch measured here, with painful, highly arousing touches eliciting the strongest responses. Even touch involving non-human objects occasionally triggered similar vicarious sensations. Using a new clustering approach, we identified three distinct profiles of vicarious touch, each characterised by unique sensory experiences, variations in the localisation and intensity of sensations, and differences in responses to human versus object touch. Overall, our results challenge the traditional view that conscious vicarious touch experiences are a rare phenomenon and underscore the diversity of vicarious sensory perception.

Introduction

When watching a film where a character's arm grazes a rough brick wall, some viewers may feel a corresponding sensation, as if their own arm had encountered the wall, while others might not react at all. The phenomenon of mirroring the sensations observed in others is known as vicarious touch, or mirror-touch. Such mirroring, which extends to emotions and actions, is proposed to be underpinned by a simulation mechanism where observing—or inferring—another's experience can activate a similar experience in the observer (Decety and Jackson, 2004; Gallese et al., 2004; Keysers and Gazzola, 2009; Smit et al., 2023). Our study uses the Validated Touch-Video Database (VTD: Smit and Rich, 2023) to examine how various attributes of observed touch, including arousal, threat level, hedonic qualities, and the specific nature of the touch, influence vicarious sensations in a university sample.

Existing research has predominantly explored the subjective quality of vicarious touch through studies that prompt participants to report sensations in their own bodies after observing images or videos depicting touch involving another person. In previous studies, ~25-60% of participants report vicarious sensations such as touch, tingling, pressure, itchiness, or scratching in such contexts (Li et al., 2022; Smit et al., 2023; Ward et al., 2018). Furthermore, approximately one-third of participants report experiencing vicarious pain sensations, such as tingling, aching, or shooting pains, when witnessing others in painful situations, including injuries from injections or joint dislocations (Giummarra et al., 2015; Grice-Jackson et al., 2017; Li et al., 2022; Osborn and Derbyshire, 2010; Vandenbroucke et al., 2013; Ward et al., 2018). While women report vicarious pain more frequently than men (Grice-Jackson et al., 2017; Li et al., 2022), no gender differences have been found in the reporting of vicarious non-painful touch (Li et al., 2022; Ward et al., 2018). These findings suggest that vicarious sensations may be relatively common in experimental settings, though individual experiences can vary substantially.

While existing research has established that reportable vicarious touch experiences are quite common, it remains unclear what factors dictate the intensity and characteristics of these mirrored perceptions. For instance, research consistently shows that tingling is one of the most common vicarious sensations when observing touch or pain in others (Banissy et al., 2009; Osborn and Derbyshire, 2010; Ward et al., 2018). If vicarious touch is the product of mirroring the *actual sensation*, then tingling should be more prevalent, relative to other types of touch, when observing pleasant, affective touch that would produce tingling sensations if experienced directly (Morrison et al., 2011; Taneja et al., 2021). However, tingling is often reported even during observations of painful interactions (Osborn and Derbyshire, 2010), where it is presumably not a major element of the direct experience. Thus, it is currently unclear to what extent tingling can be ascribed to a sensory mirroring process versus some other more generic process such as arousal or heightened bodily awareness (Tihanyi et al., 2018; Tihanyi and Köteles, 2017).

Further exploration is also needed to fully comprehend how the emotional qualities of observed touch, such as arousal, threat, and valence, influence subjective vicarious sensations. For instance, previous self-report studies found that observing a threatening touch—such as a knife tip touching a face—evokes stronger and more frequent mirrored sensations than benign touches like those from a fingertip or feather (Holle et al., 2011; Ward et al., 2018). While functional Magnetic Resonance Imaging (fMRI) studies have investigated the various neural mechanisms involved in observing social, affective, pleasant, and unpleasant touches, (Bolognini et al., 2013; Ebisch et al., 2011; Gazzola et al., 2012; Lamm et al., 2015; Lee Masson et al., 2018; Lee Masson and Isik, 2023; Morrison et al., 2011; Riva et al., 2018), it remains largely unclear if these varying observed touches evoke differing *reportable sensations* in the observer.

A core limitation in our current understanding of vicarious touch is that much of what is known comes from studies on individuals with mirror-touch synaesthesia (Banissy and

Ward, 2007; Banissy et al., 2009; Blakemore et al., 2005; Gillmeister et al., 2017; Holle et al., 2013, 2011; Ioumpa et al., 2019; Li et al., 2022; Medina and DePasquale, 2017; Ward et al., 2018). This rare condition is characterised by frequent and intense localised tactile sensations, such as touch or pressure, rather than generalised sensations like tingling or itching (Banissy et al., 2009). Individuals with mirror-touch synaesthesia also show a clearer distinction between observing human versus object touch than non-synaesthetes and reportedly exhibit enhanced social abilities, including heightened emotional empathy (Banissy and Ward, 2007; Banissy et al., 2009; Holle et al., 2011; Ward et al., 2018). However, distinguishing between mirror-touch synaesthesia and more common forms of vicarious touch remains challenging, because they share overlapping sensory characteristics and comparatively little is known about vicarious touch experiences in non-synaesthetes – that is, people who do not report such experiences in daily life.

One intriguing possibility is that different vicarious touch profiles exist within the general population (Gillmeister et al., 2017). For instance, some individuals might be more susceptible to localised tactile sensations, while others experience more generalised sensations. These sensory differences could be accompanied by variations in the intensity of sensations, distinct responses to pain, different reactions to human versus object touch, and varying levels of emotional empathy. Such tendencies could either distinctly categorise individuals, or vary along a continuum, with mirror-touch synaesthetes at the extreme end (de Vignemont, 2017; Fitzgibbon et al., 2012; Rothen and Meier, 2013; Simner, 2012). Clustering approaches have been used to study vicarious pain profiles, showing that some individuals use predominantly localised and sensory descriptors (e.g., sharp, touch) for their experience, and others using more generalised and affective terms (e.g., ticklish, nauseating) (Grice-Jackson et al., 2017; Li and Jamie Ward, 2022). Using a clustering approach could similarly provide valuable insights into possible vicarious touch profiles.

In this study, we evaluate reported vicarious sensations in a large sample of undergraduate students using validated touch video stimuli (Smit and Rich, 2023). Initially, we assess the general characteristics of vicarious touch within our sample, including the prevalence of vicarious touch reports, gender differences, and the relationship with emotional empathy. Subsequently, we investigate how different types of observed touch and their affective properties influence the frequency, intensity, and quality of the sensations reported. Finally, we use a data-driven clustering approach to explore distinct sensory profiles in our sample.

2. Materials and Methods

All video stimuli, analysis scripts and data can be found online (https://osf.io/npqu3/).

2.1. Participants

We recruited naïve undergraduate students via the Macquarie University subject pools and participants received course credit for their participation (N = 422; 292 women, 129 men, 1 non-binary; mean age = 21.17 years, SD = 5.77 years, range = 17-56 years). As we only had one non-binary participant, we could not include their data in our analyses of gender. Students who had previously participated in our study for validating touch videos from the VTD (Smit and Rich, 2023) were not eligible to participate, as familiarity with the visual stimuli could potentially influence their experience. The study was approved by the Macquarie University Human Research Ethics committee and participants provided written consent.

2.2. Stimuli

We incorporated stimuli from the VTD (Smit and Rich, 2023), consisting of 90 videos featuring touch to a female left hand against a dark backdrop, viewed in first-person with the palm down. These videos, previously validated by an independent group of participants, display varying

levels of arousal, threat, hedonic qualities, types of touch, and either object- or human-induced touch. Using the validation data, we selected ten videos representing each hedonic category (neutral, pleasant, unpleasant, painful; 40 total) for the current study. Further, we included five additional (non-validated) videos showing tactile interactions with an object (white block). These object videos were filmed under the same conditions as the hand videos and depicted stroking the object with a soft brush, touching the object with a knife, tapping the object with a finger, stroking with a plastic brush next to the object, and tapping with a finger next to the object.

2.3. Experimental procedure

After participants signed up to our study, they were given a link to an online questionnaire hosted on Qualtrics. We instructed participants to complete the task remotely on their own devices and to use a desktop computer or laptop instead of a phone or tablet. The questionnaire included the 45 touch videos presented in randomised order. To ensure that participants were ready and paid full attention to the entire video, we disabled auto-play, and the first frame of each video was a white screen with the text "Press play to start video". After watching each video, participants were asked the following questions:

Q1: *While watching the video, did you experience a tactile sensation on YOUR body?* [Yes/No]. If participants answered 'No', they would go on to the next video. If they answered 'Yes', they would be presented with these follow-up questions:

Q2: *Which of these options describes the sensation on YOUR body?* (multiple answers allowed) [answer: Touch, Pain, Tingling, Pressure, Scratching, Ticklish, Warm, Cold, Other (describe)]

Q3: *How intense was it?* [answer: 1 = not at all, 10 = extremely]

Q4: *How did it feel?* [single answer out of the following options: neutral, pleasant, unpleasant, painful]

Q5: *How __ (pleasant/unpleasant/painful; only one category was presented and depended on the previous answer) was the touch?* [answer: 1 = not at all, 10 = extremely]

Q6: *Where on YOUR body did you feel the tactile sensation?* (multiple answers allowed) [answer: Left hand, Right hand, Another body part (describe), A general feeling (describe), Other (describe)]

After finishing this part of the survey, participants were also asked five questions taken from the short Emotional Quotient (EQ) to assess emotional reactivity (Muncer and Ling, 2006). The entire questionnaire took between 10 and 30 minutes to complete depending on how often the participant responded 'Yes' to the first question (as this resulted in five additional questions for each video).

2.4. Analyses

Our analyses can be divided into three sections. In the first section, we investigate the general characteristics of vicarious touch in our population sample, exploring the prevalence of reported vicarious sensations, any gender differences, and the potential link with emotional empathy. In the second section, we look at the effects of observed affective qualities (arousal, threat, valence) and the type of touch in the videos (e.g., stroking versus pressing) on the prevalence, intensity, and phenomenology of various touch experiences. In the third section, we cluster participants on the basis of their total number of vicarious touch endorsements and the number of reported exteroceptive and interoceptive sensations. We then show that the resulting clusters systematically vary on a number of other dimensions. Together, this analysis reveals several distinct vicarious touch profiles in our sample.

All statistical analyses in our study are Bayesian, including t-tests, ANOVAs, correlation assessments, and contingency tables. These were conducted using the R programming language (R Core Team, 2023). We employ the Bayes Factor R package to

calculate Bayes Factors (BFs) using the default prior, a Cauchy distribution centred at zero with scale parameter $r = 0.707$, which allow for a wide range of possible effect sizes (Morey et al., 2018). BFs enable us to quantify the evidence for our alternative hypothesis against our null hypothesis. For instance, a BF_{10} of 3 indicates that the evidence provided by our data in favour of the alternative hypothesis is three times stronger than that for the null hypothesis. Generally, a BF > 1 provides evidence for the alternative hypothesis and a BF < 1 for the null, with BFs between 1 and 3 often considered insufficient evidence in either direction (Jeffreys and Jeffreys, 1998). This Bayesian approach assesses the strength of evidence for one hypothesis over another without relying on dichotomous decision making, thereby permitting a more exploratory analysis without the pitfalls inherent to multiple comparisons in a frequentist framework.

