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Vicarious touch: a potential substitute for social touch during touch deprivation

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ABSTRACT

Restricted interpersonal touch experiences, for instance due to COVID-19 social distancing measures, results in detrimental effects on anxiety, loneliness and psychological well-being. Yet, interventions capable of mitigating the impact of social touch deprivation, as experienced during the COVID-19 pandemic, remain insufficient. In this study, conducted during a period of enforced physical distancing and touch deprivation, we investigated whether prosocial, vicarious (i.e. visually seen) touch during interactions involving human-human touch and human- pet touch, compared to human-robot touch, could alleviate self-reported feelings of stress. To this end, 1490 participants completed an online video-viewing task in which they self-reported their stress level before and after viewing video clips depicting prosocial tactile interactions. Human-pet and human-human vicarious touch reduced perceived stress, while human-robot touch increased it. Moreover, the extent of the calming effect provided by vicarious touch depended on individual differences, including participants' anxiety states and personal preferences regarding the perceived pleasantness and awkwardness of the video clips. In particular, individuals experiencing higher levels of anxiety prior to watching interactions exhibited a more pronounced calming response to vicarious human-pet touch. Altogether, these findings underscore the significant role of vicarious touch in a context where somatosensory touch is lacking and warrant the development of further randomised, controlled testing of related interventions for conditions of physical distancing.

Keywords: vicarious touch, anxiety, loneliness, COVID-19, social touch

INTRODUCTION

Social touch is crucial for development and well-being, being one of the most efficient ways to communicate affective emotions (e.g., Bremner & Spence, 2017; Kirsch et al., 2018). Evidence across many fields, ranging from animal studies to developmental and adult psychological and neuroscientific studies in humans, suggests that touch has beneficial effects for both physical and mental health (Harlow & Zimmerman, 1959; Nelson & Panksepp, 1998; Sharp et al., 2012; Maitre et al., 2017). For example, maternal-preterm skin-to-skin contact enhances child physiological regulation, attachment, and cognitive control across long developmental epochs in humans (Feldman et al., 2014). Evidence also suggests that touch by conspecifics has analgesic and stress-alleviating effects (e.g., von Mohr, Kirsch & Fotopoulou, 2017; von Mohr, Krahe, Beck & Fotopoulou, 2018; Korosi & Baram, 2010) mediated by neurobiological pathways involved in social bonding (Nelson & Panksepp, 1998). In particular, human interpersonal touch is suggested as an important stress buffer as it plays a key regulatory function in the body's responses, including cortisol and heart rate responses (Ditzen et al., 2007) and neural responses typically implicated in affective regulation (Coan, 2006). Importantly, some psychological states such as depression were associated with an increased wish to be held (Stein & San Filippo, 1985), while perceived loneliness was reduced in certain contexts by touch in adults (Heatley Tejada et al., 2020).

As such, it is not surprising that touch deprivation beyond the lab can be associated with negative health outcomes, particularly increased distress. For example, a well-known field study conducted in Romania's notorious state-run orphanages found that orphans who were deprived of any physical contact for several years exhibited high distress and severe developmental and behavioural deficits (Nelson et al., 2014). However, such studies typically involve only unfortunate, geographically isolated circumstances that cannot be designed and replicated ethically 'in the wild'. Nevertheless, COVID-19-related restrictions such as social distancing have allowed the systematic study of the extent to which the lack of tactile experiences affects mental health (von Mohr, Kirsch & Fotopoulou, 2021; Meijer et al., 2022). In particular, touch deprivation during the early stages of COVID-19 was associated with people reporting heightened longing for touch and increased perceived pleasantness of observing touch (Meijer et al., 2022), increased anxiety and feelings of loneliness (von Mohr, Kirsch & Fotopoulou, 2021) along with indications of broader mental health concerns (Field et al., 2020). Consequently, measures and practical solutions to mitigate social touch deprivation, and the related anxiety and loneliness, have gained significant attention in both scientific and policy domains.

Research in cognitive social neuroscience suggests that there may be a potential, and easy to implement in everyday life, solution to touch deprivation. This potential solution is based on the scientific observation that overlapping brain areas are involved in processing sensory and affective states in both the self and other people (Keysers et al., 2004; Morrisson et al., 2011). For example, functional neuroimaging studies have revealed that similar brain areas are activated when observing others experiencing pain and when perceiving pain on one's

own body (e.g. Lamm, Decety & Singer, 2011). The theoretical origins of these observations lie in the Simulation Theory as developed in cognitive science and philosophy of mind (Gallese, 2003; Gallese and Goldman 1998; Goldman, 2006). This theory posits that we use our own mental states to simulate how we might feel in a given situation, and hence to understand other minds. Accordingly, the basic tenet of this shared networks account is that perceiving someone else's sensory and affective state activates neural representations coding for this state when we experience it ourselves. While this overlap is not complete (see Lamm & Singer, 2010 for review) and ongoing debates exist regarding the precise mechanisms and implications of such self-other processing overlap (Heyes & Catmur, 2021; Lamm & Majdandžić, 2015), there is agreement that this overlap encompass not only unpleasant or negative states but also pleasant or positive sensory and affective states, including the experience of pleasant affective touch.

Additionally, a series of neuroimaging studies have found that somatosensory evoked potentials (SEPs) are modulated not only by the direct experience but also by the observation of touch (also referred to as vicarious touch; Bufalari et al., 2007; Pisoni et al. 2018; Rigato et al. 2019). Critically, touch perception and observation shared an effective connectivity network in the beta band, typically associated with unconscious tactile processing, and vicarious touch from full-body social interactions entails shared sensorimotor as well as socio-affective experiences (Schirmer & McGlone, 2019). Moreover, given that vicarious and pleasant touch may activate similar brain regions, as well as elicit similar emotional experiences, including feelings of pleasantness (as long as it is wanted), it is believed that vicarious touch may have similar benefits to actually experiencing touch (e.g., Morrison et al., 2011; even in clinical populations such as autism, see Haggarty et al., 2021). However, to the best of our knowledge, no study to date has investigated how different types of vicarious touch can counter the negative health outcomes, such as anxiety and loneliness, especially associated with physical distancing.

The neuroscientific findings above offer an interesting translational possibility during times of touch deprivation, namely the possibility to use vicarious touch via observation to potentially buffer stress. First, using vicarious human-human touch might be beneficial, considering the analgesic and stress-buffering effects of humans' tactile interactions (as discussed above; von Mohr, Kirsch & Fotopoulou, 2017; Korosi & Baram, 2010; Ditzen et al., 2007; Morrison, 2016). However, even though the effects of human-human touch are typically beneficial, there can be contrary findings as the meaning of touch and individual preferences regarding social touch can have important effects on perception (e.g. Sailer & Ackerley, 2019; Croy et al., 2021). An alternative to vicarious touch between humans that may buffer stress is observing human-pet touch interactions, as different to tactile interactions between humans, pets are considered as less evaluative than humans. Indeed, human-pet interactions have been shown to promote health and well-being, providing comfort and relaxation (Young, Pritchard, Nottle, & Banwell, 2020) as well as stress reduction (Charry-Sanchez et al., 2018). Furthermore, animal-assisted therapy has demonstrated positive effects on human health across various conditions and patients, including dementia, depression and post-traumatic

stress disorder, although there is still debate about the exact underlying mechanism (see Eckstein et al., 2020 for a review). Thus, to investigate whether the beneficial, subjective effects of prosocial touch previously observed in humans (e.g. Maitre et al. 2017) and in other mammals (e.g. Young, Pritchard, Nottle, & Banwell, 2020) also applies to vicarious touch, we examined the effects of observing videos of human-human and human-pet touch. These were compared with a non-social touch condition involving touching robots, which we call human-robot touch hereafter. Whereas a few but not all previous studies on human-robot touch have found that touching robots and artificial devices can attenuate markers of stress and loneliness and more generally improve mental health outcomes (e.g., Robinson et al., 2015; Sefidgar et al., 2015; see Eckstein et al 2020 for a review), we reasoned that while all vicarious touch would have calming effects, the effects of human-human and human-pet touch would be greater than those of human-robot touch given the attachment, or social bonding mechanisms, involved between humans and between humans and pets, that should be absent or at least reduced in the case of robots. As such, the aim of the present study was to investigate whether observing tactile interactions involving human-human or human-pet touch in comparison to observing human-robot touch, could calm participants, in order to explore potential strategies for reducing the stress lack of social touch, as observed during the COVID-19 pandemic. Indeed, as reported elsewhere (von Mohr et al., 2021), this study took place at early stages of the pandemic and participants were found to experience touch deprivation.

