

# **The meaning of touch: Relational and individual variables shape emotions and intentions associated with imagined social touch**

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**Acknowledgments:** AF was supported by a European Research Council Consolidator Award [ERC-2018- COG-818070].

**Author contributions:** Michael J. Banissy, Claudia Hammond, Aikaterini Fotopoulou, and Paul M. Jenkinson contributed to the study conception and design. Paul M. Jenkinson, Aikaterini Fotopoulou, and Athanasios Koukoutsakis wrote the study pre-registration. Athanasios Koukoutsakis and Charlotte Krahé prepared the material. Charlotte Krahé performed all analyses. Charlotte Krahé wrote the original draft of the manuscript. Aikaterini Fotopoulou and Paul M. Jenkinson reviewed and edited the draft together with Charlotte Krahé. All authors read and approved the final manuscript.

### **Abstract**

Touch is a key channel for conveying meaning in social interactions. The affective quality of touch and its effects on wellbeing are shaped by relational context (relationship between touch giver vs. recipient) and person variables (e.g., adult attachment style). Yet, such effects have not been explored in relation to the *meaning* ascribed to touch. We used data from the Touch Test, the world's largest touch survey, which included questions on the degree to which people felt and related specific emotions and intentions to imagined gentle stroking touch and hugs. In  $N = 23,428$ , we examined how relational context (imagined source of touch), and person variables (gender, recalled positive childhood touch, and adult attachment style) were associated with positive (e.g., love, desire, support) and negative (e.g., fear, anger, warning) emotions and intentions related to imagined touch. Love, desire, and support were endorsed more when participants had had their partner (vs. someone else) in mind, and women (vs. men) gave lower ratings for desire overall. Gentle stroking touch was most linked with arousal when participants had had their partner in mind. Further, more positive childhood touch and secure and anxious attachment scores were associated with more positive emotions and intentions, while the opposite was found for avoidant attachment scores. Lastly, positive childhood touch and higher anxious attachment scores were related to greater discrimination between distinct emotion and intention categories, while higher attachment avoidance was associated with reduced discriminability. Thus, contextual and person variables matter in shaping the meaning of prosocial touch.

*Keywords:* social touch, affective touch, communication, emotion, intention, attachment style

## **The meaning of touch: Relational and individual variables shape emotions and intentions associated with imagined social touch**

Our sense of touch is integral for exploring and communicating with the world around us. We touch surfaces and objects to understand their properties, move them, and use them. We touch other people, and are touched by other people, to convey meaning (e.g., love or support; Hertenstein et al., 2006; Kirsch et al., 2018; McIntyre et al., 2022) and to influence other people, such as affecting their emotions (e.g., soothe and buffer their stress; Van Puyvelde et al., 2019; von Mohr et al., 2017) or behaviours (e.g., the famous example that touch increases restaurant tipping; Crusco & Wetzel, 1984). These two functions of social touch have been considered in ‘signal’ and nonverbal ‘effecting’ models, respectively (Schirmer et al., 2022), though the two functions are arguably linked, with the meaning (i.e., signal) conveyed by touch influencing its effects (Sailer & Leknes, 2022). Crucially, both the *affective quality* of touch (e.g., its pleasantness) and *touch effects* are shaped by relational context and person variables, such as personality traits. Regarding context, for example, the soothing effects of stroking touch in 9-month-old infants were reversed when infants believed they were being stroked by a stranger rather than their parent (Aguirre et al., 2019). In adulthood, the perceived pleasantness of such stroking touch is modulated by how much touch people are generally exposed to (Sailer & Ackerley, 2019) and personality traits, such as their mental representations of close relationships (adult attachment styles; Krahe et al., 2018; Spitoni et al., 2020). However, how relational context and person variables shape the imagined *meaning* that is ascribed to social touch is only beginning to be explored (Price et al., 2022). In the present study, we used data from the world’s largest survey on touch to date (the Touch Test) to examine how relational context and person variables shape the meaning of imagined social touch.

The Touch Test focused on prosocial touch, specifically hugs and gentle caressing touch, in the tradition of viewing such forms of touch as critical for positively regulating others’ affective states. From birth, our caregivers touch us to help us reduce negative affective states, such as pain, hunger, or feeling cold, by stroking or holding, feeding, or dressing us (Fotopoulou & Tsakiris, 2017). These early touch experiences set the stage for affect regulation through social touch across the lifespan (see

Fotopoulou et al., 2022, for a theoretical review). A wealth of evidence supports the idea that social touch reduces negative affective states such as emotional pain (von Mohr et al., 2017), physical pain (von Mohr et al., 2018) and stress (Morrison, 2016), even when touch is imagined rather than directly experienced (Jakubiak & Feeney, 2016a). Furthermore, social touch also exerts positive effects on wellbeing (Debrot et al., 2020; Field, 2019; Jakubiak & Feeney, 2017), in part through touch promoting the formation and maintenance of close social bonds (Bendas & Croy, 2021), and the perception of those bonds (Jakubiak & Feeney, 2016b). For example, Jakubiak and Feeney (2016b) found that receiving touch (holding hands, arms around body) from the romantic partner was associated with greater self-reported state attachment security, including feeling safe, comforted, and loved. As well as hand-holding and hugs, a specific type of slow, gentle caressing touch seems especially important in facilitating prosocial approach behaviour (Pawling et al., 2017) and strengthening social bonds and intimacy between people. Slow, gentle stroking at speeds of 1-10cm/s optimally activates a class of unmyelinated C tactile (CT fibres) in the skin, and activation of CT fibres is positively correlated with perceived pleasantness (Löken et al., 2009). Thus, this type of social touch is often termed ‘affective touch’ as – compared to faster stroking touch at ‘non-CT-optimal’ speeds – it has a positive hedonic valency: it generally feels pleasant (Löken et al., 2009).

However, contextual and individual factors shape the perceived pleasantness of touch. In adults, the strength of the emotional bond with the person providing touch is positively related with touch pleasantness and touch permissibility (Suvilehto et al., 2019). In close relational contexts, such as romantic relationships, slow gentle stroking touch is perceived as pleasant and erotically arousing (Bendas et al., 2017; Panagiotopoulou et al., 2018), but this appears to depend on gender, with women rating slow, gentle touch as more erotic than men (Bendas et al., 2017). Personality traits are also related to differences in the perceived affective quality of touch. In particular, attachment styles, including mental representations regarding the availability of close others to one’s needs, influence the perceived pleasantness of slow, gentle touch (e.g., Krahe et al., 2018; Spitoni et al., 2020) and its effect on negative affective states, such as pain (Krahe et al., 2016). Attachment styles develop through early experiences with caregivers, which critically include early touch experiences, such as caregivers signalling affection

and closeness through touch and using touch to fulfil children's basic needs (Fotopoulou et al., 2022). Prosocial and especially affective touch is key in maintaining proximity to caregivers and forming secure attachment bonds (e.g., Bendas & Croy, 2021), and (cross-sectionally) attachment styles are linked to affective touch experiences (Beltrán et al., 2020). Importantly, past touch experiences and attachment styles appear key in the ability to discriminate between different types of touch in terms of their pleasantness. For example, fewer overall experiences of being touched are associated with a poorer ability to discriminate between CT-optimal and non-CT-optimal touch on the basis of pleasantness (Sailer & Ackerley, 2019). This reduced discriminability is also seen in individuals with a more insecure attachment style, and especially at higher levels of attachment anxiety (Krahé et al., 2018). Overwhelmingly, however, studies have focused on perceived pleasantness of touch as the outcome, and have not examined how the meaning ascribed to touch might be affected by relational context (relationship with toucher) and person variables (gender, touch history, and attachment styles).