3. Results

3.1. Broad characteristics

3.1.1. Prevalence & Intensity

We tallied the number of hand-touch trials out of 40 total where participants answered 'yes' to the question "*While watching the video, did you experience a tactile sensation on YOUR body?*". Across all participants, 84% reported at least one such instance, leaving 16% never reporting it (Fig. 1). For those reporting vicarious touch, the average number of endorsed trials was 12.72 and the average intensity of these vicarious sensations was 3.44 ("*How intense was it?"* answer: 1 = not at all, 10 = extremely). Out of the whole sample, 70% of participants reported at least one *exteroceptive* sensation (a clearly *tactile* sensation felt on the skin, including touch, pressure, scratching), which may be a stronger indication of sensory mirroring (Ward et al., 2018) than other vicarious sensations, and 50% of the whole sample reported vicarious *pain*. The relative frequency of all reported sensations were as follows: tingling

(23%), pressure (18%), pain (15%), ticklish (13%), touch (11%), cold (6%), warm (6%), scratching (5%), and other (3%).

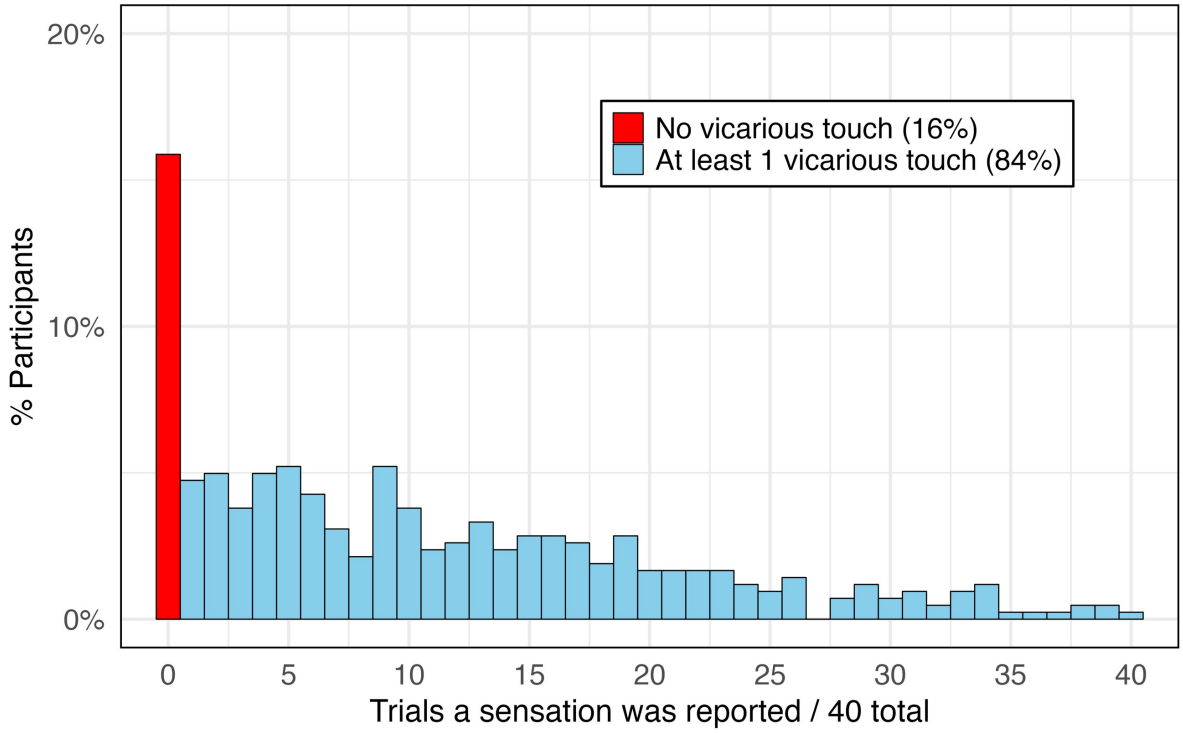

Figure 1. Distribution of the number of endorsed vicarious touch trials in our sample. The bar graphs represent the number of trials (out of 40 total) where participants (N = 422) reported a vicarious touch after viewing 40 unique videos of a hand being touched. Each bar indicates the percentage of participants who reported the sensation across the specific number of trials (videos). Red indicates the percentage or participants who never reported vicarious touch, while blue represents those who reported it in at least one trial.

3.1.2. Location of vicarious touch

When participants reported experiencing a sensation while watching a video (all showing touch to a left hand), we asked them where they felt it. We first computed the responses individually for each participant and then averaged these results across all participants for each body part. This approach ensures that our analysis reflects the typical participant response without being skewed by individuals with more frequent endorsements. Our findings

indicate that, on average, 85% of trials where vicarious touch was endorsed involved the hands—53% in the left hand, 27% in the right hand, and 5% in both hands. Sensations in other body parts accounted for 11% of responses, 9% were described as a general feeling, and 0.7% were categorised as 'other' (these percentages exceed 100% because participants were allowed to select more than one option). Out of all participants who endorsed vicarious touch, 98% indicated a sensation in one or both hands in at least one trial. Thus, most vicarious touch responders experience sensations in a location congruent with the depicted tactile interaction—in this instance, the hand.

3.1.2. Gender differences

More women (88%) than men (76%) reported vicarious sensations in at least one trial, which was supported by a Bayesian contingency table (independent multinomial distribution with a prior scale parameter *a*=1) indicating substantial evidence (BF_{10} = 7.67) against the null hypothesis of independence. An independent samples Bayesian t-test showed a higher average of 13.19 endorsed trials for women compared to 11.50 for men (BF_{10} = 4.40). The average intensity of these experiences did not differ between the genders (3.52 for women vs. 3.25 for men: BF_{10} = 0.44). There was insufficient evidence regarding vicarious *pain* being more prevalent in women (54%) compared to men (41%) (BF_{10} = 2.32), although women did endorse a higher number of pain trials (4.82 vs. 3.64: BF_{10} = 9.5). There was again no difference in intensity (4.52 vs. 4.22: BF_{10} = 0.27). Finally, women had higher empathy scores than men in our sample (mean: Women = 11.22; Men = 10.09, BF_{10} = 491.67)

3.1.3. Vicarious touch and emotional empathy

To assess a link between vicarious touch and emotional empathy, we calculated the BF for the Pearson correlation between the number of trials in which participants endorsed vicarious touch and their scores on the emotional reactivity subscale of the EQ (Muncer and Ling, 2006)

(Fig. 2). There was inconclusive evidence regarding the small positive correlation between the number of trials in which participants reported vicarious touch and their empathy scores (r = 0.12, BF_{10} = 2.04). We also compared empathy scores between individuals reporting vicarious touch on at least one trial (EQ score mean = 10.99) and those not reporting vicarious touch (EQ score mean = 10.31). We found inconclusive evidence in the direction of the null (BF_{10} = 0.86) which specifies no difference in empathy scores between the two groups. These results were qualitatively the same for men and women (see Supplementary Fig. 2).

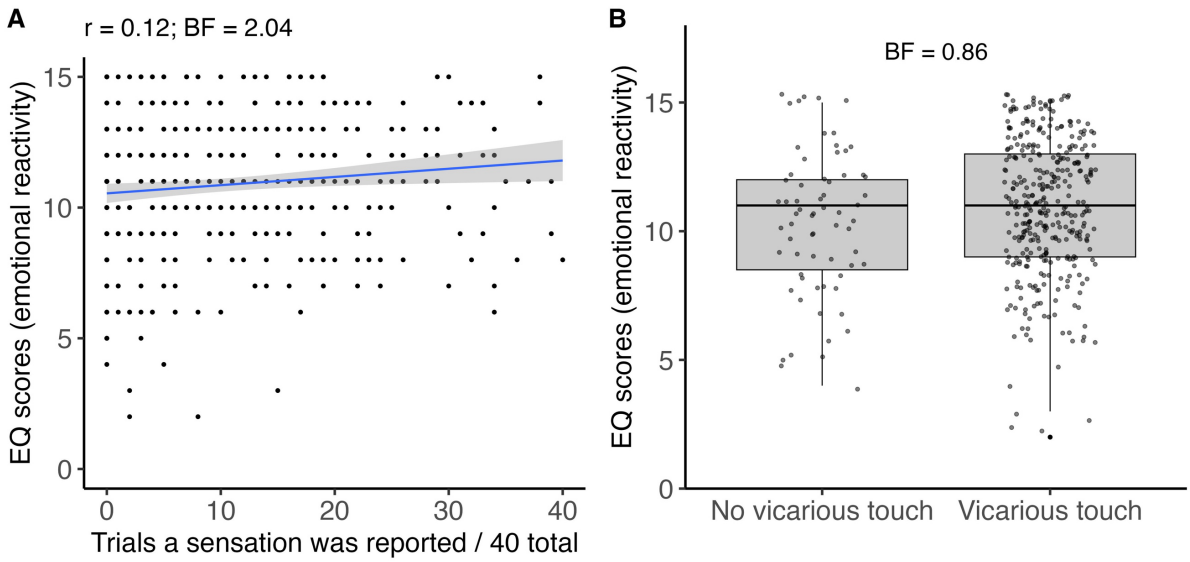

Figure 2. Vicarious touch endorsements and emotional reactivity scores. (Left) Scatterplot depicts the relationship between the number of vicarious touch endorsements out of 40 trials total and emotional reactivity scores based on five questions from the EQ (higher scores suggest higher emotional empathy). Line shows linear regression with shaded 95% confidence intervals. (Right) Comparison between participants with no vicarious touch and at least one vicarious touch response. Scatterplots show the distribution of empathy scores for the two groups. The line within each box indicates the median, the box boundaries indicate the interquartile range (IQR), and the whiskers extend to 1.5 times the IQR.

3.2. The influence of stimulus characteristics on vicarious touch experiences

3.2.1. Hedonic qualities of observed touch

For each individual video, we calculated the percentage of all participants who reported a vicarious touch sensation, and among those, we assessed the average intensity of the sensations. We then grouped the videos by their hedonic category (Fig. 3) as validated in the VTD (Smit and Rich, 2023). Based on prior research (Holle et al., 2011; Li et al., 2022; Ward et al., 2018), we hypothesised that videos portraying pain or threat would be particularly effective in eliciting vicarious touch responses.