To this aim, we conducted an online intervention study where participants were required to watch video clips picturing tactile interactions involving humans, pets and robots in different conditions. Before watching any video clip and after each video clip, participants were asked to rate how they felt on a 0 to 100 VAS scale (ranging from 0 very calm to 100 very stressed). Given the stress-buffering effects of touching pets or other humans (see Ditzen et al., 2007; Morrison, 2016, Charry-Sanchez et al., 2018 for reviews) we expected that watching vicarious touch would have a calming effect, particularly in social contexts such as human-human and human-pet interactions, when compared to human-robot interactions. After watching each video clip, we also asked participants to rate on a VAS how pleasant and awkward they perceived the video clip itself to capture related individual preferences and their potentially moderating effects on soothing stress. We expected that a higher level of pleasantness would lead to a stronger calming effect, while an increased level of awkwardness would result in a weaker calming effect. Third, participants completed the STAI-SF (Marteau & Bekker, 1992) to assess their level of anxiety, and the UCLA-Loneliness scale (Hughes et al., 2004), to assess their level of loneliness before the intervention. We hypothesised that the potential calming effect of watching these types of socio-tactile interactions would be moderated by interindividual states, such as loneliness and anxiety. For example, one would expect that the higher the loneliness or anxiety, then the more powerful the effects of vicarious touch. Notably, studies have shown that substitutes for human touch (such as petting animals) can reduce loneliness and stress in people lacking social support (Applebaum et al., 2021; Ratschen et al., 2020). Finally, to further statistically confirm that the intervention

would have more effect in anxious individuals as defined by a clinical cut-off, we conducted an exploratory and proof of concept analysis, in a selected proportion of our sample based on pre-intervention STAI scores criteria to create and compare between two groups i.e. non-anxious (STAI<38; N=550) and anxious groups (STAI>45; N=688). We expected the intervention to have a greater impact in the anxious group than the non-anxious group. Overall, the present study represents an initial step in determining whether vicarious touch has a calming effect and an even greater soothing impact on participants with higher anxiety.

METHODS

Participants

1746 participants were recruited online as part of a larger study on touch during COVID-19-related social restrictions (see also: von Mohr, Kirsch & Fotopoulou, 2021 and for more details in SM). 746 participants were recruited via social media and 1000 were recruited via Prolific (<https://prolific.ac/>) during the high social restrictions period between the 21/04/2020 and the 13/05/2020 (i.e. first lockdown severe restrictions). Out of the 1746 participants, 256 reported having been diagnosed in the past/present with a psychiatric disorder and were thus removed from data analyses, resulting in a final sample size of 1490 participants (949 female, 539 male, 2 other; $M_{\text{age}} = 37.08$, $SD_{\text{age}} = 14.30$). All participants gave formal consent and the research was conducted in accordance with the Declaration of Helsinki (except for pre-registration) and was approved by the Ethics Committee of the Research Department of Clinical, Educational and Health Psychology, University College London.

Procedure

After consenting to take part in the study, participants completed self-reports regarding their degree of social isolation and the amount of touch they had experienced and desired during COVID-19 (for details see von Mohr et al., 2021) as part of a broader investigation. Next, participants completed the short version of the State-Trait Anxiety Inventory (STAI-SF; Marteau & Bekker, 1992) to assess their anxiety state level prior to the intervention. Participants also rated their level of 'calmness' at that moment, using a 0 = "calm" to 100 = "stressed" VAS scale, in order to establish a baseline for their calmness/stressed level prior to the main task.

During the main task, participants watched three pre-recorded video clips depicting (i) human-human tactile interaction, (ii) human-pet tactile interaction, and (iii) human-robot tactile interaction, in a randomised order. After each video clip, participants were asked to rate once again their current level of 'calmness' and to respond to a series of questions regarding their experience with that particular video clip (i.e. perceived pleasantness and awkwardness).

Finally, participants retook the short version of the STAI-state (STAI-SF; Marteau & Bekker, 1992) and completed demographic questions (age, country of residence, nationality,

psychiatric history and health). The STAI-SF collected after the intervention was not a primary outcome measure and was only used to examine the general effects of vicarious touch on anxiety (details can be found in Supplementary Results). Detailed description of the measures of interest are provided below.

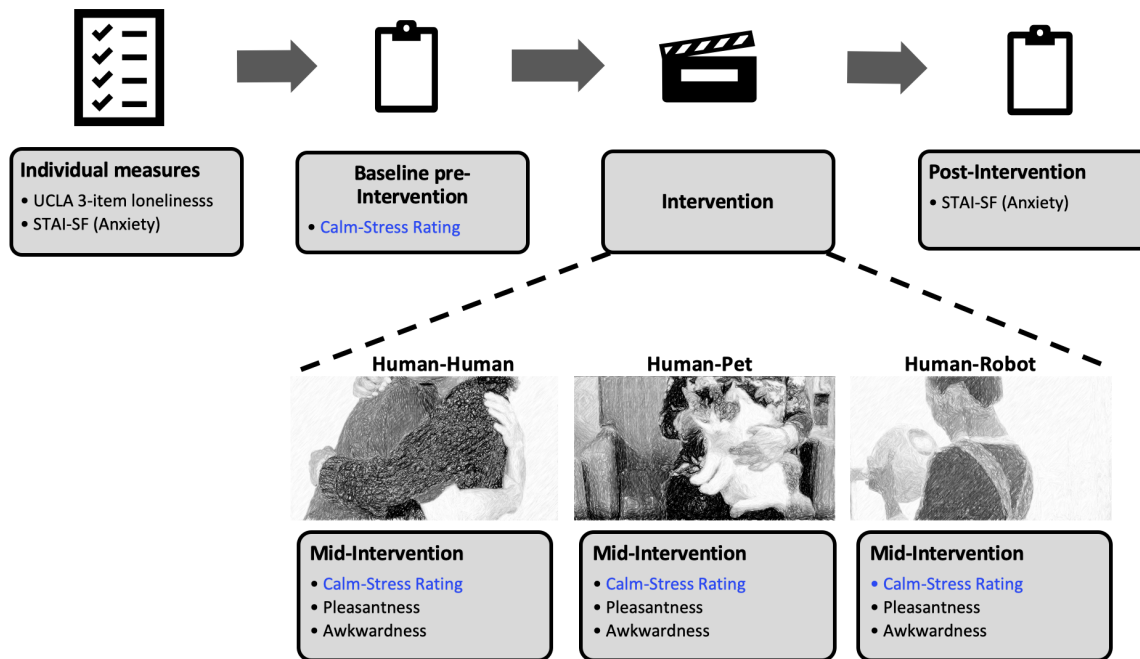


Figure 1. Experimental Procedure with main measures. Participants first filled baseline questionnaires (STAI-SF and UCLA 3-item loneliness scale; see Procedure section), and rated how they felt (calm-stress) before watching 3 video clips that were presented in randomised order. After each video clip, participants rated their level of calm-stress, as well as rated the video clip they just watched (pleasantness and awkwardness). Note video clips were shown in full colour, and presented here as still sketches. STAI-SF was also collected after the intervention, but this was only used for supplementary analyses looking at the general effects of vicarious touch on anxiety.

Video clip stimuli

In the vicarious touch part, participants were presented with three video clips in a randomised order, each consisting of brief, edited scenes of tactile interactions between either two humans, one human and one pet, or one human and one robotic device (see examples in Figure 2). All video clips had a duration of 21 secs each, filmed and shown in colour, contained 10-12 individuals, and had 3 main types of tactile interaction (hugs, stroke, arm holding), with a combination of equal quantity of whole body and body-part interactions in each condition. They were all filmed in indoor settings, with balanced gender, age and ethnicity of actors in each video clip.