Touch serves as a non-verbal channel of communicating meaning. Focusing on conveying emotions, Hertenstein et al. (2006) demonstrated that individuals can decode discrete prosocial emotions from different types of touch; for example, love was reliably decoded from gentle stroking, either experienced or observed. McIntyre et al. (2022) further showed that messages (construed more broadly than emotions, and including attention, love, happiness, calming, sadness, and gratitude) could be identified by receivers within a close relationship context. Further, when core features of the touches conveying these messages were extracted to construct 'standardised' touch profiles, participants could also decode the intended messages when standardised touches were provided by strangers. Messages of love and calming involved slow, stroking movements as opposed to e.g., tapping movements to indicate happiness or attention (McIntyre et al., 2022). Focusing specifically on emotions and intentions conveyed by slow, gentle (CT-optimal) touch vs. faster non-CT-optimal speeds, Kirsch et al. (2018) found that stroking at CT-optimal velocities was interpreted as arousal/desire (emotion) and social support (intention). Faster touch, on the other hand, was perceived to convey joy/fear (emotions) and warning (intention). Importantly, however, such studies that had relatively small sample sizes, and have not directly investigated the influence of different relational contexts and person variables on self-

reported meaning from touch; that is, how touch is interpreted or ‘read’ depending on contextual and personal characteristics.

While most studies have examined touch that is directly experienced, we can think about what touch means without receiving sensory input. Indeed, imagining affective touch induces feelings of pleasantness (Panagiotopoulou et al., 2018) and activates neural regions (anterior insula) involved in interpreting the affective meaning of the touch (Lucas et al., 2014). Imagined touch can also influence positive cognitions (e.g., around state attachment security; Jakubiak & Feeney, 2016b) and can buffer stress (Jakubiak & Feeney, 2016a). However, to our knowledge, no large-scale study has investigated which emotions and intentions people associate with imagined touch, or which factors moderate these associations.

Accordingly, in this pre-registered study, we accessed data from the Touch Test (Bowling, Vafeiadou, & Banissy, 2020), in which nearly 40,000 participants were asked about different aspects of touch, including which emotion and intentions they would associate with two types of prosocial touch, namely hugs and slow, gentle touch. Participants imagined these types of touch and indicated who they had in mind when responding to questions. Although testing only ‘imagined touch’ with a self-report methodology has limitations (see discussion), the large sample of our survey, derived from the general UK population, allowed us to look at the influence of many other variables on the meaning of touch as we explain below. Indeed, participants also completed self-report measures of attachment style and touch history and provided demographic details regarding their gender. We used this data to test a series of pre-registered hypotheses (<https://osf.io/gvjqz>). First, to replicate existing studies (e.g., McIntyre et al., 2022; Hertenstein et al., 2006; Kirsch et al., 2018), we tested the hypothesis that people would generally interpret slow, gentle caressing touch and hugs as evoking and communicating positive (rather than negative) emotions and social intentions (H1). Next, we examined how interpretation of touch would vary by relational context. Based on the wealth of literature regarding the links between social touch and close emotional bonds, we tested the hypothesis that people would interpret slow, gentle touch and hugs as eliciting and indicating more positive emotions and intentions (specifically, desire, love, and social support) when they had their partner vs. others in mind (H2). We also explored

gender differences, hypothesising that women would be more likely than men to report love, desire, and social support from their partner (vs. others), whereas men were expected to report more desire than women regardless of touch source (H2.1). Next, following previous work (Bendas et al., 2017; Panagiotopoulou et al., 2018), we focused on erotic arousal, testing the hypothesis that people would interpret slow, gentle, caressing touch as more erotic (arousal/lust/desire emotions and intentions) than a hug, particularly when they had their partners in mind (H3). Women potentially interpret slow touch as a ‘sexual cue’, while men may see it more as a ‘sexual reward’ (Bendas et al., 2017) but beyond that, we do not have a clear understanding of gender influences on emotions and intentions associated with imagined touch. Finally, we examined individual differences in attachment style and touch history (amount of positive parental touch in childhood) to test the hypothesis that less secure attachment and less touch during childhood would be associated with rating slow, gentle caressing touch and hugs as eliciting and conveying less positive (H4.1) and less distinct (H4.2) emotions and intentions.

## **Methods**

### **Design and procedure**

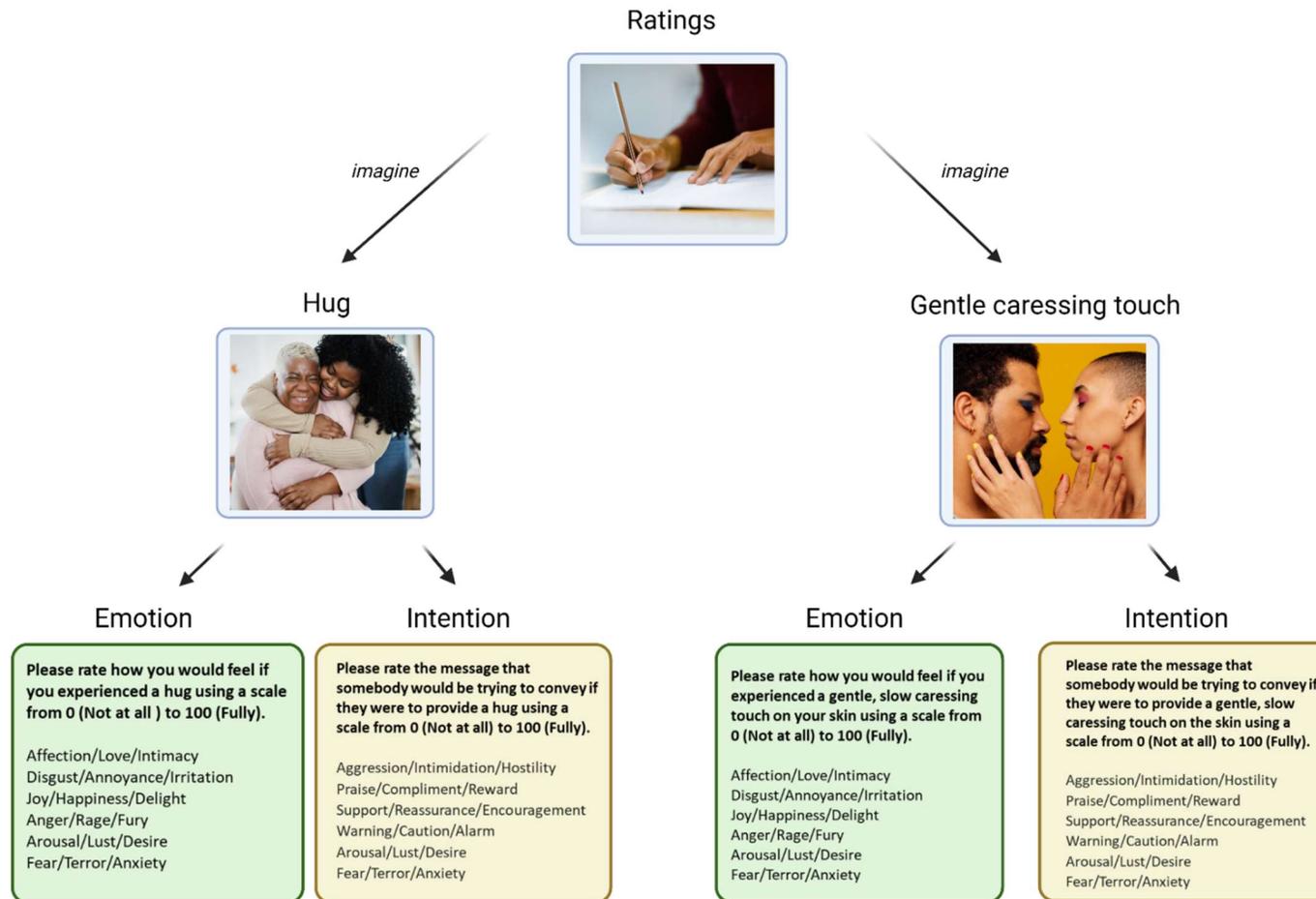
The study employed a cross-sectional survey design. Data was obtained online through the ‘Touch Test’. The Touch Test survey was created by Goldsmiths (University of London) and University College London as academic partners, and organised by the Wellcome Collection in collaboration with the British Broadcasting Corporation (BBC). The survey was accessed via a purpose-built online platform ([www.touchtest.org](http://www.touchtest.org)). It was launched by BBC Radio 4 on 21<sup>st</sup> January 2020 and was widely advertised to the general public in the UK through radio broadcasts and social media by BBC radio and the Wellcome Collection. It remained open to the public for completion until 30<sup>th</sup> March 2020. On accessing the survey, participants were presented with an information sheet and provided informed consent before proceeding to the survey. The survey had two parts and participants could choose to complete one or both parts. The ratings and measures included in this paper were drawn from both parts of the questionnaire; thus, only participants who completed both parts were included. Questionnaires in each part were presented in a random order, and the full survey was expected to take 30-45 minutes to complete. Participants could interrupt and return to the survey as many times as they wanted until seven