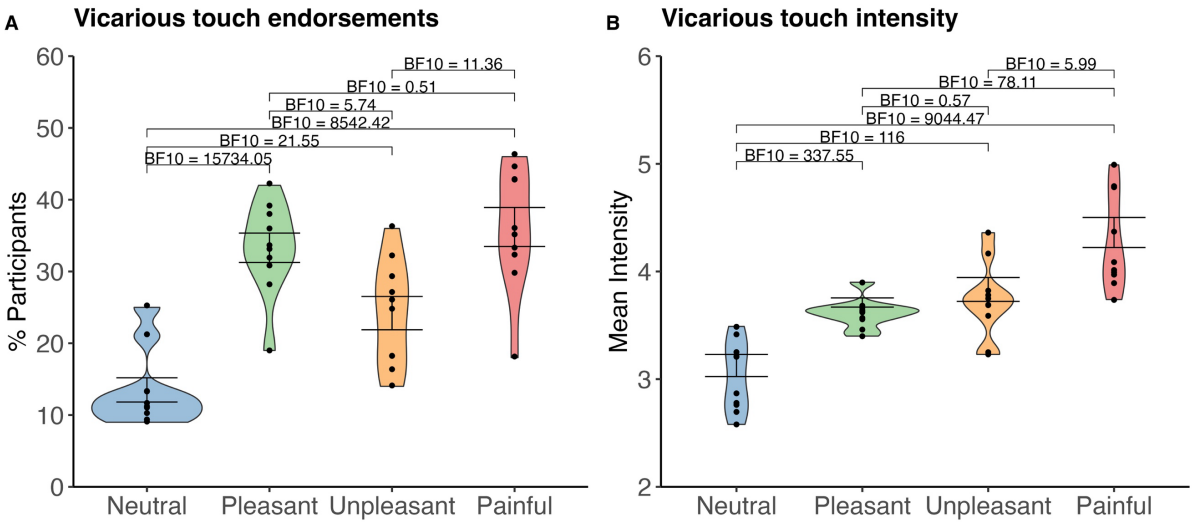

Figure 3. Vicarious touch endorsement and intensity across different hedonic categories. Dots (10 per hedonic category) show results for the individual videos. (A) Percentage of participants who endorsed vicarious touch for each video within the different categories. (B) Mean reported vicarious touch intensity for videos within the different categories (scale from 1-10 (1 = not at all, 10 = extremely). Violin plots convey the data distribution for each hedonic category: neutral, pleasant, unpleasant, and painful. The width of the violins indicates the density of the data, with broader sections representing higher densities. Error bars represent the 95% CIs.

A one-way Bayesian ANOVA on vicarious touch endorsements provided strong support (BF_{10} = 313802.5) for a main effect of hedonic category. Post-hoc contrasts confirmed that painful

videos were most frequently endorsed (36% of participants on average), with evidence for endorsement rates being higher than those for unpleasant (24%; BF_{10} = 11.36) and neutral videos (13%; BF_{10} = 8542.42) but not pleasant videos (33%; BF_{10} = 0.51). Similarly, pleasant videos were endorsed more frequently than neutral (BF_{10} = 15734.05) and unpleasant videos (BF_{10} = 5.74). The endorsement rate for unpleasant videos was higher than that for neutral videos (BF_{10} = 21.55). In sum, on average, painful and pleasant videos evoked vicarious touch in most participants, followed by unpleasant, and then neutral videos.

An analogous ANOVA on vicarious touch intensity also showed strong evidence for a main effect of hedonic category (BF_{10} = 2.34e+39). Post-hoc contrasts showed that painful videos evoked the highest average ratings (mean = 4.26), relative to unpleasant (mean = 3.73; BF_{10} = 5.99), pleasant (mean = 3.61; BF_{10} = 78.11), and neutral videos (mean = 3.03; BF_{10} = 9044.47). Unpleasant and pleasant videos were also rated higher than neutral videos (BF_{10} = 116.00 and BF_{10} = 337.55 respectively), but there was no clear evidence for difference between unpleasant and pleasant videos (BF_{10} = 0.57). Overall, on average, painful videos evoked the most intense sensations, followed by pleasant and unpleasant videos, and finally neutral videos.

In summary, participants indeed reported most frequent and intense vicarious sensations for painful videos, with neutral videos least likely to elicit vicarious touch and producing the lowest intensity when they did. These findings resonate with previous research (Holle et al., 2011; Li et al., 2022; Ward et al., 2018) and underscore the impact of the hedonic quality of observed touch on the frequency and intensity of vicarious touch experiences.

3.2.2. The effects of arousal and threat on vicarious touch

Validation data from the VTD indicates that videos depicting painful touch are perceived as highly threatening and arousing (Smit and Rich, 2023), which might explain why they often elicit frequent and intense vicarious touch sensations. To examine this, we correlated the

mean arousal and threat ratings for each video (using the validation data) with the percentage of all participants that endorsed vicarious touch for each video and the mean intensity scores (Fig. 4).

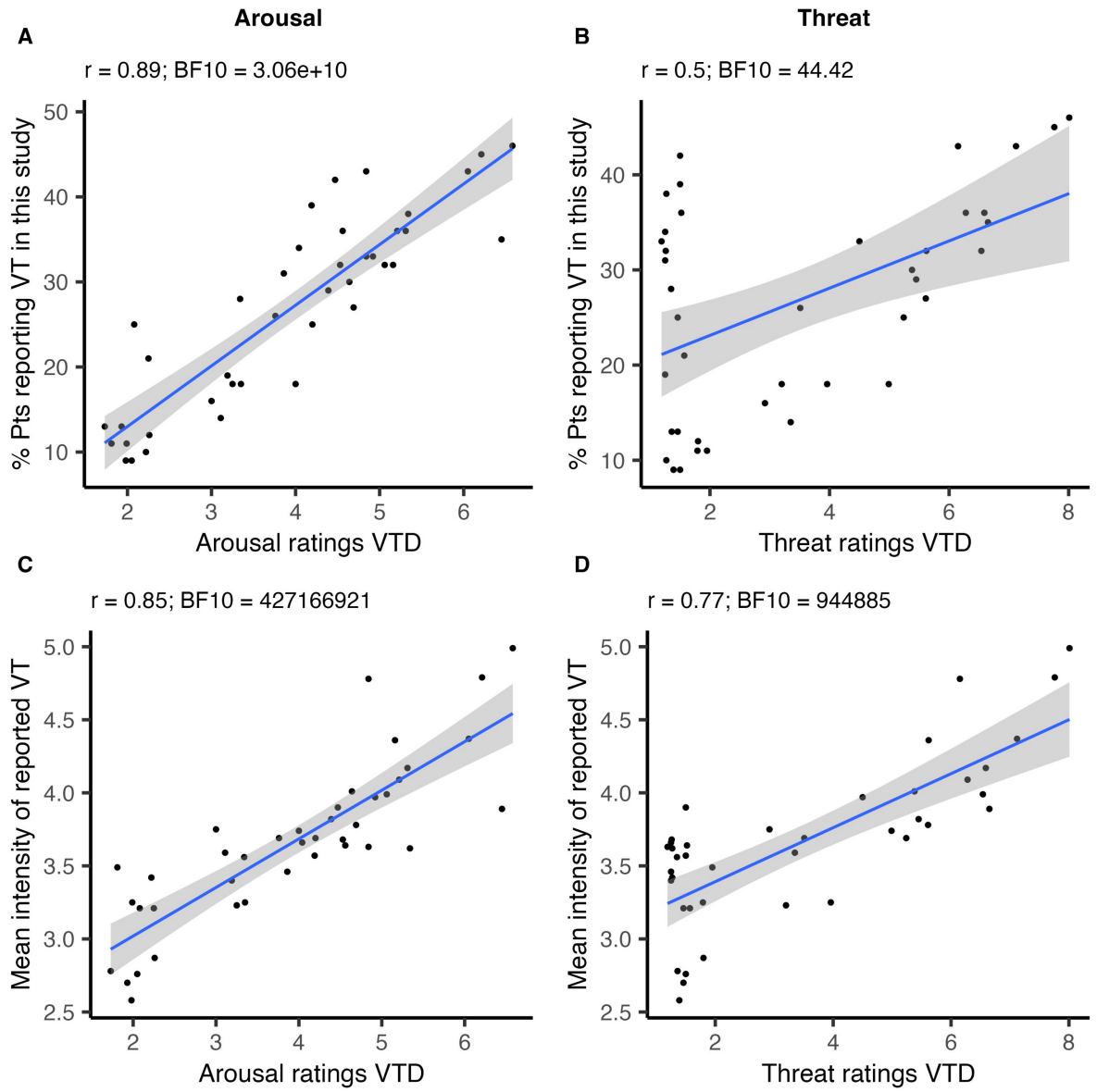

Figure 4. Correlation between the arousal and threat ratings from the VTD and percentage of participants who endorsed vicarious touch (top row) and mean intensity (bottom row) for each video. Scatterplots depict the relationship between the independently rated (A, C) arousal and (B, D) threat on a scale from 1-10 (1 = not at all, 10 = extremely) from the VTD (Smit and Rich, 2023) and the endorsement (top) and intensity (bottom) of evoked vicarious touch for each video. Each dot signifies the percentage of participants that endorsed vicarious touch, or mean intensity ratings across

participants, for the individual videos, with 40 videos in total. Lines show linear regression with shaded 95% confidence intervals.

The rated arousal of the touch in videos was strongly correlated with both the percentage of participants who endorsed vicarious touch (r = 0.89, BF_{10} = 3.06e+10) and the average intensity of reported vicarious sensations (r = 0.85, BF_{10} = 4.27e+08). Threat ratings showed a moderate correlation with the percentage of participants who endorsed vicarious touch (r = 0.50, BF_{10} = 44.4) and a stronger correlation with the mean intensity of these sensations (r = 0.77, BF_{10} = 944885). However, closer inspection of Figure 4B suggests that these correlations are likely reduced by the cluster of observations with low VTD threat ratings but high vicarious touch endorsements. As shown in Supplementary Fig. 1 these observations derive entirely from neutral and pleasant videos. When correlations are computed separately on data grouped by hedonic video type, we observe strong correlations with unpleasant and painful videos for both vicarious touch endorsements (r = 0.89, BF_{10} = 20.05 and r = 0.78, BF_{10} = 5.11 respectively) and intensity (r = 0.69, BF_{10} = 2.89 and r = 0.72, BF_{10} = 3.57 respectively) but not for neutral and pleasant videos for vicarious touch endorsements (r = -0.07, BF_{10} = 0.63 and r = 0.54, BF_{10} = 1.47 respectively) and intensity (r = 0.37, BF_{10} = 0.89 and r = 0.42, BF_{10} = 1 respectively). A likely explanation for these findings is the limited range of threat ratings for neutral (1.27 – 1.95) and pleasant (1.19 – 1.52) videos, compared to the much broader range for unpleasant (2.92 – 6.59) and painful (4.5 – 8.01) videos. Additionally, there was a strong correlation between threat and arousal ratings (r = 0.72, BF_{10} = 62473.23), indicating that videos perceived as more threatening also tend to elicit higher arousal levels. These results collectively suggest that both arousal and threat are significant modulators that influence the likelihood and intensity of evoking vicarious touch sensations.