Primary outcome measure: Calmness

Participants rated how they felt *'right now'*, using a 0 = "calm" to 100 = "stressed" VAS scale prior to all video clips as well as after each video clip. We named this rating "calmness rating" hereafter. This allowed us to compute an index of the calming effect for each video clip condition, as the difference between 'Feeling Calm' before and 'Feeling Calm' after the video,

with positive scores denoting a calming effect. We did not take a global post-intervention calmness rating as we wanted to assess the effects of each of the components of the intervention.

Interindividual psychological states

Anxiety

To assess anxiety, we employed the validated six-item short-form of the state scale of the State-Trait Anxiety Inventory (STAI-SF; Marteau & Bekker, 1992). This scale consists of six items rated on a 4-point scale (1= not at all and 4=very much). Items were summed (after reverse-scoring appropriate items) and multiplied by 20/6, yielding an anxiety score on the same scale as the original version from 20 to 80 with higher score indicating higher anxiety levels. The STAI-SF is well-validated and displays strong internal consistency (Cronbach's $\alpha = 0.84$). Participants with STAI scores below 38 were categorised as having no or low anxiety, while those with STAI score above 45 were categorised as having high anxiety (Spielberger, 1983; Marteau & Bekker, 1992). Anxiety levels were measured at baseline prior to watching the videos, as well as after watching all videos, used to examine the general effects of vicarious touch on anxiety (see Supplementary Results i. for details).

Loneliness

To examine feelings of loneliness, we used the validated, UCLA 3-item loneliness scale (Hughes et al., 2004); ('How often do you feel that you lack companionship?', 'How often do you feel left out?', 'How often do you feel isolated from others?') as a measure of loneliness, as well as a single question asking 'How often do you feel lonely?', as recommended by the office for national statistics (2018). Items were rated on a 4-point (0=Never and 3=Often) and a 5-point scale (1=Never and 5=Often/Always), respectively. A summed score was computed for our measure of loneliness based on the three UCLA items, and demonstrated good internal consistency with the single question measure of loneliness, Cronbach's $\alpha = 0.79$. Thus, we averaged these loneliness scores to produce an index of loneliness for each participant, as advised by the NIH guidelines and the office for national statistics (2018), with higher scores denoting higher perceived loneliness. On average, the loneliness score was $M=3.61$ ($SD=1.62$).

Interindividual preference: pleasantness and awkwardness ratings of the videos

Right after each vicarious touch video clip, in order to measure interindividual preferences, participants were required to answer the following questions on a 0 = "Not at all" to 100 = "Extremely" VAS scale: "How pleasant was it to watch this video?", and "Did it feel awkward to watch this video?".

Data analyses

All analyses were carried out in RStudio. Given the big sample, we opted for a conservative approach of $p < .01$ rather than the conventional $p < .05$ to denote statistical significance, and included effect sizes to interpret our results. When sphericity was violated, Greenhouse-Geisser correction was used where appropriate. Continuous variables were mean-centred in order to avoid multi-collinearity issues. Moreover, using the *carr::vif* R package, variance inflation scores (VIF) were calculated for each independent variable to make sure that there were in fact no multi-collinearity issues in our regression/mixed models. VIF scores above 5 indicate that there is a problematic amount of collinearity (Hastie et al., 2006; James, Witten & Hastie, 2019). Marginal R^2 as well as conditional R^2 were computed for the multi-level regressions using the *tab_model* function of the R package *sjPlot*. The marginal R^2 considers only the variance of the fixed effects, while the conditional R^2 takes both the fixed and random effects into account. Estimated marginal means and standard errors are reported when appropriate.

Details on each analysis conducted are presented with the corresponding hypotheses below.

Main analyses

(i) Vicarious Touch Experience and effects on calmness ratings. First, in order to characterise the effects of vicarious touch on feelings of calmness, we conducted a repeated measure ANOVA on calmness ratings, specifying within-subjects factor of time (pre, post) and video clip type (human-human, human-pet, human-robot). In particular, we expected that watching vicarious touch (i.e., all video clips in general) would have a calming effect and particularly when observing social living beings, such as human-human and human-pet interactions, in comparison to human-robot interactions. To compare further the calming effect between video clips types, we conducted posthoc comparisons on the calmness ratings for each video type condition.

(ii) Interindividual preferences for the video clips moderating the calming effect of vicarious touch. To examine whether interindividual preferences for the video clips, such as pleasantness and awkwardness, moderated feelings of 'calmness', we specified a multi-level regression model with the difference score of calmness ratings (pre minus post) as the outcome variable, type of video clip (human-human, human-pet, human-robot; with human-robot entered as the base level) as a categorical predictor, and perceived awkwardness and pleasantness, as continuous predictors. We included all interaction terms. Pleasantness and Awkwardness variables were mean-centred in order to avoid multi-collinearity issues. VIF scores were computed in order to check for potential severe multicollinearity, but all VIF were below 3. Random effects were included to account for the repeated assessment of the outcome variable within individuals, as well as the order of presentation of the video clips (that were randomised across participants). In particular, we expected that the higher the pleasantness, the higher the calming effect, with the reverse pattern for awkwardness.

(iii) Interindividual states moderating the calming effect of vicarious touch. To examine whether the potential calming effect of watching these types of socio-tactile interactions was moderated by interindividual states, such as loneliness and anxiety, we specified a multi-level regression model with the difference score of calmness ratings (pre minus post) as the outcome variable, type of video clip (human-human, human-pet, human-robot) as a categorical predictor, and self-reported loneliness and anxiety, as continuous predictors. Human-robot was the base level. VIF scores were computed in order to check for potential severe multicollinearity, but all VIF were below 3. Random effects were included to account for the repeated assessment of the outcome variable within individuals, as well as the order of presentation of the video clips (that were randomised across participants). We expected that the higher the anxiety or loneliness, the higher the calming effect.

(iv) Exploratory and proof of concept analyses on cut-off clinical anxiety. As an exploratory and proof of concept, we sampled our participants based on the pre-intervention STAI-SF scores to obtain two groups: non-anxious (with STAI score < 38; N=550) and anxious participants (STAI score > 45; N=688). These cut-offs are based on the fact that STAI scores are commonly classified as “no or low anxiety” (20-37), “moderate anxiety” (38-44), and “high anxiety” (45-80) (Spielberger, 1968). To investigate whether vicarious touch soothes even more participants with high anxiety compared to people with no or low anxiety state levels, a multilevel regression model was specified with calming effect (feeling pre minus post) as the outcome variable, type of video clips (with robot as base level), and STAI Group, and their interactions as prediction variables. Random effects were included to account for the repeated assessment of the outcome variable within individuals, as well as the order of presentation of the video clips.

Additional analyses

In addition to the main analyses, we conducted complementary analyses that we present in the Supplementary Materials to not disrupt the main message and the reader, however we discuss them briefly in the discussion, as they strengthen the results.

(i) Analysis on the buffering effect of vicarious touch in general. In order to show that overall, watching tactile interactions (vicarious touch) can reduce anxiety, as measured by a standardised questionnaire (STAI-SF), we conducted a linear mixed model to compare anxiety state before and after watching all videos, while controlling for video order. Acknowledging the limitation it implies (time effect), we do not draw strong conclusions on this analysis.

(ii) Exploratory analysis in relation to the lack of touch participants were experiencing. In order to explore whether vicarious touch could calm participants the more people are lacking social touch (measured as the average difference between the amount of social touch participant were getting in the past week and the amount of social touch participant wished to have experienced in the past week, see details in von Mohr, Kirsch & Fotopoulou, 2021), we specified a multi-level regression model with the calming scores as the outcome variable, type of video clip (human-human, human-pet, human-robot) as a categorical predictor

(human-robot as base level), and average self-reported lack of touch as a continuous predictor.

(iii) Interindividual preferences for each video clip type. In order to investigate whether the video clips were rated differently in pleasantness and awkwardness, one-way repeated measures ANOVA were conducted separately on each measure.

RESULTS

Vicarious Touch Experience and effects on calmness ratings.