days after they had started. However, most participants (89.76%) completed the survey in one day. The study was approved by the Research Ethics and Integrity Sub-Committee, Goldsmiths, University of London.

In this paper, we focused on specific parts of the larger survey relevant to testing our pre-registered hypotheses (<https://osf.io/gvjqz>). We report only data from questions asking participants to imagine slow, gentle touch and hugs and rate different emotion and intention terms as well as who they had in mind when rating these, and relevant demographic variables and self-reported measures of developmental touch history and attachment style. The emotion and intention terms were taken from Kirsch et al. (2018) and are presented in Figure 1 and in *Touch Ratings* below. Briefly, participants rated six emotions and six intentions in relation to a) imagined gentle, stroking touch and b) hugs, yielding 24 ratings in total. Outcomes of interest were mean ratings for emotions and intentions, and distinctiveness scores (see Plan of analysis). Predictors, depending on hypothesis, were touch source (partner vs. other), touch type (gentle touch vs. hugs), touch valence (negative vs. positive), specific emotion or intention categories (see below), gender (identifying as men or women), attachment anxiety and avoidance (continuous scores), and developmental touch history (continuous score). We also controlled for covariates linked theoretically to touch ratings, such as general touch experiences and attitudes (see below).

## Participants

Members of the general population were invited to take part in the world's largest online survey on touch.  $N = 39,254$  participants completed at least part of the survey. The open nature of this survey meant that we received responses from an extremely heterogenous sample. As pre-registered on the Open Science Framework (<https://osf.io/gvjqz>), we only included participants self-identifying as men or women, living in the UK, and aged 19 years and over (because in Tanzer et al., 2022, participants who reported being aged 18 were excluded due to a disproportionately high number of respondents in this age category, which can indicate that individuals under the age of 18 completed the survey and selected this age). This left  $N = 23,475$  predominantly white (95.7%) participants with a mean age ( $SD$ ) of 57.05 years (13.92; range 19 – 94) of whom 25.2% self-identified as men and 74.8% as women (see



**Figure 1.** Breakdown of touch ratings for hugs and gentle caressing touch. Participants gave six emotion and six intention ratings separately for hugs and gentle caressing touch, resulting in 24 ratings.

Table 1 for full demographic information). Almost all participants completed the survey before the first UK COVID-19 lockdown began on 23<sup>rd</sup> March 2020, but we nevertheless controlled for when the survey was completed in analyses to account for any effects of the onset of the pandemic. Participants indicated that the last time somebody had touched them “*intentionally, not including formal gestures such as handshakes in meetings?*” was overwhelmingly in the last day or less (45.9%). We controlled for last time people were touched in our analyses. As pre-registered, participants who completed fewer than 80% of items on the various measures were excluded from analyses (see Plan of Analysis). Therefore, there was a slightly different *N* in each analysis, and the total *N* is reported for each analysis.

**Table 1. Demographic characteristics**

		<i>N</i>	Mean	<i>SD</i>	Min	Max
Age		23,428	57.05	13.92	19	94
		<i>N</i>	%			
Gender	Men	5,909	25.20			
	Women	17,536	74.80			
Ethnicity	White	22,426	95.70			
	Black	119	0.50			
	Asian	273	1.20			
	Mixed/multiple	349	1.50			
	Other background/prefer not to say	263	1.10			
Sexuality	Heterosexual	20,989	89.50			
	Bisexual	976	4.17			
	Gay or Lesbian	745	3.18			
	Prefer not to say	306	1.30			
	Prefer to self-describe	435	1.86			
	Within last hour	5,927	25.30			

Recent touch experience/last time touched	Last day or less	10,765	45.90
	Last week or less	4,455	19.00
	In the last month	1,378	5.90
	Over a month ago	666	2.80
	Over a year ago	284	1.20
Completed before first UK lockdown began on 23 <sup>rd</sup> March 2020	Yes	23,175	98.92
	No	253	1.08

## Materials and measures

### *Demographic information:*

We accessed information on age, gender, sexuality, ethnicity, and date of survey completion (to control for the possible influence of the COVID-19 restrictions).

### *Touch rating outcome:*

Participants were asked to rate emotions they would feel and intentions which they felt were conveyed by gentle, slow caressing touch and hugs (see Figure 1). Specifically, for emotions they were asked (separately for gentle touch and hug, but presented together here for parsimony), “Please rate how you would feel if you experienced a gentle, slow caressing touch / hug on your skin using a scale from 0 (not at all) to 100 (fully)” and for intentions, “Please rate the message that somebody would be trying to convey if they were to provide a gentle, slow caressing touch on the skin / hug using a scale from 0 (not at all) to 100 (fully)”.

Then, six emotion categories / six intention categories were provided based on previous work (see Kirsch et al., 2018). Each emotion category contained three semantically-related words that described the represented emotion. Positive emotions included 1) Affection/love/intimacy (love as the overarching category with linked concepts), 2) Joy/happiness/delight (happiness), and 3) Arousal/lust/desire (desire). Negative emotions included 4) Disgust/annoyance/irritation (annoyance as

the umbrella concept), 5) Anger/rage/fury (anger), and 6) Fear/terror/anxiety (fear). For intentions, each category also contained three semantically related words. Positive intentions included 1) Support/reassurance/encouragement (support as overarching concept), 2) Praise/compliment/reward (praise), and 3) Arousal/lust/desire (desire). Negative intentions included 4) Aggression/intimidation/hostility (aggression), 5) Warning/caution/alarm (warning), and 6) Fear/terror/anxiety (fear). We did not create averages for emotion or intention ratings; instead, all six emotion categories / six intention categories were concurrently entered into each multivariate multilevel model as dependent variables (see *Plan of Analysis*).