3.2.3. Sensations are felt across the body with a focus on the hands

We examined the specificity of sensation localisation in relation to the four hedonic categories identified in the VTD (Fig. 5). Participants were asked the question, "Where on YOUR body did you feel the tactile sensation?" and could select multiple response options. We first calculated the average percentage per participant and then averaged these percentages across participants for each body part. This analysis revealed that the most common response was the left hand (video type: neutral 61%, pleasant 52%, unpleasant 52%, painful 51%), followed by the right hand (video type: neutral 30%, pleasant 25%, unpleasant 30%, painful 28%), and then both hands (video type: neutral 3%, pleasant 7%, unpleasant 7%, painful 5%). On some trials, participants indicated having a 'general feeling', which was more pronounced in response to observing painful videos (video type: neutral 1%, pleasant 7%, unpleasant 6%, painful 11%). In addition, we examined the responses described when participants indicated feeling touch on 'another body part' (video type: neutral 2%, pleasant 5%, unpleasant 3%, painful 4%). These reported sensations were dispersed across the body, especially in response to painful videos, with a notable concentration in the upper body regions, including the back, neck, chest, stomach, and arms. Participants rarely chose the 'other' option (neutral 0%, pleasant 1%, unpleasant 1%, painful 1%).

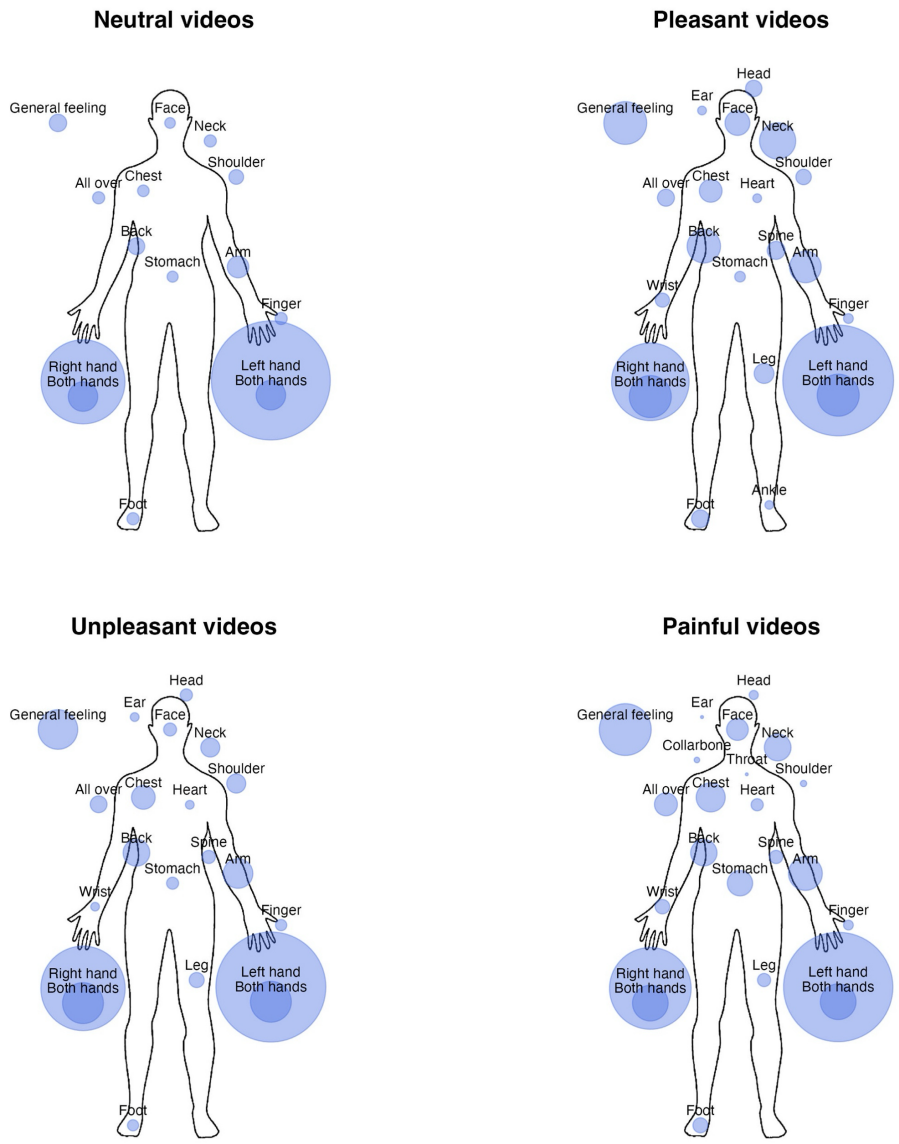

Figure 5. Location of reported sensations across different hedonic categories. Each body plot represents vicarious touch responses to 10 videos belonging to one of four hedonic categories: neutral, pleasant, unpleasant, and painful. Note that all videos depict a left hand being touched. The response options were: Left hand, Right hand, Another body part (describe), A general feeling (describe), Other (describe). The body regions where sensations were felt are represented by purple circles. The size of these circles indicates the relative number of trials in which a sensation was reported in that region. For the hands, the larger lighter circle shows the responses for each hand separately with the darker blue showing responses of 'both hands'.

3.2.4. Valence of vicarious touch response

In each trial where a vicarious sensation was reported, participants classified this vicarious sensation as being neutral, pleasant, unpleasant, or painful. We tested the general valence of the reported sensations (Fig. 6A), and the valence intensities (e.g., *how* pleasant was the touch?) (Fig. 6B). Across all participants, vicarious touch trials were predominantly rated as 'neutral' (43%), followed by 'unpleasant' (34%), 'pleasant' (18%), and 'painful' (5%). A Bayesian ANOVA indicated that valence intensity scores were different across the four categories (BF_{10} = 7.72e+23). 'Painful' sensations were rated as most intense (mean = 6.35), and this differed from both 'pleasant' (mean = 5.07; BF_{10} = 4.88e+12) and 'unpleasant' (mean = 4.77; BF_{10} = 1.08e+25) sensations, with little evidence for a difference between 'pleasant' and 'unpleasant' sensations (BF_{10} = 1.55).

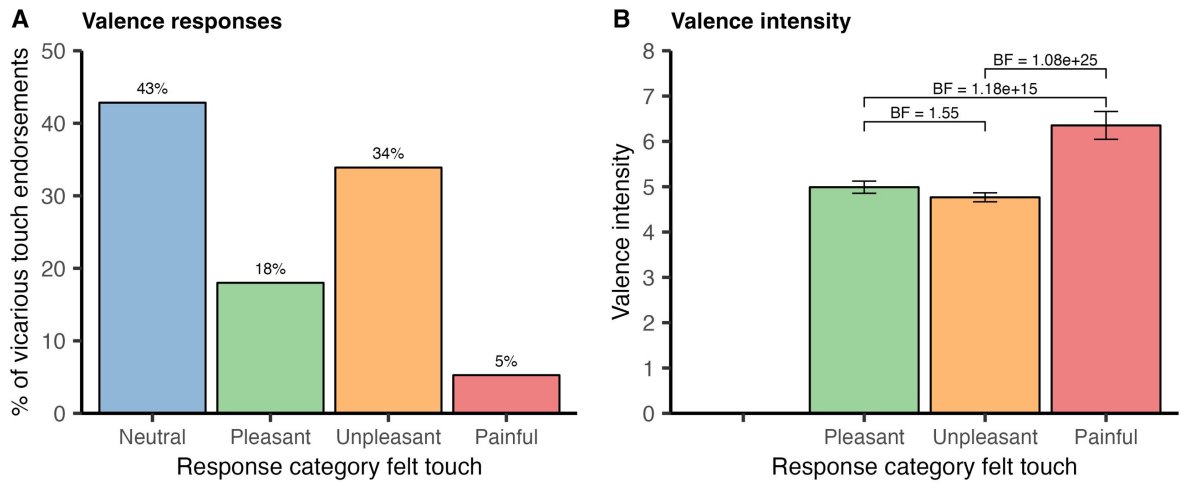

Figure 6. Vicarious touch responses with different valences. (A) The percentage of all endorsed vicarious touch trials in which participants assigned valence (neutral, pleasant, unpleasant, and painful) to the vicarious touch they experienced. (B) The corresponding average intensities for each valence (participants were only asked about valence intensity – how pleasant/unpleasant/painful was the touch? - for valanced touch reports, i.e., not neutral). Intensity was scored on a scale from 1-10 (1 = not at all, 10 = extremely), with higher values indicating stronger sensations. Error bars represent 95% confidence intervals for each category.

3.2.5. The valence of felt touch sensations

Next, we tested whether the hedonic quality of the observed touch portrayed in the videos influences the valence of reported sensations (Fig. 7). Neutral videos predominantly evoked neutral sensations (78%), while both pleasant and unpleasant videos frequently elicited either valence-congruent sensations (48% and 45% respectively) or neutral ones (46% and 47% respectively). Notably, when participants viewed videos showing painful touch, they predominantly reported the sensation as being unpleasant (64%), with few instances of painful (12%). This highlights that the hedonic quality is typically mirrored but with reduced valence negativity for videos depicting painful touch.

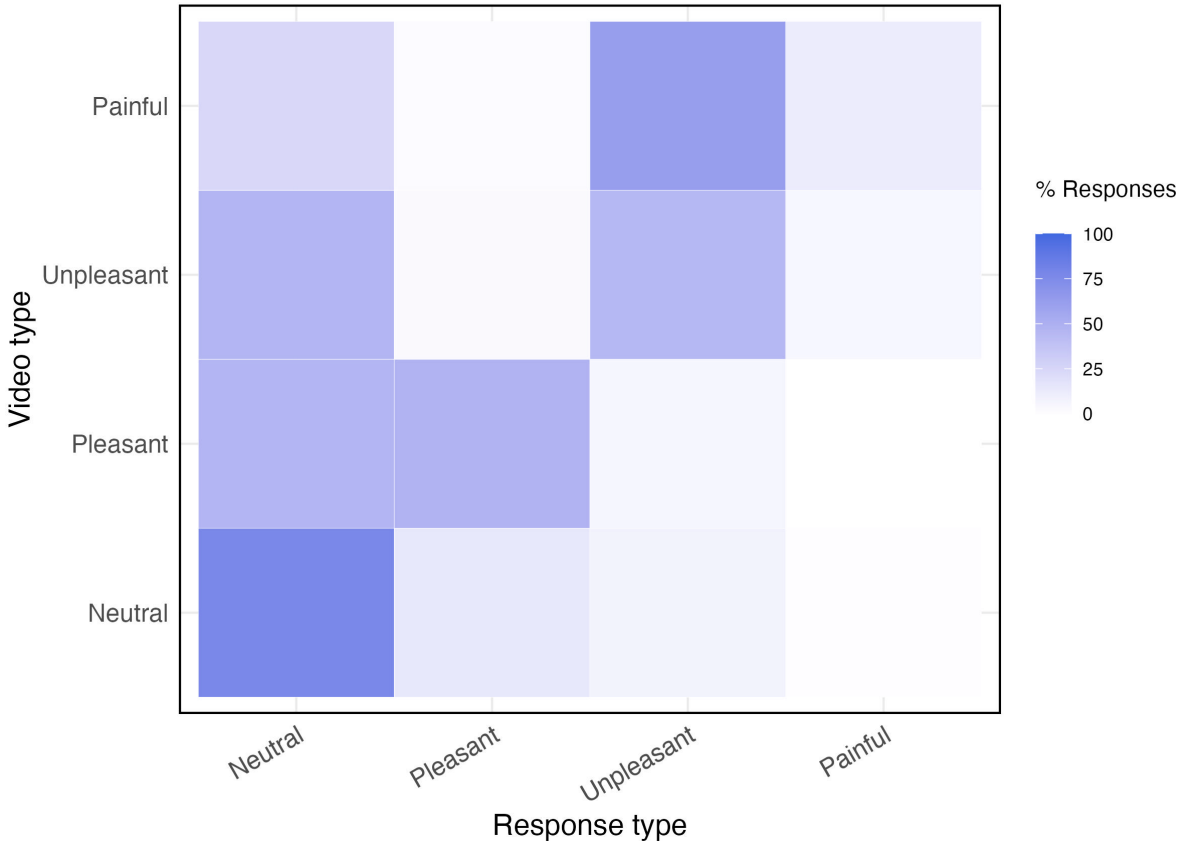

Figure 7. Impact of hedonic quality of video touch on the valence of vicarious touch sensations. The colour intensity represents the percentage of trials where sensations were reported with a particular valence for each of the ten videos within each hedonic category. Hedonic categories of the videos are predefined based on validation data from (Smit and Rich, 2023).