By conducting a repeated measure ANOVA on feelings of calmness, we observe a main effect of Time ($F(1,1489)=180.335$, $p<0.001$, $\eta_p^2=0.108$), a main effect of video clip type ($F(2,2978)=77.397$, $p<0.001$, $\eta_p^2=0.049$), and an interaction between time and the type of video ($F(1.958,2915.421)=155.048$, $p<0.001$, $\eta_p^2=0.094$). This suggests that each video clip type had a different effect on the calming ratings. Indeed, following-up this interaction, we observed that participants felt less calm after the video clip of human-robot interactions than before ($t(1489)=-7.05$, $p<0.001$, $CI(-4.19,-2.36)$, $d=-.183$), with small effect; while participants felt more calm after watching human-pet interactions ($t(1489)=20.98$, $p<0.001$, $CI(8.28,9.98)$, $d=.544$), with moderate effect, and more calm after watching human-human interactions ($t(1489)=2.97$, $p=0.003$, $CI(0.45,2.19)$, $d=.08$), with negligible effect. See Figure 2.

To further compared the effect of video type on the calming effect (difference ratings pre-post), posthoc comparisons showed that human-pet vicarious touch had a greater calming effect than human-human ($t(1489)=10.966$, $p<0.001$, $CI(6.105, 9.518)$, $d=.452$), with moderate effect, and human-robot ($t(1489)=17.415$, $p<0.001$, $CI(10.7, 14.112)$, $d=.717$), with strong effect. Moreover, human-human vicarious touch was significantly more calming than watching human-robot interactions ($t(1489)=6.450$, $p<0.001$, $CI(2.88,6.301)$, $d=.266$), with a small effect.

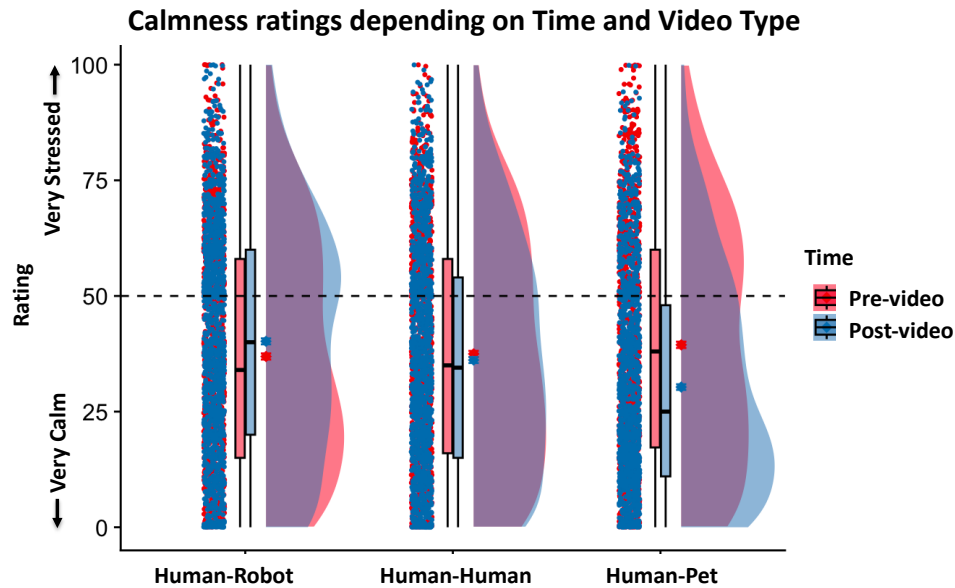


Figure 2. Calmness rating before and after each video clip type. Participants rated how they felt right now on a scale from 0=Very calm to 100=Very stressed. Jittered dots represent ratings for each individual participant. Boxplot presents the central tendency. The half violin provides data distribution. Diamond represents the mean for each bias, and the error bars denote the standard error of the mean.

Interindividual preference ratings of the video clips moderating the calming effect of vicarious touch.

In this model, when taking into account interindividual preference ratings of the video clips, the type of video clip predicted the calming effect (as computed by the difference between feeling ratings before and after each video clip): watching human-pet interactions ($M=5.31$, $SE=1.65$) had a stronger calming effect than human-robot interactions ($M= 1.53$, $SE=1.63$; $\beta=3.78$, $CI(2.24-5.32)$, $p<0.001$), whereas there was no significant difference in the calming effect between human-human interactions ($M=1.04$, $SE=1.60$) and human-robot interactions in this model ($\beta=-0.49$, $CI(-1.83,0.84)$, $p=.468$; see Supplementary Table 1 for details). Moreover, as shown in Figure 3, we observe a main effect of awkwardness, suggesting that the more awkward the video clips were rated, the less calming the effect ($\beta=-0.10$, $CI(-0.12,-0.07)$, $p<0.001$). In contrast, a main effect of pleasantness was found suggesting that the more pleasant the video clips were rated, the more calming the effect ($\beta=0.16$, $CI(0.13,0.19)$, $p<0.001$ - see Supplementary Table 1 for details). Interestingly, we also found that relative to human-robot*awkward, there was a significant interaction between human-pet*awkward ($\beta=0.08$, $CI(0.02,0.13)$, $p=.004$), in that awkwardness has less impact on the calming effect of the human-pet video clip than for the human-robot video clip; but the impact of pleasantness ratings did not significantly differ depending on the type of video clips (human human: $\beta=-0.02$, $CI(-0.07 - 0.02)$, $p=.329$; human-pet: $\beta=0.03$, $CI(-0.02 - 0.09)$, $p=.206$). Note that the effect size for the full model is medium: marginal $R^2 = 0.182$ and conditional $R^2 = 0.209$. VIF scores were all below 1.76.

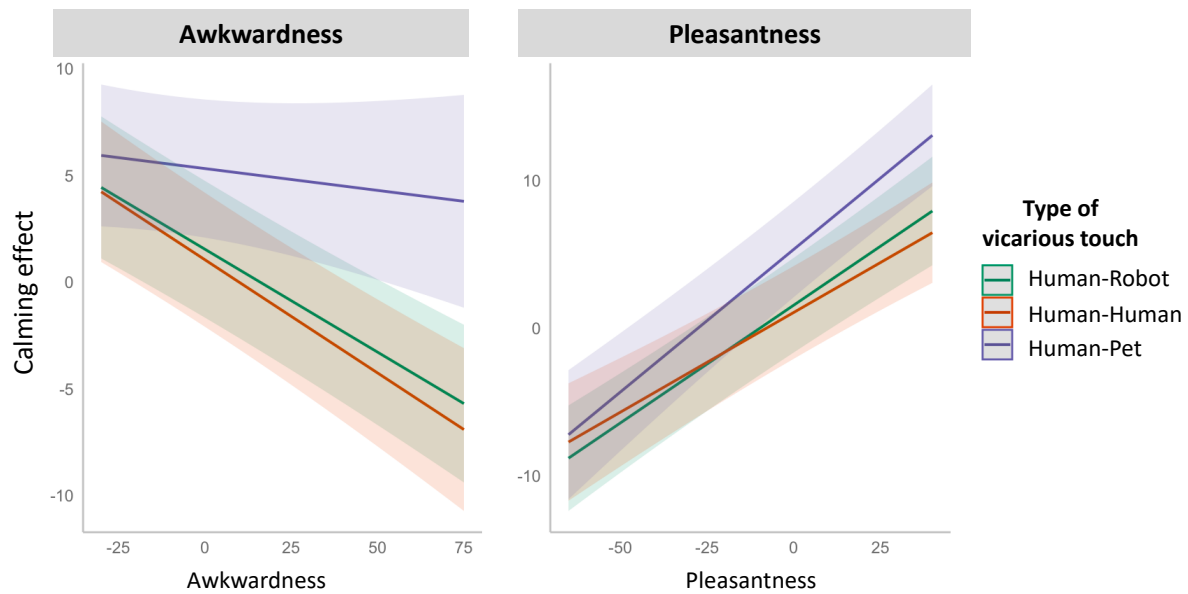


Figure 3. Interindividual preference (Pleasantness and Awkwardness) moderating the calming effect of vicarious touch. Calming effects on the y-axis are calculated as the difference between the feeling ratings before and after each video, for each type of video clip. Higher scores on the y-axis denote higher calming effects (feeling calmer after than before the video). The x-axis reflects Awkwardness (left panel) and Pleasantness (right panel) ratings mean-centred with shaded areas depicting confidence intervals.

Interindividual states moderating the calming effect of vicarious touch.