*Relational context predictor:*

After providing the ratings, participants were asked “*Who did you have in mind when you were answering the last set of questions?*” and were provided with the options “a friend”, “a partner”, “a family member”, “a stranger”, “no one in particular” or “someone else [specify in free text]”. Not everyone answered this question; of those who did ( $N = 16,193$ ), most participants commonly indicated having had their partner in mind ( $N = 8,576$ ), followed by a friend ( $N = 2,630$ ), no one in particular ( $N = 2,586$ ), a family member ( $N = 1,150$ ), someone else ( $N = 963$ ), and a stranger ( $N = 288$ ). As relational context hypotheses pertained to romantic partner vs. someone else, we created a binary predictor variable for touch source (partner vs. other) from these six categories but also explored specific comparisons (see below).

*Individual differences predictors:*

*Adult attachment style:* Adult attachment style was measured using the 12-item short form of the Experiences in Close Relationships questionnaire (Lafontaine et al., 2016), yielding scores on adult attachment avoidance (captured by 6 items, such as “*I don't feel comfortable opening up to romantic partners*”) and anxiety (6 items, such as “*I worry about being abandoned*”) dimensions. Items were rated from 1 (strongly disagree) to 7 (strongly agree) and averaged for each dimension (after reverse-scoring items, as appropriate) with higher scores denoting higher attachment anxiety and avoidance, respectively. Cronbach’s alphas were  $\alpha = .86$  for avoidance and  $\alpha = .86$  for anxiety dimensions. These

dimensions were entered into the models together with their interaction term, as pre-registered. Where interactions between dimensions were significant, we were able to conceptualise attachment style as secure (low scores, operationalised as 1SD below the sample mean) or insecure, with the latter divided into different types of insecure attachment (see Bartholomew & Horowitz, 1991) in the following ways: scores +1SD anxiety/-1SD avoidance were termed anxious attachment (preoccupied in Bartholomew & Horowitz, 1991, but we chose the terms used in the ECR-S), -1SD anxiety/+1SD avoidance scores were termed avoidant attachment (dismissing in Bartholomew & Horowitz, 1991), and +1SD scores on both dimensions were termed fearful attachment.

*Positive childhood touch:* To assess how much positive touch participants received in childhood, we created a composite average score of two items from the Childhood Touch subscale of the Touch Experiences and Attitudes Questionnaire (TEAQ; Trotter et al., 2018). We used this composite score rather than the full Childhood Touch subscale score as, due to space constraints, a shortened 12-item version of the TEAQ was used, with the two items with the highest loading on each subscale included in the survey. Ratings on items which loaded most strongly on the Childhood Touch subscale, namely, “*My parents were not very physically affectionate towards me during my childhood*” (item 9, reversed) and “*As a child, my parents would tuck me up in bed every night and give me a hug and a kiss goodnight*” (item 22), were averaged and higher scores denoted a more positive developmental touch history. Cronbach’s alpha was  $\alpha = .75$ .

*Covariates:*

We controlled for variables that we considered to possibly be linked to ratings of emotions and intentions from imagined hugs and gentle touch.

*Time when survey was completed:* To account for any effects of the onset of COVID-19 pandemic-related social restrictions in the UK (first national lockdown commenced on 23<sup>rd</sup> March 2020), we included, as a continuous variable, the number of weeks since the beginning of 2020 that had elapsed at the point of survey completion for each participant.

*Attitudes towards intimate touch:* Given that the imagined touch related to hugs and slow, gentle caresses, we assessed participants' general attitudes to intimate touch. *Attitudes about Intimate Touch* (AIT) is one of six subscales of the TEAQ. For this subscale, the two highest loading items, which were included here, were “*I like to stroke the skin of someone I know intimately*” and “*I enjoy the feeling of my skin against someone else's if I know them intimately*”. Participants rated how much they agreed with each item on a 5-point Likert scale ranging from “*disagree strongly*” to “*agree strongly*”. Items were averaged and higher scores denoted more positive attitudes to intimate touch. Cronbach's alpha was  $\alpha = .76$ .

*Recent touch experiences:* As differences in the perceived affective quality of touch have been reported to vary as a function of touch exposure (Sailer & Ackerley, 2019), we asked participants about their recent touch exposure. Participants were asked, “*When was the last time that somebody touched you intentionally, not including formal gestures such as handshakes in meetings?*” and indicated whether this last touch had occurred “*In the last hour*”, “*In the last day or less*”, “*In the last week or less*”, “*In the last month or less*”, “*Over a month ago*” or “*Over a year ago*”. This item was included as a fixed-effect categorical covariate (6 levels) in analyses.

*Ability to empathise:* Decoding emotions and intentions from imagined touch might be shaped by a person's general ability to understand somebody else's emotional state. Therefore, we controlled for ability to empathise as measured by the Empathy Quotient-Short Form (EQ-10; Wakabayashi et al., 2006). This 10-item measure includes items such as, “*I really enjoy caring for other people*” and “*I can sense if I am intruding, even if the other person does not tell me*”, and participants rated their agreement with each statement on a 4-point Likert scale ranging from “*strongly disagree*” to “*strongly agree*”. Items were reverse scored, as appropriate, and a total score computed, with higher scores denoting greater self-reported empathy. Cronbach's alpha was  $\alpha = .77$ .

*Perceived ability to notice bodily signals:* Slow, gentle, caressing touch has been conceptualised as an interoceptive modality (McGlone et al., 2014) and people differ in their ability to sense interoceptive signals. Here, we controlled for interoceptive sensibility, that is, self-reported (rather than objective)

accuracy in sensing bodily signals, by including a single item from the Interoceptive Accuracy Scale (Murphy, 2018) focusing on how accurate people think they are at discriminating between affectionate and non-affectionate touch: “*I can always accurately perceive when someone is touching me affectionately rather than non-affectionately*”. Responses were captured on a 5-point scale from “*Strongly Agree*” to “*Strongly Disagree*”. This single item was included as a fixed effect covariate in our analyses.

### **Plan of analysis**

The analysis plan for this study was pre-registered on the OSF (<https://osf.io/gvjqz>). The dataset used in the analyses can be accessed here: <https://osf.io/qt53j/>. All analyses were carried out in Stata 16 (StataCorp, 2019), and effect sizes were calculated in R (version 4.2.1). Any changes to the plan of analysis and additional exploratory analyses that were not part of the pre-registration are outlined below and in the Results section.

#### *Effect size considerations:*

Given the overall large sample size of the survey, some of our analyses were assumed to have very high statistical power and even very small effects would be identified as significant ( $p < .05$ ). However, the modular nature of the survey and expected variability in the sample size of each analysis (due to incomplete surveys and missing data; see below), meant that some sub-analyses would have a much smaller sample and lower statistical power than others. Therefore, we did not apply a standard cut-off for a meaningful effect size of interest, since this would result in many small effects being detected when our analyses included a very large sample from the full survey, but also interesting but small effects being missed in our smaller sample sub-analyses. Therefore, we reported the effect size, and statistical significance of our analyses so that the basis of our interpretations would be transparent. We used  $\alpha = .05$  and Bonferroni correction (where applicable and specified) to control the Familywise Error Rate (i.e., when conducting multiple post-hoc comparisons and planned contrasts).