To further explore the relationship between the valence of the observed and felt touch, we examined whether the valence intensity also matched. Participants first categorised their sensations as neutral, pleasant, unpleasant, or painful (i.e., see Q4 in the methods section), and then rated the valence intensity of *the felt touch* (e.g., if they indicated that the sensation was pleasant, we would ask *how* pleasant on a scale from 1-10; see Q5 in the methods section). These ratings were compared to scores from the VTD (Smit and Rich, 2023) where an independent cohort had rated the valence intensity of *touch in the videos* using the same scale. Our analysis revealed that on average, within each hedonic valence category, the mean ratings obtained across videos in from the VTD was very similar to the mean ratings of vicarious touch reported here. In particular, the average VTD rating for pleasant touch was 6.26, with vicarious sensations averaging 5.11; the average VTD rating for unpleasant touch was rated at 5.15 with vicarious sensations averaging 4.63; the average VTD rating for painful touch was 7.11, with vicarious sensations at 6.40. Overall, the intensity of felt touch was consistently rated slightly lower than that of observed touch across all categories (1.15, 0.52, and 0.71 points lower for pleasant, unpleasant, and painful, respectively). Upon further inspection, however, we found that, while there was a clear relationship in *average* ratings across hedonic categories as just described, there was noticeable variability in valence matching for the individual videos in each category (see Supplementary Fig. 5). Overall, we found that 1) the general hedonic valence of videos are reliably mirrored in the vicarious touch experiences, 2) the *average* rated valence intensity was very similar for both observed touch in the videos and vicarious touch felt on the body, but slightly lower than that of observed touch across all categories, and 3) there was variability in how well the seen and felt touch matched in valence intensity when considering the individual videos.

3.2.6. Different types of vicarious sensations

We investigated the type of sensation elicited by viewing touch videos of different hedonic qualities, such as whether the participants described tingling, touch, temperature, pressure and so on. To achieve this, we calculated the percentage of each type of reported sensation relative to all reported sensations across the ten videos within each of the four categories (Fig. 8).

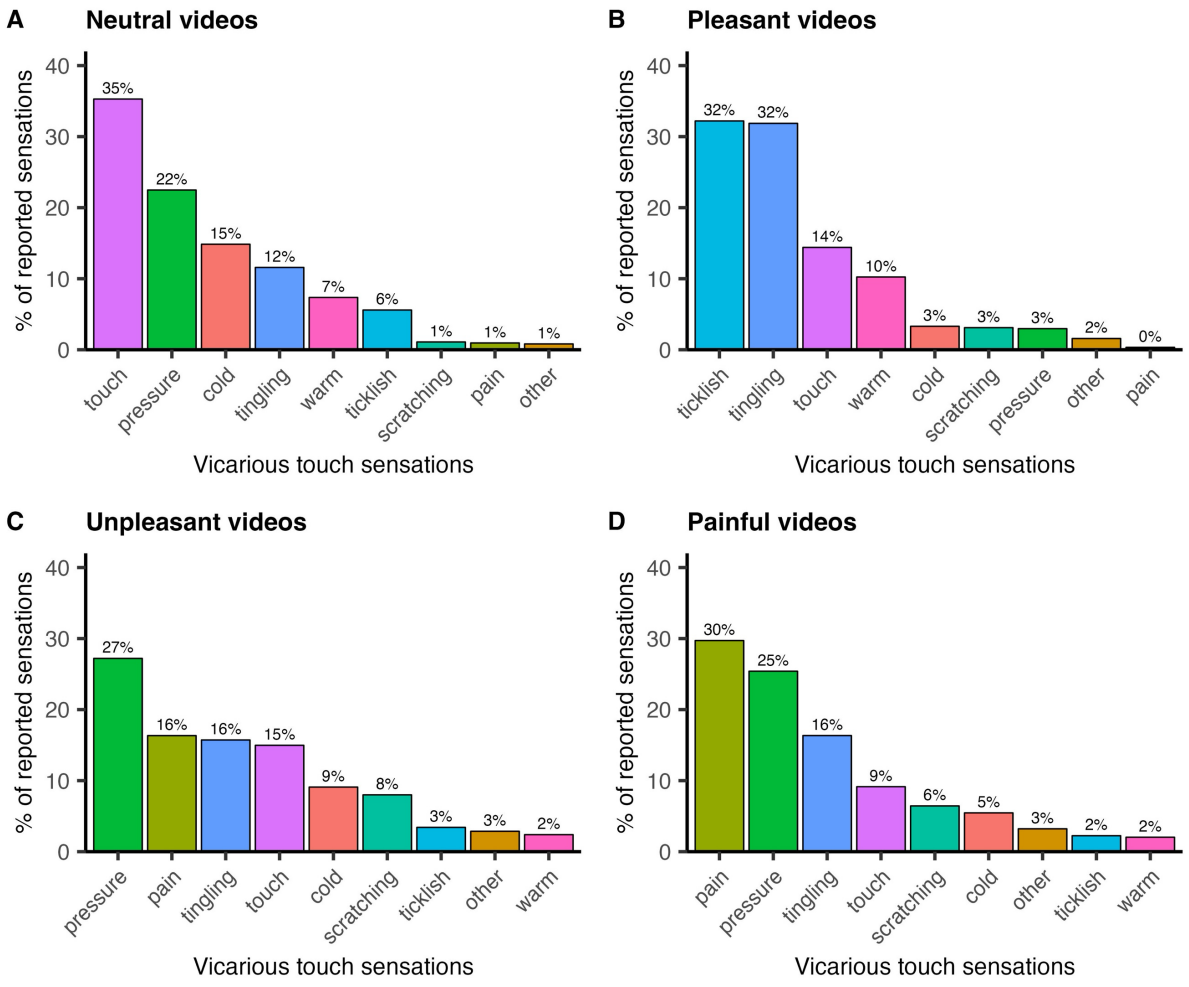

Figure 8. Differential sensation reporting across hedonic video categories. The distribution of vicarious touch sensations reported by participants following the viewing of ten videos categorised as (A) Neutral, (B) Pleasant, (C) Unpleasant, and (D) Painful. The y-axis displays the percentage of each sensation type relative to all reported sensations across the ten videos within

each of the four categories. The colour of the bars code for sensation type and this is consistent across all four panels.

Our findings revealed that the quality of the touch depicted in the videos tended to produce vicarious sensations with similar qualities (see Supplementary Fig. 3 for sensation reporting for each of the 40 videos). Specific mirroring occurred on a fine-grained level: for example, participants reported feeling mostly pressure when touch with scissors was applied forcefully from the top to the bottom of the hand, but they reported mostly tingling when a similar touch with scissors was applied softly. Overall neutral videos, often depicting a singular touch application with moderate pressure (see VTD; Smit and Rich, 2023), primarily elicited sensations of 'touch' and 'pressure'. Pleasant videos, showing a gentle stroke using soft objects like brushes, fabrics, or another hand, predominantly evoked 'ticklish' and 'tingling' sensations. Unpleasant videos, where the touch generally applied significant pressure, triggered responses of 'pressure' and 'pain'. In videos categorised as painful, which often portrayed touch using strong pressure or a sharp object, the predominant sensations were 'pain', and 'pressure'. Videos categorised as pleasant typically evoked warm sensations, while those deemed unpleasant frequently led to cold sensations, likely reflecting the temperature-related properties of the objects used, such as a metal spoon or knife (cold) versus soft materials or a flat hand (warm). These findings suggest that the type of touch, the intensity or pressure, and the characteristics of the object being used to perform the touch, shape the specific sensations experienced.

3.2.7. Observed touch to an object

Previous research suggests that although observing touch to either humans or objects can elicit vicarious touch sensations, these responses are more common and intense for touch to humans (Holle et al., 2011; Ward et al., 2018). Similarly, in our study, we found that only 32% of all participants reported at least one vicarious touch when observing touch to an object (5

trials total), compared to the much higher 84% who had at least one vicarious touch instance when observing touch to a *hand* (40 trials total). This is not just because we had less object videos: on average, a single video showing touch to the hand evoked sensations in 27% of participants, whereas touch to the object or adjacent to the object elicited responses in only 12% and 7% of participants, respectively. The type of touch on the object influenced vicarious responses: a soft brush stroke on an object triggered sensations in 22% of participants, nearly three times as much when the object was simply touched with a finger which evoked sensations in 8% of participants. Participants described similar sensations in line with the type of touch (e.g., touch with a finger, Fig 9). These findings suggest that while human touch observations have a higher propensity to elicit vicarious sensations, the type of sensations reported are the same, irrespective of whether the target is human or an object.