In this model, when taking into account loneliness and anxiety state levels, the type of video clip predicted the calming effect: watching human-pet interactions ($M=9.12$, $SE=1.73$; $\beta=12.49$, $CI(11.27,13.70)$, $p<0.001$) and human-human interactions ($M= 1.30$, $SE=1.73$; $\beta=4.66$, $CI(3.45,5.88)$, $p<0.001$) had a more calming effect than watching human-robot interactions ($M=-3.37$, $SE=1.73$; see Supplementary Table 2 for details). We also found a main effect of anxiety (as measured by the STAI-SF at baseline; $\beta=0.10$, $CI(0.03,0.17)$, $p=0.007$), suggesting that the more the people were anxious at baseline, the greater the calming effect of watching the video clips, regardless of the type of video clip. However, there was an interaction between type of video clip and anxiety, suggesting that the higher the anxiety, the more the calming effect of human-pet vicarious touch ($\beta=0.19$, $CI(0.09,0.29)$, $p<0.001$) but not human-human ($\beta=0.06$, $CI(-0.04,0.16)$, $p=.271$), as compared to human-robot (see Figure 4). Contrary to our hypothesis, however, there was no significant effect of loneliness, when included in the same model ($\beta=-0.13$, $CI(-0.72,0.46)$, $p=0.670$; see Supplementary Table 2 for details). Note that the effect size for the full model is small to medium: marginal $R^2 = 0.104$ and conditional $R^2 = 0.136$. VIF scores were all below 1.3.

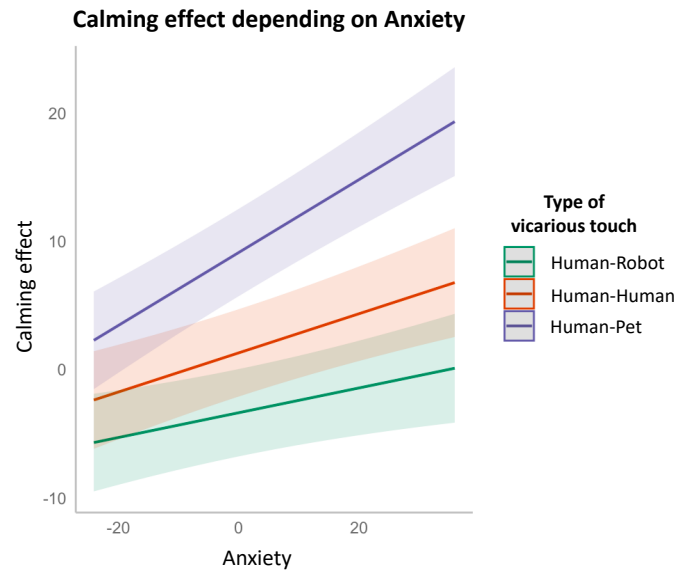


Figure 4. Anxiety State (STAI-SF) moderating the calming effect of vicarious touch. Calming effects on the y-axis are calculated as the difference between the feeling ratings before and after each video clip, for each type of video clip. Higher scores on the y-axis denote higher calming effects (feeling calmer after than before the video). The x-axis reflects the mean-centred Anxiety scores (as measured by the STAI-SF questionnaire, before any vicarious touch) with shaded areas depicting confidence intervals.

Exploratory and proof of concept analyses on cut-off clinical anxiety.

As before, in this model, the type of video clip predicted calmness ratings: human-pet ($M=9.12$, $SE= 1.73$; $\beta=9.05$, $CI(7.06,11.03)$, $p<0.001$) and human-human ($M= 1.30$, $SE= 1.73$; $\beta=4.73$, $CI(2.74,6.71)$, $p<0.001$) had a more calming effect than human-robot ($M=-3.37$, $SE=1.73$; see Supplementary Table 3 for details). Supporting our predictions, we observe a more calming effect in the Anxious group ($M=4.59$, $SE=1.78$; $\beta=2.88$, $CI(1.00-4.77)$, $p=.003$) than in the non-anxious group ($M=0$, $SE= 1.79$); with a specific interaction for the pet-human interaction in comparison to the robot-human interaction in anxious participants ($\beta=5.54$, $CI(2.88-8.20)$, $p<0.001$); not present for human-human interaction ($\beta=-0.41$, $CI(-3.07,2.25)$, $p=0.762$); suggesting that the calming effect was even more present for the human-pet interaction in the anxious group (as shown in Figure 5). Note that the effect size for the full model is small to medium: marginal $R^2 = 0.100$ and conditional $R^2 = 0.133$. VIF scores were all below 1.

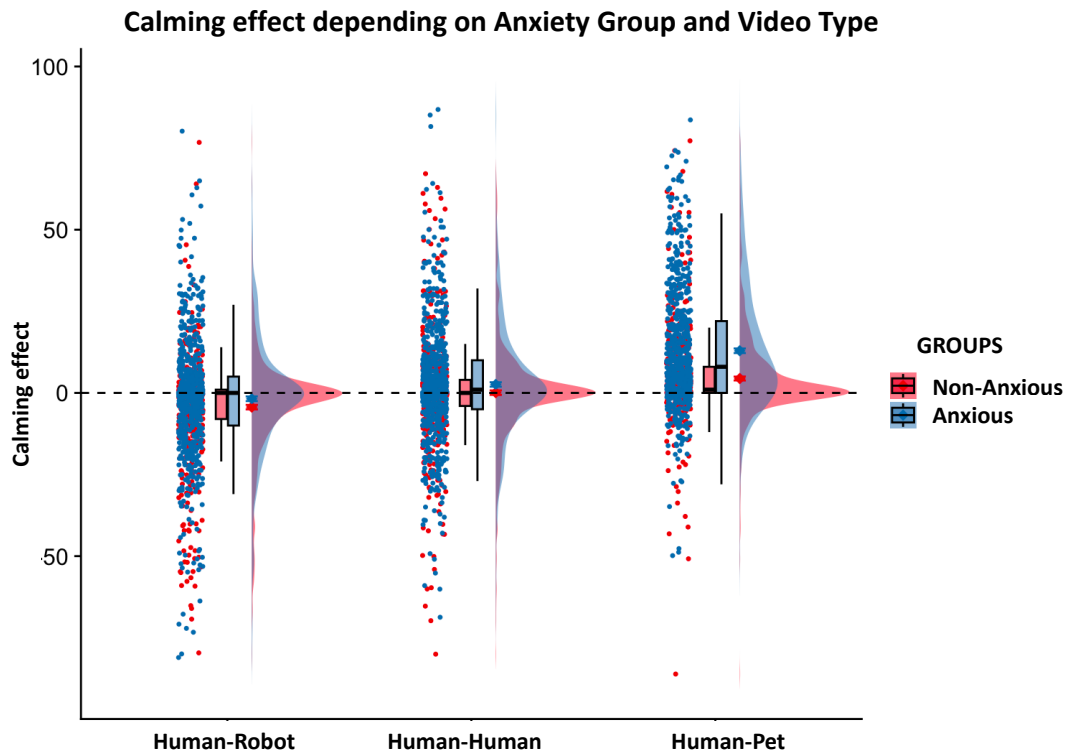


Figure 5. Calming effects depending on STAI groups (Anxious vs non-Anxious) and type of Vicarious Touch. Higher scores on the y-axis denote higher calming effects (feeling calmer after than before the video). Jittered dots represent calming effects for each individual participant. Boxplot presents the central tendency. The half violin provides data distribution. Diamond represents the mean for each bias, and the error bars denote the standard error of the mean.

DISCUSSION

Social touch deprivation is known to profoundly impact one's psychological states (Nelson et al., 2014). We have previously demonstrated that touch deprivation experienced during periods of COVID-19 enforced social isolation had a direct impact on touch deprivation and longing for touch, increasing feelings of anxiety and loneliness (von Mohr, Kirsch & Fotopoulou, 2021; see also Meijer et al., 2022). Thus, there is a need to find ways to compensate for the negative impact of lack of social touch, in any situation involving social isolation. Here we examined how different types of vicarious touch (i.e. observing prosocial touch interactions in brief video clips) can counter negative health outcomes, such as anxiety and loneliness, as experienced during touch deprivation in the COVID-19 pandemic. On average, the human-human and human-pet clips, but not the human-robot, were perceived as pleasant and while they were all skewed towards being perceived as not awkward, the one perceived as most awkward was the human-robot clip (see Supplementary Results iii and Supplementary Figure 3). With respect to their calming effects, first, we found that individuals reported feeling the calmest after watching the human-pet and human-human vicarious touch, while observing human-robot touch had negative effects on perceived stress). Second,

we found that such effects were moderated by individual ratings of perceived awkwardness and pleasantness of each video clip, in that the more pleasant the clip was rated, the more the calming effect, regardless of the video type. In contrast, the more awkward the video clips were rated, the less calming the effect, but less so for the human-pet video clip in comparison to the human-robot interaction. Third, we found that the calming effect of vicarious touch depended on people's level of anxiety but not loneliness. Finally, our exploratory analysis revealed a more pronounced calming effect of vicarious touch within the anxious group compared to the non-anxious group. We discuss these findings in detail below.