#### *Assumptions and transformations:*

Assumptions of normality were checked using gg-plots, histograms, and tests of normality (e.g., Kolmogorov-Smirnov tests). For moderate skew or kurtosis, log-transformations or similar were applied. For extreme deviations from normality, we planned to use equivalent non-parametric tests (not necessary after inspecting the data). To deal with outliers in our analyses, we planned to use robust methods for multilevel analysis. However, as no small demographic subgroups were included, we did not exclude any outliers from analyses, and used maximum likelihood estimation instead of robust methods.

*Analysis procedure:*

We ran stepwise multivariate multilevel modelling (MMLM) to examine our predicted effects. Emotions and intentions were examined in separate MMLM. All six emotion categories / six intention categories were concurrently entered into each multivariate MMLM as dependent variables. In each of these analyses, last time participants were touched, ability to empathise (EQ-10), attitudes to intimate touch, week of the year in which the survey was completed (coronavirus control), and interoceptive sensibility were included as (fixed effect) covariates. All relevant independent variables, such as touch type (hug vs. gentle caressing touch), touch source (partner vs. somebody else), attachment style (anxiety, avoidance and their interaction), and positive childhood touch were entered as fixed effects of interest. Gender (men vs. women) was included as a fixed effect in certain analyses as described in specific hypotheses. The intercept of Participant ID was included as a random effect. We varied from our pre-registered analysis to include recent touch experiences (last time touched) as an additional fixed covariate, given the potentially valuable information provided by this variable. We further did not include as random effects demographic factors as we included only participants living in the UK.

Within this stepwise analysis, from each model to the next, we added one independent variable. Rather than using ANOVA to decide whether including independent variables improved the explanatory power of the model, we used the Akaike Information Criterion (AIC) to decide whether to retain the more complex models; lower AIC indicate a better-fitting model. The analysis took the following sequential steps: a) we used the random effect as the baseline model, b) we evaluated the

effect of any covariates with respect to the baseline, c) we evaluated the effects of independent variables and their interactions with respect to the previous steps, d) where 2- and 3-way interactions were identified, we performed planned contrasts to identify the effects driving the interactions of interest. In exploratory analyses, we also conducted the same analyses with the same steps for only the people that stated that they had thought of a current partner.

*Outliers and exclusions:*

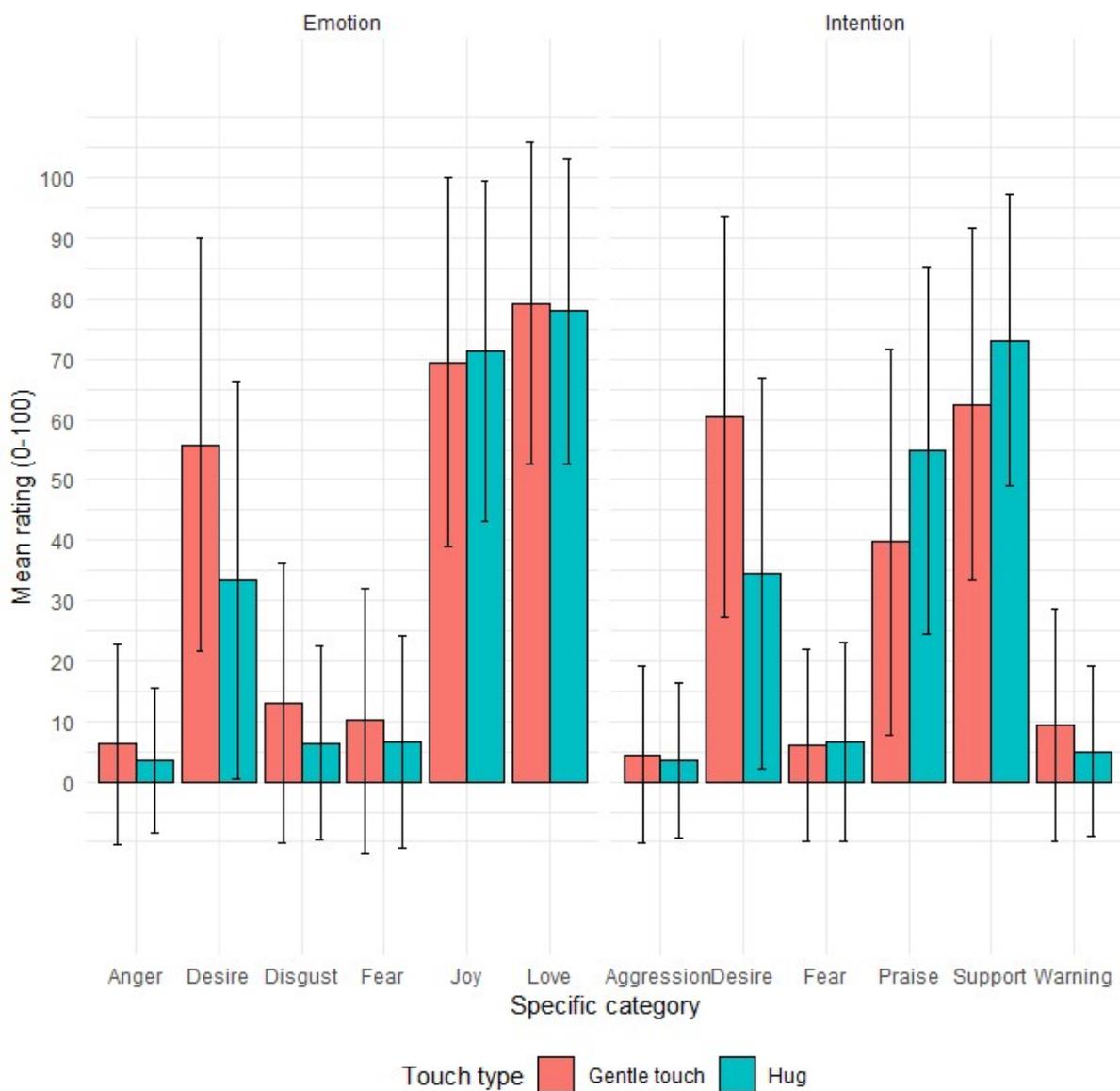
Where individual cases possessed demographic characteristics that are extremely rare and under-represented (e.g., < 1% of respondents), we excluded these individuals from our analyses. Thus, we included only men and women in our analysis on gender effects, and limited our analyses to UK residents (see also *Participants*). Individuals identified as having extreme values in group comparisons (i.e.,  $2.5SD$  from the group mean in normal or normalised distributions, or else the equivalent Interquartile Range) within a relatively small demographic subgroup (and therefore likely to have an excessive influence on the results of this group) were planned to be removed as outliers (but this did not need to be done).

*Missing data:*

As the survey had a modular structure, hypotheses that depend on independent variables contained in the later (optional) parts, which may be missing, were examined only in the subset of participants who completed these parts and most of the questions of interest. Specifically, participants needed to have completed at least 80% of each scale or subscale (e.g., subscales of the ECR-12) for that data to be included in an analysis. Where less than 80% of items were completed, data was excluded. Subscales were treated individually; a participant could be excluded from analysis for one subscale but still be included in analyses for other subscales on that scale, where data was sufficient. If analysis focused on a single item/question from the survey, we included all participants who completed the question.