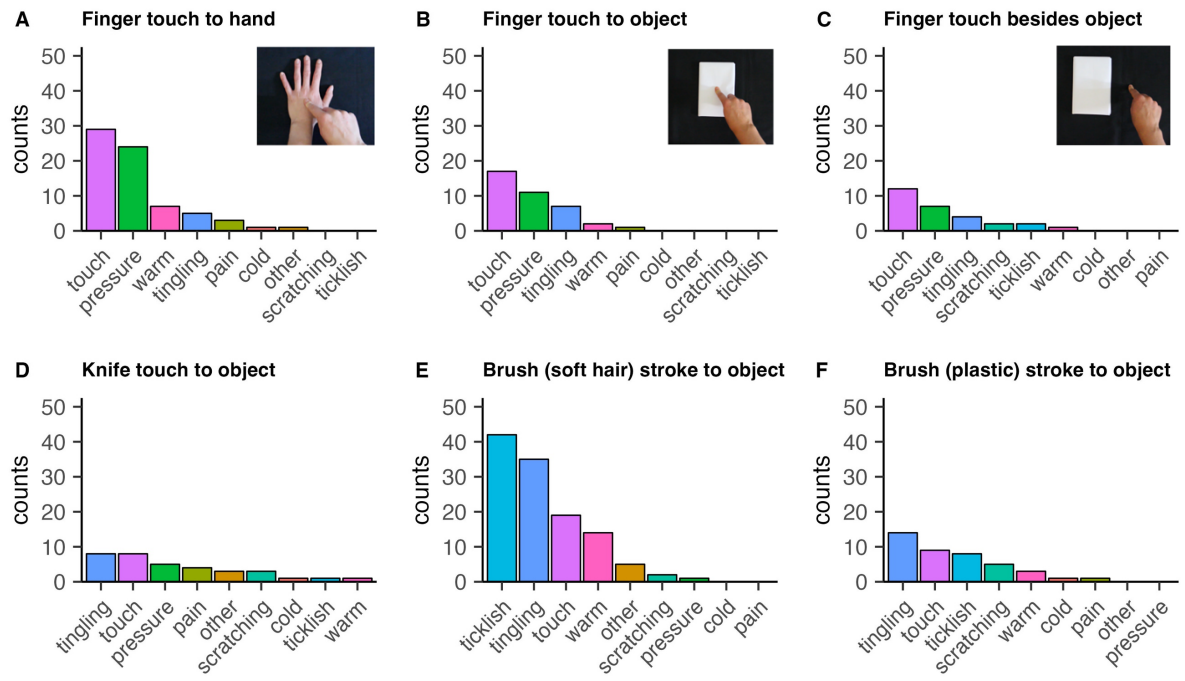

Figure 9. Sensations reported when observing touch to an object or besides an object. (A, B, C) Comparison of reported sensations for videos depicting identical touch interactions with a hand, an object, and besides an object. (D, E, F) Responses to the remaining object-touch videos (a total of 5 object videos). Note that the y-axis represents the *total counts* of reported sensations rather than

relative frequencies to illustrate the frequency of sensations for hand-touch versus object-touch. Sensations are ordered by the highest count.

We next investigated the locations where participants reported feeling touch while observing the object videos. We again established the responses for each participant and then averaged across participants. Participants could report sensations in multiple areas for each trial. The reported locations were: **right hand** (29%), **left hand** (28%), **general feeling** (12%), **both hands** (6%), **face** (2%), **back** (2%), **neck** (2%), **arm** (2%), **chest** (1%), **stomach** (1%), **finger** (1%), **leg** (1%), **spine** (<1%), **all over** (<1%), **ear** (<1%), **head** (<1%). The predominance of sensations in the hands suggests a possible priming effect from the other videos, which featured touch to a left hand, or a general tendency among participants to mirror observed touch to objects onto their own hands. One obvious explanation is that when a right index finger is the touching agent, this may result in evoked touch (see also Ward et al., 2018). We therefore analysed responses specifically from the two videos where a right-hand finger was the touching agent. Here, reported sensations were indeed most likely to be localised to the **right hand** (48%), with other reports of **left hand** (27%), **both hands** (6%), **general feeling** (3%), **finger** (1%), **head** (<1%), **chest** (<1%), **stomach** (<1%), and **leg** (<1%). Overall, we found that while the sensations reported are similar regardless of the target, human touch evokes a higher prevalence of vicarious sensations. Holle et al., (2011) propose that this type of result may be due to empathy towards the receiving person.

3.3. Different vicarious touch profiles in a general population

In this third section of our findings, our objective was to determine if our data revealed subgroups of individuals who experience vicarious touch in qualitatively distinct ways. To test this, we applied a clustering approach based on the total number of trials in which a participant: 1) endorsed vicarious touch (i.e., answered 'yes' to the first question), 2) reported an exteroceptive sensation, or 3) reported an interoceptive sensation. For example, if in a trial

where vicarious touch was endorsed, a participant reported two exteroceptive sensations which are felt on the skin (e.g., touch and pressure) and one interoceptive sensation which is felt from within (e.g., tingling), this would count as one instance for each of the three categories, regardless of the number of sensations reported. We only included participants who experienced at least one instance of vicarious touch. Drawing on prior research (Ward et al., 2018), we hypothesised that individuals with a higher number of total vicarious touch endorsements may report relatively more exteroceptive sensations compared to those with fewer vicarious touch endorsements, who may experience relatively more interoceptive sensations.

We used k-means clustering and the Elbow Method (MacQueen, 1967) to determine the optimal number of clusters for our dataset (see Supplementary Fig. 4). We analysed the difference between successive values of the within-cluster sum of squares (WCSS) (James et al., 2013) and used the point of inflection to select our number of clusters. This showed that two or three clusters would be the most appropriate number of clusters based on the variance explained. We decided to include three (rather than two) clusters to increase the likelihood we would capture those on the more extreme ends of the vicarious touch distribution.

We assessed compactness within each cluster by calculating the average of all pairwise Euclidean distances among observations, reflecting how closely data points are grouped. In addition, inter-cluster distances were calculated as the average of all distances between points across different clusters, providing insight into the distinctness and separation of each cluster. These measurements demonstrated significant differentiation between clusters, with intra-cluster distances averaging 8.67 (range: 5.53 to 12.04) and inter-cluster distances averaging 23.74 (range: 15.31 to 34.18). The clustering validity was further supported by a Dunn Index (Dunn, 1974) of 1.271, indicating reasonable separation and compactness. Additionally, the Silhouette Score (Rousseeuw, 1987), averaging 0.504, confirmed that the clusters are well-separated, aligning with the Dunn Index findings. This

combination of metrics validates our clustering approach, demonstrating both effective separation and internal cohesion within clusters.

Figure 10 presents a scatter plot of the clusters, with the number of interoceptive sensations on the x-axis and the number of exteroceptive sensations on the y-axis. The size of the markers represents the total number of reported vicarious touches. Note that the total number of vicarious touches is not simply the sum of interoceptive and exteroceptive sensations, as participants could report both types of sensations in a single trial. Cluster 1 (purple), comprising 124 participants (36% of vicarious touch responders; 95 women, 28 men, 1 non-binary), displayed the lowest levels of vicarious touch endorsements (mean 5.56, range 1-14) and reported more interoceptive than exteroceptive sensations (mean 3.18 vs. 2.09). This can be seen in Figure 10, where more Cluster 1 points are scattered below the diagonal line. Cluster 2 (green), the largest group with 187 participants (53% of vicarious touch responders; 129 women, 58 men), showed moderate vicarious touch endorsements (mean 17.11, range 10-29) and relatively more interoceptive compared to exteroceptive sensations overall (mean 9.66 vs. 7.15). However, the distinction between the two sensation types was less pronounced compared to Cluster 1 as can be seen in Fig. 10. Cluster 3 (yellow), comprising 44 participants (12% of vicarious touch responders; 32 women, 12 men), registered the highest vicarious touch endorsements (mean 30.80, range 22-40) and had a notably higher proportion of exteroceptive compared to interoceptive sensations (mean 21.07 vs. 13.93). In Figure 10, Cluster 3 points are predominantly located above the diagonal line.

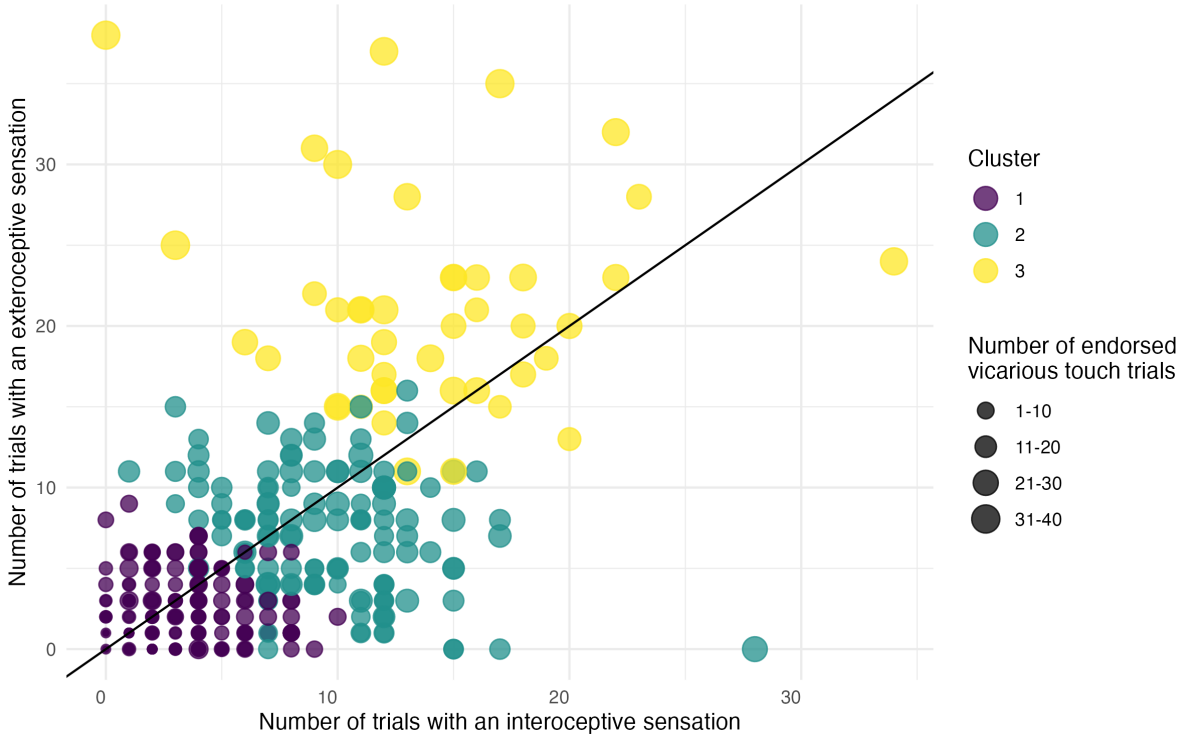

Figure 10. Scatter plot representing the results of a data-driven cluster analysis based on the number of trials with endorsed vicarious touch, exteroceptive sensations, and interoceptive sensations. Each point represents a single participant. The size of the points indicates the total number of vicarious touch trials, while the colour denotes cluster identity. The diagonal line indicates an equal number of interoceptive and exteroceptive sensations. This line helps distinguish the relative proportions of sensations for each cluster, with points above the line indicating more exteroceptive sensations and points below the line indicating more interoceptive sensations.