Our first finding suggests people felt calmer after watching the human-pet and human-human interactions, while they felt more stressed after watching human-robot interactions. The magnitude of these effects was moderate ($d=.54$), negligible ($d=.08$) and small ($d=.18$), respectively. This finding provides evidence about the beneficial effect of vicarious social vs. non-social interactions and is consistent with previous studies showing that actual physical touch reduces negative feelings, such as social exclusion (von Mohr, Kirsch & Fotopoulou, 2017), as well as with more recent findings suggesting that observing someone being touched on the forearm is perceived as pleasant, especially for individuals who longed for touch during the initial COVID-19 lockdown (Meijer et al., 2022). Here, we extend this line of research by showing that, similar to real, actual physical touch, watching tactile interactions of both humans touching or humans touching pets can alleviate negative feelings, such as feelings of stress during a forced physical distancing period that involved social touch deprivation. As suggested elsewhere (e.g., Morrison et al., 2011), vicarious touch may offer similar benefits to actually experiencing touch, with this process leading to the activation of brain regions crucial for the integration of sensory salient experiences, such as the insula. While this a plausible explanation, it may also be that people did not like robots, as evidenced by this clip being rated as the least pleasant and more awkward (see Supplementary Results iii). However, that also means that people were not showing social desirability and they rated their calmness as going both up and down.

In addition, the difference in perceived calmness between before and after was significantly more pronounced for human-pet interactions relative to human-human interactions, and to human-robot interactions, with a moderate and large effect, respectively ($d=.45$, $d=.72$). This suggests that the effects of vicarious human-pet touch were had more effect than those of vicarious human-human touch. This is important as studies have demonstrated that interacting with pets promotes health and well-being by fostering comfort and relaxation (Young, Pritchard, Nottle, & Banwell, 2020) as well as stress reduction (Charry-Sanchez et al., 2018). These previous findings could explain why the effects of vicarious human-pet touch were so powerful in the present study. Indeed, during the COVID-19 pandemic, there was an unprecedented increase in adoption of cats and dogs, resulting in reports of emptied animal shelters (Young et al., 2020) and overwhelmed breeders, with demand for new puppies being four times greater (Pesce, 2020; Thomas, 2020). Moreover, a recent large survey on pet-owning older adults in the US suggested that pets may fulfil some social and emotional needs for older adults during this particularly isolating event. Despite reporting less social support,

older adults with pets reported feeling less lonely than their younger counterparts (Applebaum et al., 2021). This qualitative study is in line with a previous survey in the UK, which demonstrated that owning a pet, compared to non-owners, was associated with smaller decreases in mental health and smaller increases in loneliness since the lockdown (Ratschen et al., 2020). Our study is not a randomised controlled trial (RCT) that could offer definite proof of efficacy for a pet-based, vicarious touch intervention, but it does offer mechanistic insights that can be further tested in future RCTs on vicarious touch. Indeed, it is worthwhile noticing that further exploratory analysis suggests a greater calming effect of vicarious human-pet tactile interactions among participants who were more deprived of social touch (see Supplementary Figure 2 and Supplementary Table 4). This finding substantiates the beneficial effect of vicarious human-pet touch for those who are lacking social touch.

Interestingly, we also observed the reverse pattern for human-robot touch. Specifically, we found that people felt less calm after watching the video depicting human-robot interactions compared to before (with a small magnitude of effect, $d=.18$). This outcome could be explained by the fact that people may not be accustomed to touching robots in their daily lives. In fact, touching robots might not be perceived as calming (Eckstein et al., 2020), possibly because robots are not “alive” and, at least until now, cannot feel “pleasantness” upon being touched. Previous lab-based studies have shown that the reciprocity of socio-affective touch is important for humans (Gentsch et al., 2015; Maister et al., 2020). Given that touching robots is (not yet) a common practice, individuals may feel awkward when observing this particular video, with our data suggesting this may well be the case (see Supplementary Materials).

In support of this notion, and in line with our second hypothesis, we found that the calming effect of vicarious touch was moderated by individual ratings of perceived awkwardness and pleasantness for each video, the magnitude of this effect being moderate ($\text{cond}R^2 = 0.209$), indicating that the regression model fits the observed data, explaining 21% of the variance. Specifically, the greater the perceived awkwardness of the video, the less calming its effect. In contrast, the more pleasant the video clips were rated, the more calming the effect. Interestingly, our findings also revealed that while perceived awkwardness of the video had little impact on the calming effect of the human-pet video, it had a more pronounced effect for the human-robot video. This suggests that interindividual preferences have an impact on the effect of the intervention, and that future studies should make sure to take this point into account.

Turning now to our third hypothesis, we found that anxiety, but not loneliness, moderated the calming effect of vicarious touch, with the model explaining 14% of the variance ($\text{cond}R^2 = 0.136$). Specifically, the higher the anxiety, the stronger the calming effects following vicarious touch. This finding is in line with previous studies showing that actual, social touch attenuates levels of anxiety in primates (Jablonski, 2021; Morrison, 2016). In humans, social touch reduces negative feelings, such as social touch reduces negative feelings, such as social exclusion (von Mohr et al., 2017). Here we extend this line of research by showing that, similar to real, actual touch, watching tactile interactions reduces stress, regardless of the source (i.e.,

pets, humans or robots) and suggests that vicarious touch may provide similar benefits as actually experiencing touch, depending on the initial level of anxiety participants had.

Critically, we also found that the moderating effect of anxiety on the calming effect further depended on the specific type of vicarious touch, with a model explaining 13% of the variance ($\text{cond}R^2 = 0.133$). Specifically, the higher the anxiety of an individual, the greater the calming effect after observing tactile human-human interactions and human-pet interactions in comparison to human-robot interactions. While previous research has demonstrated the beneficial effects of interacting with pets, including animal-assisted therapy, which has been found to improve human health (see Eckstein et al., 2020 for a review), as well as the fact that tactile interactions between humans may work as a stress buffer (Morrison, 2016; Fotopoulou, von Mohr, Krahe, 2021), our study reveals that such beneficial effects may also emerge from merely observing human-pet and human-human interactions. Future studies are warranted to investigate the extent to which the calming benefits of vicarious and real, actual physical touch are genuinely comparable.

Next, we explored as a proof of concept that vicarious touch could be especially useful in reducing stress among individuals with high anxiety, approaching clinical cut-off levels. Indeed, as suggested by the results described above, the more anxious people were, the greater the calming effect of vicarious human-pet touch interaction. To delve further into this aspect, we selected participants who had scored below a cut-off indicating no or little anxiety, as well as those who scored above the cut-off indicating high anxiety (commonly used to define probable clinical levels of anxiety), and we repeated our analyses. As expected, we found a more pronounced calming effect in the Anxious group than in the non-anxious group. This finding implies that the calming effect of vicarious touch is more potent in individuals with high anxiety and constitutes the first-step towards developing potential interventions for touch-deprived individuals with anxiety.