## Results

Descriptive statistics for all ratings are presented in Figure 2 (values in Supplementary Table 1). Without considering the role of relational context and personal variables, there was marked variability in the ratings, with large standard deviations for most categories.



**Figure 2.** Mean ratings for each specific emotion (left panel) and intention (right panel) category by type of touch (gentle touch; hugs). Errors bars denote  $\pm 1SD$ .

Correlations between self-report measures are presented in Supplementary Table 2. All correlations were weak to moderate.

*Question 1: Do people consistently interpret slow, gentle, caressing touch and hugs as communicating specific, positive emotions and social intentions?*

Before investigating the role of context and person variables in the perception of emotions and intentions communicated by touch, we first tested the pre-registered hypothesis that people would generally interpret slow, gentle, caressing touch and hugs as communicating positive (vs. negative) emotions and intentions (H1). Valence (positive vs. negative) was the predictor of interest. Full model results are presented in Supplementary Table 3; for these and all subsequent analyses, the best-fitting models were the final models including the predictors of interest. As expected, we found that gentle touch and hugs were rated as eliciting more positive ( $M = 64.68, SE = .10$ ) than negative ( $M = 7.59, SE = .10$ ) emotions ( $f^2 = 1.12$ ) and conveying more positive ( $M = 54.32, SE = .10$ ) than negative ( $M = 5.65, SE = .10$ ) intentions ( $f^2 = 1.15$ ), with a large effect size.

*Question 2: Do people consistently interpret slow, gentle, caressing touch and hugs as more erotic (desire emotions and intentions), loving and socially supportive if they have their partners in mind than if they have others in mind? Is there a difference between men and women in these effects?*

We next investigated the impact of who participants had had in mind ('touch source') when they rated imagined touch (across both hugs and gentle touch) and how this varied by gender. Specifically, we tested the hypotheses that slow, gentle, caressing touch and hugs would elicit higher ratings for love and desire, and would be rated more highly in terms of conveying social support desire intentions when people had had their romantic partners rather than other people in mind (H2). Furthermore, we hypothesised that women would give higher ratings than men for love, desire, and

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<sup>1</sup> Conditional  $f^2$  values were calculated in R using lme4 and sjPlot packages. For models with only one predictor of interest, the full model was compared to the covariates-only model. To isolate effects of individual predictors in models with several predictors of interest, the full model was compared to a reduced model without that specific predictor. Where specific predictors were also included in interaction terms, interaction terms including the predictor of interest were also removed from the reduced model given that interaction effects may influence effects of individual predictors. Where the effect of interest was a 3-way interaction, only the 3-way interaction term was removed from the reduced model; resulting effect sizes were very small.

support when they had had their partners vs. others in mind, whereas men were expected generally to rate desire more highly than women (H2.1).

We considered desire and love for emotions, and desire and support for intentions, and created a binary predictor variable for touch source (partner vs. other) from initially six categories (partner, friend, family member, stranger, no one in particular, someone else); groups were very similar in size with  $N = 8,256$  participants reporting having thought of their partner, and  $N = 7,180$  having thought of someone else in the emotions analysis, and  $N = 8,292$  participants having reported thinking of their partner, and  $N = 7,255$  of someone else in the intentions analysis (total  $N$  reduced due to missing data on the touch source question, and slightly different  $N$  between emotion and intention given exclusions; see *Plan of Analysis*). We also entered gender (men, women) and the specific emotion/intention (love and desire for emotion; support and desire for intention) and all interaction terms as predictors of interest.

Full model results are presented in Table 2. Considering main effects, there was a significant effect of touch source for emotions ( $f^2 = .07$ ) and intentions ( $f^2 = .04$ ): Ratings were higher when participants had their partner ( $M = 67.63$ ,  $SE = .23$ ) vs. someone else in mind ( $M = 56.33$ ,  $SE = .25$ ) for emotions, and their partner ( $M = 62.14$ ,  $SE = .23$ ) vs. someone else in mind ( $M = 53.63$ ,  $SE = .25$ ) for intentions, supporting Hypothesis 2. Furthermore, participants rated love and support higher than desire, and women gave lower ratings than men overall (see Figure 3).

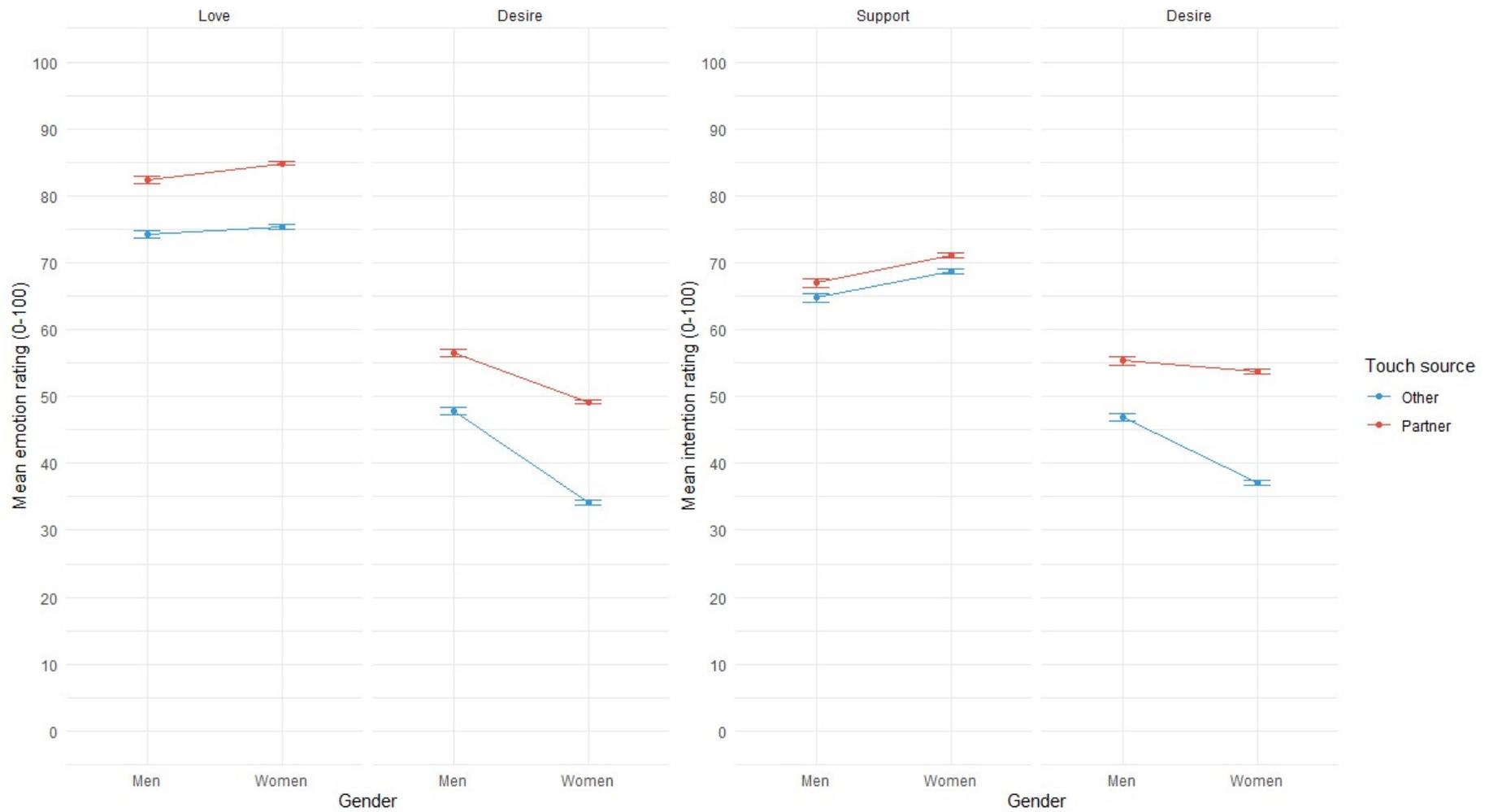
Regarding Hypothesis 2.1., the 3-way interaction between gender, touch source, and specific category was significant for both emotions ( $f^2 < .001$ ) and intentions ( $f^2 < .001$ ). Specific contrasts (Bonferroni-corrected) revealed that both women and men gave lower ratings for love and desire (emotions) if they had someone else vs. their partner in mind (men: contrast =  $-8.36$ ,  $SE = .67$ ,  $p < .001$ ; women: contrast =  $-12.27$ ,  $SE = .39$ ,  $p < .001$ ) and rated support and desire (intentions) lower if they had someone else vs. their partner in mind (men: contrast =  $-5.34$ ,  $SE = .67$ ,  $p < .001$ ; women: contrast =  $-9.55$ ,  $SE = .39$ ,  $p < .001$ ), in contrast to Hypothesis 2.1, which predicted this effect for women only. However, women did give lower ratings for desire generally than did men for emotions (contrast = -