In addition to variations in the total number of vicarious touch endorsements and the interoceptive and exteroceptive sensations used for the clustering algorithm, these clusters exhibit additional distinguishing characteristics not used as inputs (see Fig. 11). Panel A displays the proportion of trials where reported sensations were localised to the hands for videos depicting touch to a hand, relative to the total number of trials where vicarious touch was endorsement. This panel reveals that individuals in Cluster 3 reported hand-localised vicarious touch more frequently than those in the other two clusters. Panel B, related to videos depicting touch to a hand, shows the proportion of trials with endorsed pain sensations relative

to the total number of trials with endorsed vicarious touch. It indicates that Cluster 2 individuals reported feeling pain in a higher proportion of trials than those in Cluster 1, and similarly, Cluster 3 reported pain sensations in relatively more trials than Cluster 2. While the evidence supporting these two comparisons was limited, there was substantial evidence confirming the differences in pain sensations between Clusters 3 and 1. Panel C illustrates the total number of vicarious touch endorsements when observing touch to an object. In this case, Cluster 2 endorsed more trials than Cluster 1, and Cluster 3 endorsed more trials than Cluster 2, suggesting that broader underlying mechanisms such as arousal or attention may influence vicarious touch experiences. This variation could also reflect different thresholds or criteria for reporting vicarious touch across clusters.

In terms of intensity, the most notable contrast was between Clusters 1 and 2, with Cluster 2 showing higher intensity across all sensation types (panels D-G) and when observing touch to an object (panel H). This indicates that for those with a low to moderate tendency to report vicarious touch, an increasing tendency to report vicarious touch was associated with higher intensity overall. However, we found moderate to strong evidence of no differences among the clusters in distinguishing between observed touch to a person versus an object, as measured by the intensity for human versus object touch (Cluster 1 vs. Cluster 2 $BF_{10} = 0.28$, Cluster 2 vs. Cluster 3 $BF_{10} = 0.19$, and Cluster 1 vs. Cluster 3 $BF_{10} = 0.18$). Interestingly, individuals in Cluster 3 did not generally experience vicarious touch with greater intensity than those in Cluster 2, except for 'pain' (panel G), which was most intense for Cluster 3. Given the relative muting of pain sensations reported earlier, this result may suggest that mirroring pain is a special case compared to mirroring non-painful touch. The clusters did not differ in their emotional empathy scores (panel I), suggesting that empathy for sensations may be dissociable from other types of empathy.

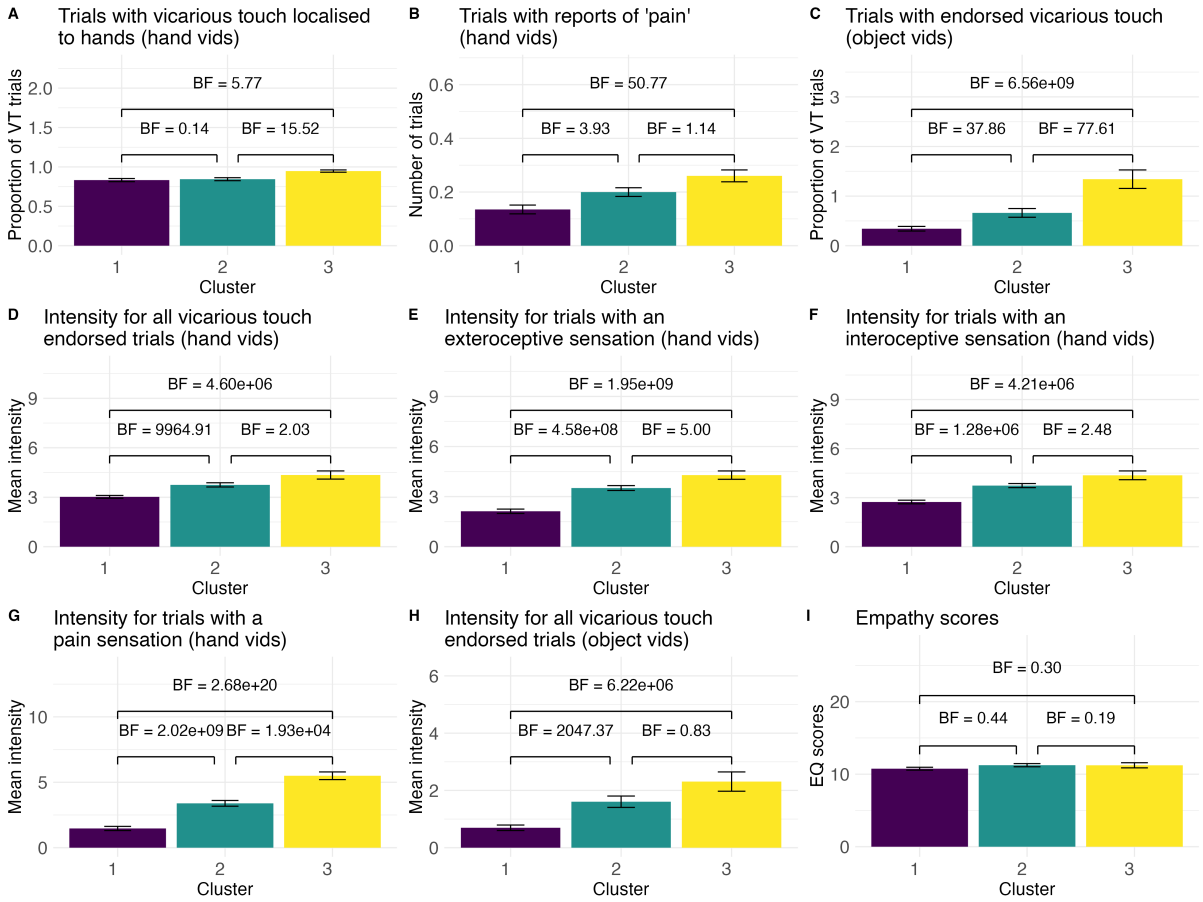

Figure 11. Bar plots showing variations in different response variables across each cluster. Panels A-C illustrate the relative proportion of specific sensations in response to certain videos, normalised by the total vicarious touch endorsements per cluster. Panels D-G display the mean intensity for different response types and H for observed touch to an object. Error bars indicate the standard error of the mean. Bayes Factors comparing the clusters are shown above each pair of bars, indicating the strength of evidence for differences between the clusters

Discussion

We investigated the characteristics of reported vicarious touch among a general population, using a controlled set of video stimuli from the Validated Touch-Video Database that depict various types of touch to a hand. The findings revealed that a large majority of participants (84%) reported vicarious sensations such as tingling, pressure, and pain when watching videos depicting various types of touch. This high prevalence underscores a broad capacity

for sensory mirroring in the general population that extends beyond the specialised phenomenon of mirror-touch synaesthesia or heightened empathic abilities often studied.

Prevalence

Our study revealed a prevalence of vicarious touch that exceeds prior studies, with 84% of participants reporting at least one sensation during trials that depicted touch to another person's hand. For comparison, earlier papers reported that approximately 25% of a Western undergraduate sample (Ward et al., 2018) and 60% of a Chinese sample (Li et al., 2022) similarly reported at least one vicarious sensation. In our sample, 70% of participants also specifically reported at least one *exteroceptive* sensation such as touch, pressure, or scratching, which is thought to be a stronger indicator of sensory mirroring than more general activations like tingling (Ward et al., 2018). The inclusion of varied touch videos, ranging from neutral (e.g., a single touch with a finger) to highly emotionally charged (e.g., a stab with a sharp knife), may have enhanced participants' emotional engagement and arousal, thereby amplifying their sensory mirroring responses. Additionally, our study found that 50% of participants reported experiencing pain specifically when viewing videos depicting painful touch. This rate is higher than that of prior research that focused more on general depictions of pain (Giummarra et al., 2015; Grice-Jackson et al., 2017; Li et al., 2022; Osborn and Derbyshire, 2010; Vandenbroucke et al., 2013; Ward et al., 2018). This implies that the specific portrayal of painful *touch* might activate more direct sensory pathways, leading to a higher incidence of localised pain sensations. Our findings emphasise the impact that both the type and context of visual touch stimuli have on studies of vicarious touch and possibly pain, suggesting that controlled experimental conditions featuring diverse and specifically targeted touch stimuli can substantially enhance sensory mirroring (see also Vandenbroucke et al., 2013 for lower incidences of self-reported vicarious pain in daily life compared to experimental contexts).

Gender & Empathy

Vicarious sensations were more frequently reported by women, both in terms of the proportion of women reporting at least one vicarious touch and the number of trials in which those with vicarious touch reported these sensations. This finding contrasts with previous research that has reported no gender differences in the perception of vicarious touch (Li et al., 2022; Ward et al., 2018). However, the intensity of the vicarious touch reported was not different between men and women in our sample. Additionally, women reported experiencing pain more frequently across trials, aligning with studies that suggest women are more likely to report vicarious pain (Grice-Jackson et al., 2017; Li et al., 2022), potentially due to stronger neural responses when observing pain in others (Singer et al., 2006; Yang et al., 2009 but see Lamm et al., 2011). Women in our sample also exhibited higher scores on measures of emotional empathy, possibly influenced by societal expectations and gender-role stereotypes (Baez et al., 2017; Baron-Cohen and Wheelwright, 2004; Eisenberg and Lennon, 1983; Löffler and Greitemeyer, 2023; Simner et al., 2006), However, we found no robust correlation between emotional empathy and the frequency of vicarious touch reports, unlike previous studies (Banissy and Ward, 2007; Goller et al., 2013; Ward et al., 2018 but see Baron-Cohen et al., 2016). This suggests that factors other than emotional empathy might drive the observed gender differences in reporting vicarious touch. Our findings emphasise the need for a nuanced understanding of how gender norms and psychological traits interact in the processes driving sensory mirroring and the perception of touch.

Emotional content & hedonic quality

The emotional content and hedonic quality of the observed touch strongly influenced the frequency and intensity of vicarious sensations. From prior research (Giummarra et al., 2015; Grice-Jackson et al., 2017; Holle et al., 2011; Li et al., 2022; Osborn and Derbyshire, 2010; Ward et al., 2018), we expected more intense sensory responses to videos depicting painful

or threatening touch. Consistent with this, videos depicting painful interactions—characterised by high arousal and perceived threat (Smit and Rich, 2023)— elicited the strongest vicarious sensations. These were followed in intensity by reactions to pleasant and unpleasant touches, with neutral touches provoking the weakest responses. Our analysis revealed a strong correlation between the arousal ratings from the VTD and the frequency and intensity of reported vicarious sensations, while the correlation with threat ratings was strong when considering only unpleasant and painful videos.

When participants categorised their vicarious touch experience—as neutral, pleasant, unpleasant, or painful—their responses mirrored the valence of the touch shown in the videos about half the time. The two main exceptions to this pattern are that (1) the other half the time, participants reported their vicarious touch as neutral across all video categories, and (2) painful videos most commonly resulted in sensations described as unpleasant rather than painful, suggesting a subdued mirroring of pain. These findings suggest that the emotional components of perceived touch are part of the ensemble of signals mirrored by sensory mirroring systems in a general population.