Limitations

Some limitations need to be acknowledged. First, our VAS measure to examine the calming effect of each video is not a validated measure, so our findings must be taken with caution. We did use the validated STAI-SF before and after the video intervention to examine the effect of vicarious touch regardless of the type of video clip, although as expected when using this validated measure, we did find generally reduced anxiety levels following the vicarious touch intervention, as a whole, compared to before (see Supplementary Results i). However, we could not use this measure to test the effects of each video as it would make the online study too long and less feasible. Second, this study was conducted online, providing the advantage of targeting a larger pool of participants, particularly in a context where universities and all non-essentials places were closed. This unique opportunity allowed us to test the effect of physical distancing in an ecological environment. However, this, in turn, prevented us from ensuring that participants were indeed focusing on the videos. Given this limitation, future studies should investigate these effects in more controlled settings, perhaps as part of an RCT with an additional control intervention. Third, one might consider that presenting all

conditions to the same participants could potentially result in carry-over effects, leading to pet-human vicarious touch being reported as the most calming. However, we believe this is unlikely. In fact, we have addressed this concern by conducting separate analyses, and controlling for the video order (that was randomised across participants). The results indicated that vicarious human-pet touch appeared to be the most powerful regardless of the order of presentation. Finally, future studies should examine what is more effective in situations where individuals are lacking social touch: actual physical touch with a pet versus vicarious pet touch interactions. Nevertheless, it is essential to consider that many people may not be able to have a pet for various reasons (e.g., allergies, city living, or insufficient energy to care for them), making vicarious touch an excellent alternative for potential interventions.

Conclusions

Taken together, the present study demonstrates the effect of vicarious touch in buffering stress feelings. This study should serve as a foundation for future research, delving deeper into the extent to which vicarious touch can potentially serve as a means to counteract a lack of social touch, particularly when it involves vicarious touch via observing human-pet tactile interactions.

Data and code availability

The data and analysis script that support the findings of this study are available on the Open Science Framework

(https://osf.io/q9k6n/?view_only=47f499e524544380909c1594523c7201).

Supplementary information and analyses are provided in supplementary material.

Any additional information required to reanalyse the data reported in this paper is available from the lead contact upon request.

Authors' contributions

L.P.K. and M.v.M. had the original idea for this study, and developed the study concept and final study design together with A.F. L.P.K and M.v.M. performed the data analysis and interpretation with additional input from A.F and A.K. L.P.K. and M.v.M. drafted the manuscript, and all other authors provided critical revisions. All authors approved the final version of the manuscript for submission.

Competing interests

The authors report no competing interests.

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Supplementary Material

Supplementary Table 1. Interindividual preference ratings of the video clips moderating the calming effect of vicarious touch.

<i>Predictors</i>	<i>Estimates</i>	<i>SE</i>	Calming	
			<i>CI</i>	<i>p</i>
(Intercept)	1.53	1.63	-1.67 – 4.74	0.348
videoType [Human]	-0.49	0.68	-1.83 – 0.84	0.468
videoType [Pet]	3.78	0.79	2.24 – 5.32	<0.001
pleasant mc	0.16	0.02	0.13 – 0.19	<0.001
awkward mc	-0.10	0.01	-0.12 – -0.07	<0.001
videoType [Human] *	-0.02	0.03	-0.07 – 0.02	0.329
pleasant mc				
videoType [Pet] *	0.03	0.03	-0.02 – 0.09	0.206
pleasant mc				
videoType [Human] *	-0.01	0.02	-0.05 – 0.03	0.636
awkward mc				
videoType [Pet] * awkward mc	0.08	0.03	0.02 – 0.13	0.004
mc				
Random Effects				
σ^2	259.10			
τ_{00} order_vid	3.05			
τ_{00} order_vid_nb	5.64			
ICC	0.03			
N order_vid	6			
N order_vid_nb	3			
Observations	4470			
Marginal R ² / Conditional R ²	0.182 / 0.209			

Supplementary Table 2. Interindividual states moderating the calming effect of vicarious touch.

<i>Predictors</i>	<i>Estimates</i>	<i>SE</i>	Calming	
			<i>CI</i>	<i>p</i>
(Intercept)	-3.37	1.73	-6.77 – 0.03	0.052
videoType [Human]	4.66	0.62	3.45 – 5.88	<0.001
videoType [Pet]	12.49	0.62	11.27 – 13.70	<0.001
loneliness mc	-0.13	0.30	-0.72 – 0.46	0.670
STAI pre mc	0.10	0.04	0.03 – 0.17	0.007
videoType [Human] *	-0.21	0.43	-1.04 – 0.63	0.629
loneliness mc				
videoType [Pet] *	0.56	0.43	-0.27 – 1.40	0.186
loneliness mc				
videoType [Human] * STAI pre mc	0.06	0.05	-0.04 – 0.16	0.271
pre mc				
videoType [Pet] * STAI pre mc	0.19	0.05	0.09 – 0.29	<0.001

Random Effects

σ^2	284.36
τ_{00} order_vid	3.84
τ_{00} order_vid_nb	6.53
ICC	0.04
N order_vid	6
N order_vid_nb	3
Observations	4470
Marginal R^2 / Conditional R^2	0.104 / 0.136

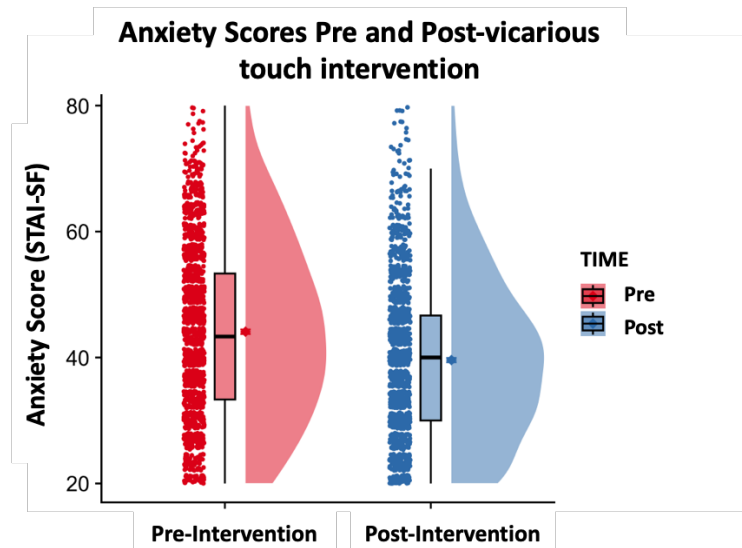
Supplementary Table 3. Calming effect of vicarious touch in Anxious vs. non-anxious participants

Predictors	Estimates	std. Error	Calming	
			CI	p
(Intercept)	-4.60	1.88	-8.28 – -0.91	0.015
GroupStai [Anxious]	2.88	0.96	1.00 – 4.77	0.003
videoType [Human]	4.73	1.01	2.74 – 6.71	<0.001
videoType [Pet]	9.05	1.01	7.06 – 11.03	<0.001
GroupStai [Anxious]*	-0.41	1.36	-3.07 – 2.25	0.762
videoType [Human]				
GroupStai [Anxious] *	5.54	1.36	2.88 – 8.20	<0.001
videoType [Pet]				
Random Effects				
σ^2	281.30			
τ_{00} order_vid	3.71			
τ_{00} order_vid_nb	7.20			
ICC	0.04			
N order_vid	6			
N order_vid_nb	3			
Observations	3714			
Marginal R^2 / Conditional R^2	0.099 / 0.133			

Supplementary Results

(i) Analysis on the buffering effect of vicarious touch in general. In order to show that overall, watching tactile interactions (vicarious touch) can reduce anxiety, as measured by a standardised questionnaire, we conducted a linear mixed model to compare the STAI before and after watching all videos, while controlling for video order. Acknowledging the limitation it implies (time effect), we do not draw strong conclusions on this analysis.

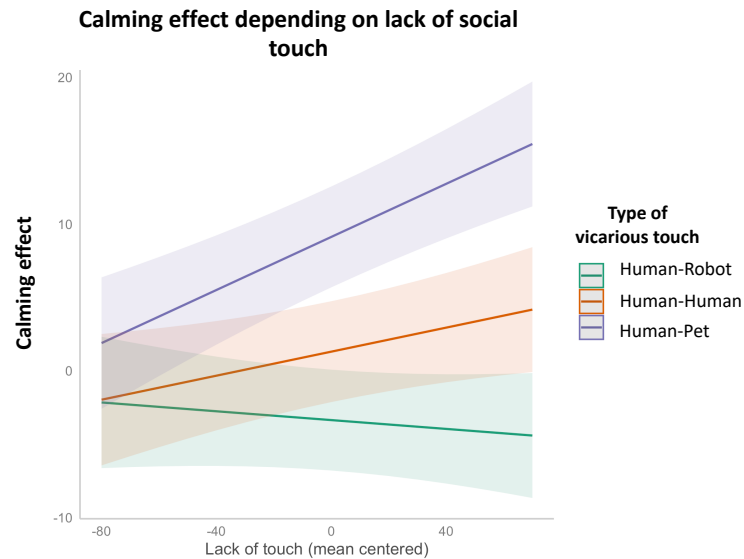
Overall, while controlling for video order, results suggest that vicarious touch reduced anxiety ($\beta=-4.51$, CI(-5.01, -4.01), $p<0.001$; $\text{cond}R^2=0.734$), with lower STAI scores observed post ($M=39.59$, $SD=12.74$) in comparison to pre-intervention ($M=44.10$, $SD=13.65$).