**Table 2.** Effects of person in mind, gender, and specific category on emotions and intentions.

		Emotions					Intentions				
		<i>b</i>	<i>SE</i>	<i>p</i>	95% CI		<i>b</i>	<i>SE</i>	<i>p</i>	95% CI	
<i>Intercept</i>		21.78	1.88	< .001	18.10	25.45	29.28	1.90	< .001	25.56	32.99
<i>Covariates</i>											
Last time touched	>1 month	1.58	1.74	.364	-1.83	4.98	1.68	1.75	.337	-1.75	5.11
	ago										
(Over a year ago = ref category)	≤ last month	1.60	1.63	.326	-1.59	4.79	2.11	1.64	.198	-1.10	5.32
	≤ last week	4.18	1.53	.006	1.17	7.18	2.96	1.54	.056	-0.07	5.98
	≤ last day	4.52	1.51	.003	1.57	7.48	4.16	1.52	.006	1.18	7.14
	Last hour	4.66	1.53	.002	1.65	7.66	4.98	1.54	.001	1.95	8.00
Ability to empathise		0.34	0.04	< .001	0.25	0.42	0.40	0.04	< .001	0.31	0.48
Attitudes to intimate touch		10.83	0.19	< .001	10.47	11.19	5.94	0.19	< .001	5.57	6.30
Week since start of 2020		0.13	0.06	.034	0.01	0.25	0.10	0.06	.098	-0.02	0.22
Interoceptive sensibility		1.18	0.20	< .001	0.80	1.56	0.68	0.20	.001	0.30	1.07
<i>Predictors of interest</i>											
Touch source		-8.16	0.79	< .001	-9.71	-6.62	-2.22	0.83	.007	-3.84	-0.60

Gender	2.42	0.64	< .001	1.16	3.68	4.17	0.67	< .001	2.84	5.49
Specific category	-25.98	0.60	< .001	-27.15	-24.81	-11.65	0.69	< .001	-13.01	-10.29
Touch source x gender	-1.38	0.90	.126	-3.16	0.39	-0.24	0.95	.801	-2.10	1.62
Touch source x specific category	-0.40	0.84	.636	-2.05	1.25	-6.24	0.98	< .001	-8.16	-4.32
Gender x specific category	-9.69	0.68	< .001	-11.02	-8.36	-5.72	0.79	< .001	-7.27	-4.17
Touch source x gender x specific category	-5.04	0.97	< .001	-6.95	-3.13	-7.94	1.13	< .001	-10.15	-5.73
Participant (random intercept)	197.84	4.35		189.49	206.56	151.84	4.46		143.34	160.85
Intercept residual	548.44	4.01		540.65	556.35	742.69	5.40		732.17	753.36

Note: For emotions, full model  $ICC = .265$ ,  $SE = .004$ , 95%  $CI = .256 - .275$ , Log-likelihood = -234080.52,  $AIC = 468199$ ,  $BIC = 468366.6$ ; model with covariates:  $ICC = .124$ ,  $SE = .004$ , 95%  $CI = .117 - .131$ , Log-likelihood = -357746.38,  $AIC = 715516.8$ ,  $BIC = 715627.1$ ; intercept-only model:  $ICC = .233$ ,  $SE = .004$ , 95%  $CI = .226 - .240$ , Log-likelihood = -441201.39,  $AIC = 882408.8$ ,  $BIC = 882437$ . For intentions, full model  $ICC = .170$ ,  $SE = .005$ , 95%  $CI = .161 - .179$ , Log-likelihood = -241642.9,  $AIC = 483323.8$ ,  $BIC = 483491.5$ ; model with covariates:  $ICC = .128$ ,  $SE = .004$ , 95%  $CI = .121 - .135$ , Log-likelihood = -358064.68,  $AIC = 716153.4$ ,  $BIC = 716263.8$ ; intercept-only model:  $ICC = .175$ ,  $SE = .003$ , 95%  $CI = .168 - .182$ , Log-likelihood = -439795.89,  $AIC = 879597.8$ ,  $BIC = 879626$ .



**Figure 3.** Emotion ratings for love and desire (left panel) and intention ratings for support and desire (right panel) by gender and touch source. Error bars denote +/- 1 standard error of the mean.