Phenomenology & tingling

Our findings illustrate distinct patterns of vicarious sensations across four hedonic video categories, aligning closely with the type of touch depicted. For instance neutral videos, which often featured a single touch with moderate pressure (see Smit and Rich, 2023), predominantly evoked sensations of 'touch' and 'pressure'. Conversely, pleasant videos involving gentle strokes with soft objects or hands typically elicited 'ticklish' and 'tingling' sensations. Additionally, the thermal characteristics of the touch were reflected in the participants' experiences, with metal objects inducing 'cold' sensations, while softer materials or another hand prompted 'warm' sensations. Consistent with previous research (Banissy et al., 2009; Osborn and Derbyshire, 2010; Ward et al., 2018), 'tingling' emerged as the most

frequently reported sensation overall, occurring more frequently in response to pleasant videos than to painful ones, despite the latter's higher threat and arousal ratings. This indicates that sensations like tingling to some extent mirror the physical characteristics of the observed touch, possibly in addition to cognitive factors such as attention, arousal, or a focused awareness of one's corresponding body part (Koster et al., 2004; Tihanyi et al., 2018; Tihanyi and Köteles, 2017; Vogt et al., 2008). We found also that reports of tingling were more prevalent among individuals with fewer and weaker vicarious touch responses (see also Ward et al., 2018). This suggests that tingling may result from diffuse, non-specific sensory activation via the somatosensory mirror system when observing touch (Keysers and Gazzola, 2009). The brain may interpret these mild or ambiguous sensory signals as tingling because the they are not strong or coherent enough to be perceived as a clear touch sensation (Tihanyi et al., 2018). These findings suggest that, like the hedonic qualities discussed in the previous section, sensory mirroring systems in the general population also mirror some physical characteristics of perceived touch. More broadly, these findings underscore the complex phenomenology of vicarious touch experiences, highlighting how visual, emotional, cognitive, and physical elements may interplay in shaping vicarious sensory perception.

Touch to objects

Observing touch to objects also evoked vicarious touch sensations, similar to those reported when observing touch to a hand, albeit at a much lower frequency. In addition, participants tended to report feeling touch in their finger or right hand when observing a hand touching an object, suggesting mirroring of touch consistent with the agent applying the touch. Our findings are consistent with prior research where individuals (even mirror-touch synaesthetes) report vicarious touch for objects (Banissy and Ward, 2007; Baron-Cohen et al., 2016; Holle et al., 2011; Li et al., 2022; Ward et al., 2018). This indicates that the mere observation of touch—whether on an object or a hand—can produce vicarious sensations (see Streltsova and

McCleery, 2014 for vicarious touch effects using electroencephalography when observing touch to an object).

Different vicarious touch profiles

Using a data-driven clustering approach we tested whether there exist distinct variations in vicarious touch perception within the general population, similar to what has been previously done for vicarious pain (Grice-Jackson et al., 2017). We clustered participants based on their total conscious vicarious touch endorsements across the 40 video trials (1-40), the total number of trials with a reported exteroceptive sensation (0-40), and the total number of trials with a reported interoceptive sensation (0-40). Our results indicated meaningful clustering into three distinct groups, suggesting that there exists different sensory response profiles in the general population, rather than vicarious touch being an uniform phenomenon, which is similar to findings on vicarious pain (Grice-Jackson et al., 2017). In addition to differences in total vicarious touch endorsements and interoceptive and exteroceptive sensations used for clustering, the clusters predicted other differences. Individuals in Cluster 3 reported hand-localised sensations more frequently than those in the other clusters, suggesting a more specific mirroring in this group. Compared to Cluster 1, members of Clusters 2 and 3 exhibited higher intensity across all sensation types, indicating that a higher tendency for vicarious touch correlates with increased sensation intensity. However, the overall intensity reported by Cluster 3 was not greater than that of Cluster 2, suggesting that vicarious touch intensity may plateau at moderate levels of responding. The exception was the intensity of reported pain, which was highest in Cluster 3. This implies that the *intensity* of mirroring painful touch might have a higher threshold before reaching a plateau. However, the clusters did not appear to clearly differ in the relatively *frequency* with which they reported pain sensations. While earlier studies found greater human–object differentiation in individuals with higher vicarious touch endorsements (measured in intensity: Holle et al., 2011; Ward et al., 2018), our findings

revealed no such distinctions across clusters. Interestingly, emotional empathy scores were also consistent across all clusters, indicating that the tendency to experience vicarious touch might be distinct from general emotional empathy (see also Baron-Cohen et al., 2016; Smit et al., 2023), which would contradict some previous findings (Banissy and Ward, 2007; Banissy et al., 2009; Ward et al., 2018).

Most knowledge about vicarious touch comes from research on mirror-touch synaesthetes (Banissy and Ward, 2007; Banissy et al., 2009; Blakemore et al., 2005; Gillmeister et al., 2017; Holle et al., 2013, 2011; Ioumpa et al., 2019; Li et al., 2022; Medina and DePasquale, 2017; Ward et al., 2018). Some individuals in our sample may exhibit characteristics of mirror-touch synaesthesia. Those in Cluster 3 frequently reported intense, localised, exteroceptive sensations rather than generalised, interoceptive sensations. However, these individuals did not show a clearer distinction in their responses to human versus object touch, nor did they exhibit enhanced emotional empathy, previously associated with mirror-touch synaesthesia (Banissy and Ward, 2007; Banissy et al., 2009; Holle et al., 2011; Ward et al., 2018). Cluster 3 comprised 10.4% of our entire sample (12% of all vicarious touch responders), closely matching the self-reported prevalence of mirror-touch synaesthesia (Banissy et al., 2009; Chun and Hupé, 2013). However, prior behavioural work using a visual-tactile interference task reported a much lower prevalence of 1.6% (Banissy et al., 2009). When we looked at an individual level, there were six participants in Cluster 3 (1.4% of our entire sample and 1.7% of vicarious touch responders) who consistently reported exteroceptive sensations (>36/40 trials) localised to the hands (100% of endorsed trials), effectively appearing as outliers in the sample. It may be the case that these six experience mirror touch synaesthesia. Future research could use objective measures, such as a visual-tactile congruency task (Banissy and Ward, 2007; Banissy et al., 2009) or neuroimaging (e.g., see Smit et al., 2023), to determine whether individuals in Cluster 3, including the six outliers, exhibit behavioural or neural differences consistent with mirror-touch synaesthesia.

Our findings collectively indicate that the conscious experience of localised vicarious touch is not a rare phenomenon, at least in experimental contexts, suggesting that these experiences extend beyond specific conditions such as mirror-touch synaesthesia (Banissy et al., 2009; Deroy and Spence, 2016, 2013; Fitzgibbon et al., 2012; Ward et al., 2018; Ward and Banissy, 2015). On one hand, this high prevalence is in line with vicarious touch representing a continuum with mirror-touch synaesthesia on the extreme end (de Vignemont, 2017; Fitzgibbon et al., 2012; Rothen and Meier, 2013; Simner, 2012). On the other hand, we also observed varying sensory response profiles within our general population sample (similar to what has been reported for vicarious pain: Grice-Jackson et al., 2017), suggesting categorical differences between people. Any such differences do not seem driven by differences in emotional empathy. Future studies could further test a link between vicarious touch profiles based on self-reported characteristics and social abilities more generally.

Limitations & future directions

Our study used validated touch videos that were standardised in terms of visual elements such as hand appearance, placement, and perspective, effectively isolating the hand to control for variables like hand posture, which has been shown to influence vicarious touch (Medina and DePasquale, 2017). This methodology strengthens the reliability of our findings by focusing purely on the sensory aspect of touch. However, it is important to consider that the emotional connection to the person being touched may enhance vicarious sensations (Serino et al., 2009, 2008). The absence of visible emotional responses in our videos might have limited the empathetic connection for some participants, potentially affecting their responses. Additionally, our reliance on self-report measures introduces the possibility of response bias (Baez et al., 2017; Orne, 1962; Paulhus and Vazire, 2007; Rueckert, 2011), where participants might report what they believe is expected rather than their true experiences. This could potentially inflate the reported rates of vicarious touch and empathy. Nonetheless, the

specificity in the ratings—such as higher endorsements for painful versus neutral touch—suggests that such bias did not overly skew the results. Further supporting this, our previous electroencephalography (EEG) study found that participants who reported vicarious touch from VTD videos exhibited neural overlap between seeing the touch videos and feeling touch directly, unlike those without vicarious touch responses, linking self-reported experiences to neural evidence of differences in vicarious touch processing (Smit et al., 2023). Finally, phenomenological control, where visual stimuli act as imaginative suggestions altering subjective experiences, may have been stronger in our experimental setting compared to real-world settings, which may have resulted in heightened vicarious touch responses than what would be expected in daily life (Lush et al., 2020).

Our broad investigation lays the groundwork for future research, which could extend to a broader and more diverse population sample, including various age groups and backgrounds. Additionally, it would be valuable to study populations with unique sensory experiences, such as individuals on the autism spectrum (Peled-Avron and Woolley, 2022), those experiencing depersonalisation (Adler et al., 2016), or individuals with autonomous sensory meridian response (ASMR: Gillmeister et al., 2022). Exploring these diverse groups could provide deeper insights into the variability of vicarious touch, potentially informing therapeutic strategies for those with atypical sensory responses (Bellard et al., 2022; Haggarty et al., 2021; Lockwood, 2016; Peled-Avron and Woolley, 2022). Profiling individuals based on their vicarious sensory perception may also yield valuable information on how best to support professions where practitioners often deal with others' pain, such as healthcare professionals, thereby optimising care while protecting the well-being of caregivers (Decety and Fotopoulou, 2015; Giummarra et al., 2016).

Conclusion

Our study used the Validated Touch-Video Database (VTD: Smit and Rich, 2023) to explore vicarious touch within a general university population. We found that a large majority of participants reported experiencing localised sensations while observing various types of touch to a hand, with these sensations being reported more frequently by women than by men. There was no correlation between vicarious touch responding and emotional empathy scores, suggesting that the capacity for sensory mirroring may be independent of one's general empathetic disposition. The type of sensation reported, such as tingling, pressure, and pain, often mirrored the physical characteristics of the observed touch, indicating a clear link between the visual stimuli and sensory response. Moreover, the emotional content and hedonic quality of the touch significantly influenced the nature, likelihood, and intensity of vicarious sensations. Videos depicting painful touch elicited the strongest responses, demonstrating that emotionally charged visual touch stimuli play an important role in enhancing sensory responses. These observations underscore the presence of a common capacity for sensory mirroring that extends beyond rare phenomena like mirror-touch synaesthesia.

CRediT authorship contribution statement

Sophie Smit: Conceptualisation, Methodology, Project administration, Data curation, Formal analysis, Visualisation, Writing – original draft, Writing – review & editing. **Matthew J. Crossley:** Conceptualisation, Methodology, Formal analysis, Visualisation, Writing – review & editing. **Regine Zopf:** Conceptualisation, Writing – review & editing, Supervision. **Anina N. Rich:** Conceptualisation, Methodology, Writing – review & editing, Supervision.

Additional information

Authors declare no competing interests.

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