Supplementary Figure 1. Anxiety Scores as measured by STAI-SF before (pre) and after the vicarious touch intervention (post). Jittered dots represent calming effects for each individual participant. Boxplot presents the central tendency. The half violin provides data distribution. Diamond represents the mean for each bias, and the error bars denote the standard error of the mean.

(ii) Exploratory analysis in relation to the lack of touch participants were experiencing. In order to explore whether vicarious touch could calm participants the more people are lacking touch (measured as the average difference between the amount of social touch participant were getting in the past week and the amount of social touch participant wished to have experienced in the past week, see details in von Mohr, Kirsch & Fotopoulou, 2021), we specified a multi-level regression model with the calming scores as the outcome variable, type of video (human-human, human-pet, human-robot) as a categorical predictor, and average self-reported lack of touch, as continuous predictor.

As shown in the main analyses, human-pet and human-human interactions were having a greater calming effect than the human-robot interactions (respectively: $\beta=12.49$, $CI(11.27 - 13.71)$, $p<.001$; $\beta=4.67$, $CI(3.44, 5.8)$, $p<.001$). There was no significant main effect of lack of touch ($\beta=-0.02$, $CI(-0.05,0.02)$, $p=.412$), however a significant interaction with the human-pet interaction ($\beta=0.11$, $CI(0.05, 0.16)$, $p<0.001$), suggesting a greater calming effect of the human-pet interaction for participants lacking more social touch (see Supplementary Figure 2 and Supplementary Table 4). Note that the effect size for the full model is small: marginal $R^2 = 0.087$ and conditional $R^2 = 0.118$. VIF scores were all below 1.



Supplementary Figure 2. Lack of touch moderating the calming effect of vicarious touch. Calming effects on the y-axis are calculated as the difference between the feeling ratings before and after each video clip, for each type of video clip. Higher scores on the y-axis denote higher calming effects. The x-axis reflects the mean-centred lack of touch (as measured as the average difference between the amount of social touch participants were getting in the past week and the amount of social touch participants wished to have experienced in the past week) with shaded areas depicting confidence intervals.

Supplementary Table 4. Role of the lack of touch on the calming effect of vicarious touch

Predictors	Calming			
	Estimates	std. Error	CI	p
(Intercept)	-3.36	1.75	-6.80 – 0.07	0.055
videoType [Human]	4.67	0.62	3.44 – 5.89	<0.001
videoType [Pet]	12.49	0.62	11.27 – 13.71	<0.001
lackTouch mc	-0.02	0.02	-0.05 – 0.02	0.412
videoType [Human] × lackTouch mc	0.06	0.03	0.01 – 0.11	0.031
videoType [Pet] × lackTouch mc	0.11	0.03	0.05 – 0.16	<0.001
Random Effects				
σ^2	289.94			
τ_{00} order_vid	3.50			
τ_{00} order_vid_nb	6.89			
ICC	0.03			
N _{order_vid}	6			
N _{order_vid_nb}	3			
Observations	4470			
Marginal R ² / Conditional R ²	0.087 / 0.118			

(iii) Interindividual preferences for each video clip type. In order to investigate whether the video clips were rated differently in pleasantness and awkwardness, one-way repeated measures ANOVA were conducted separately on each measure. Both analyses revealed significant difference between each video clip, with a main effect of video clip type on pleasantness ($F(1.921,2861.1)=1107.842, p<0.001, \eta_p^2=0.427$) and awkwardness ratings ($F(1.890,2814.417)=588.609, p<0.001, \eta_p^2=0.283$). The video clip with human-robot interaction were rated as less pleasant and more awkward ($M_{pleasant}=39.2, ; M_{awkward}=45.2$) than the human-human ($M_{pleasant}=62.96; M_{awkward}=30.3$), than the human-pet interactions ($M_{pleasant}=77.9; M_{awkward}=11.8$). Details of posthoc comparisons are presented below.

A. Pleasantness ratings

Post Hoc Comparisons – VideoType ▼

		Mean Difference	95% CI for Mean Difference		SE	t	Cohen's d	95% CI for Cohen's d		P _{bonf}	P _{holm}
			Lower	Upper				Lower	Upper		
Pet	Human	14.942	12.953	16.930	0.830	18.002	0.584	0.502	0.666	< .001	< .001
	Robot	38.734	36.745	40.722	0.830	46.667	1.513	1.411	1.616	< .001	< .001
Human	Robot	23.792	21.804	25.780	0.830	28.665	0.930	0.842	1.017	< .001	< .001

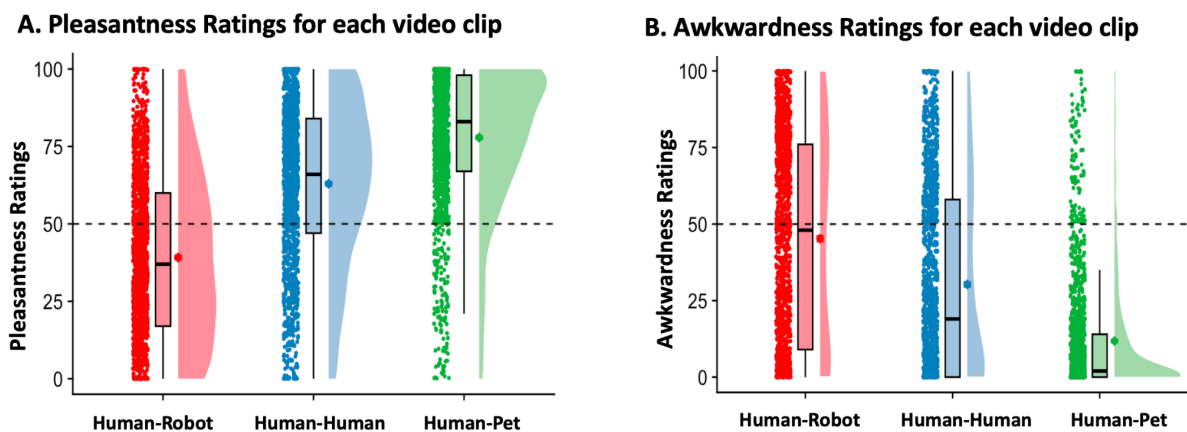
Note. P-value and confidence intervals adjusted for comparing a family of 3 estimates (confidence intervals corrected using the bonferroni method).

B. Awkwardness ratings

Post Hoc Comparisons – VideoType

		Mean Difference	95% CI for Mean Difference		SE	t	Cohen's d	95% CI for Cohen's d		P _{bonf}	P _{holm}
			Lower	Upper				Lower	Upper		
Pet	Human	-18.482	-20.819	-16.145	0.976	-18.944	-0.628	-0.712	-0.544	< .001	< .001
	Robot	-33.411	-35.748	-31.074	0.976	-34.246	-1.135	-1.229	-1.041	< .001	< .001
Human	Robot	-14.929	-17.266	-12.592	0.976	-15.302	-0.507	-0.590	-0.425	< .001	< .001

Note. P-value and confidence intervals adjusted for comparing a family of 3 estimates (confidence intervals corrected using the bonferroni method).



Supplementary Figure 3. “Wishing to get that type of touch” ratings for each type of vicarious touch (Human-Robot in red, Human-Human in blue and Human-Pet in green). Jittered dots represent calming effects for each individual participant. Boxplot presents the central tendency. The half violin provides data distribution. Diamond represents the mean for each bias, and the error bars denote the standard error of the mean.