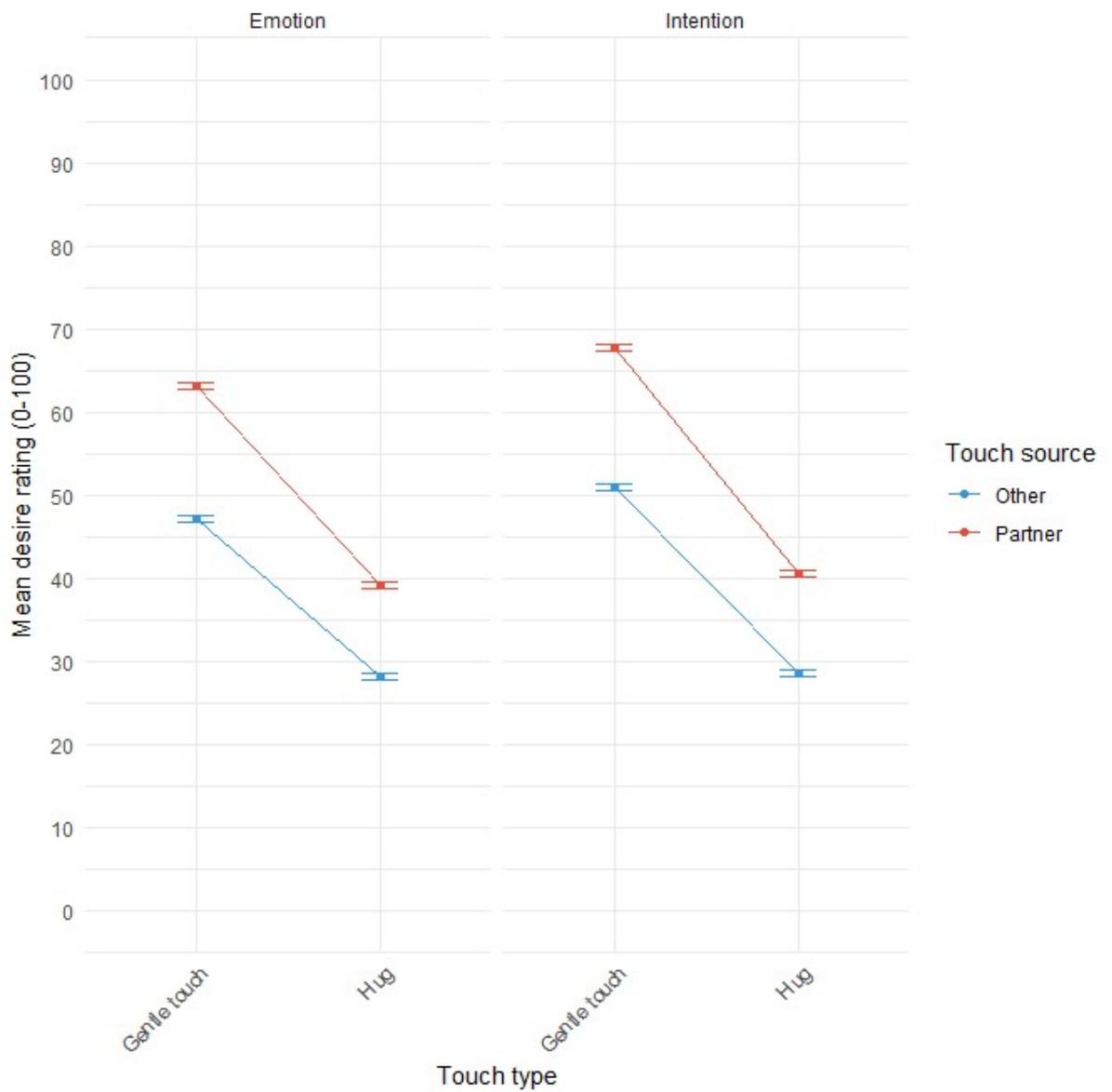
10.48,  $SE = .47$ ,  $p < .001$ ) and intentions (contrast = -5.64,  $SE = .49$ ,  $p < .001$ ), partially supporting the second part of Hypothesis 2.1.

Acknowledging the heterogeneous nature of the ‘other’ category, we also explored (analysis not pre-registered) possible differences between common sources of love and support by contrasting partner, family member, and friend for love (emotion) and support (intention). For love, the interaction between touch source and gender was significant ( $\chi^2(2) = 26.62$ ,  $p < .001$ ): both women and men reported feeling most love when they had had their partner in mind, followed by family member and then friend (see Supplementary Table 4 for full model results). All Bonferroni-corrected contrasts were significant for women, but friend and family member touch sources did not differ significantly for men. Regarding support, there were no significant effects of touch source, gender, or their interaction; see Supplementary Figure 1 for these exploratory results.

*Question 3: Do people consistently interpret slow, gentle, caressing touch as more erotic (desire emotions and intentions) than a hug, and particularly when they have their partners in mind?*

To test the third hypothesis that gentle, caressing touch would be experienced as and be seen to convey more arousal/lust/desire than a hug, especially if people had had their romantic partners rather than other people in mind (H3), we examined the effects of type of touch, touch source, and their interaction on ratings for desire only (separately for emotion and intention). Full model results are presented in Supplementary Table 5 (fit was best in full models). Confirming the first part of the question, gentle touch was rated as significantly more erotic than hugs for both emotions ( $f^2 = .13$ ;  $M = 55.70$ ,  $SE = .27$  for slow, gentle touch, and  $M = 34.04$ ,  $SE = .27$  for hugs) and intentions ( $f^2 = .16$ ;  $M = 59.92$ ,  $SE = .28$  for slow, gentle touch, and  $M = 34.99$ ,  $SE = .28$  for hugs). Furthermore, desire was rated more highly if participants had their partner vs. someone else in mind. These main effects were further qualified by a significant interaction between touch type and touch source for both emotions ( $f^2 = .001$ ) and intentions ( $f^2 = .001$ ); see Figure 4. While all Bonferroni-corrected contrasts were significant, the difference between hug and gentle touch was greater if participants had had their partner vs. someone else in mind for both emotions (partner contrast = -23.98,  $SE = .37$ ,  $p < .001$ ; other contrast = -18.96,  $SE = .40$ ,  $p < .001$  and intentions (partner contrast = -27.11,  $SE = .38$ ,  $p < .001$ ; other contrast

= -22.40,  $SE = .40$ ,  $p < .001$ ), supporting Hypothesis 3: gentle touch was rated as eliciting and conveying more desire when participants had thought of their partner as the source of the touch.



**Figure 4.** Emotion (left panel) and intention (right panel) ratings for desire by touch type and touch source. Error bars denote  $\pm 1$  standard error of the mean.

*Question 4: Is the communication of specific, positive emotions and social intentions via slow, gentle caressing touch and hugs predicted by individual differences in attachment, and positive recollection of childhood touch?*

We ran analyses separately for attachment and childhood touch. While the two concepts were significantly related (see Supplementary Materials), correlations between positive childhood touch and attachment anxiety ( $r = -.07, p < .001$ ) and attachment avoidance ( $r = -.22, p < .001$ ) were weak, warranting us to examine positive childhood touch and attachment as separate constructs. We hypothesised that less secure attachment (i.e., higher attachment anxiety and avoidance scores), would be associated with less positive (H4.1) and less distinct (H4.2) emotions and intentions for slow, gentle caressing touch and hugs. The same direction of effects was predicted for less positive parental touch recalled from childhood. We did not anticipate differences between types of touch, as both are used to signal closeness and support (Jakubiak & Feeney, 2016b; Morrison, 2016), and so tested our hypotheses across both types of touch in the analyses, as pre-registered. However, as an exploratory analysis (not pre-registered), we also repeated analyses for hugs and gentle touch separately – patterns of effects were identical to those in the pre-registered analysis except that, for emotions only, all ratings were higher for gentle touch compared to hugs (see Supplementary Figure 2).

*Attachment style:* Valence, attachment anxiety, attachment avoidance, and all interaction terms were examined as predictors of interest. All touch ratings were entered as the outcome. Full model results are presented in Table 3, and model fit was best for full models. There was a significant interaction between valence, attachment anxiety and attachment avoidance for both emotions ( $f^2 = .002$ ) and intentions ( $f^2 < .001$ ). We broke this interaction down by examining effects of valence at  $-1SD$  and  $+1SD$  for attachment anxiety and avoidance scores (Aiken & West, 1991), an approach which allows us to conceptualise attachment dimensions as ‘categories’ (Bartholomew & Horowitz, 1991), though using scores rather than grouping individuals. As outlined in Methods,  $-1SD$  on both anxiety and avoidance was labelled as ‘secure attachment’,  $+1SD$  anxiety/ $-1SD$  avoidance as ‘anxious attachment’,  $-1SD$  anxiety/ $+1SD$  avoidance as ‘avoidant attachment’, and  $+1SD$  on both dimensions as ‘fearful attachment’. Results are presented in Figure 5. Bonferroni-corrected planned contrasts (with secure

attachment as reference category) are presented in Supplementary Table 6. Higher avoidant and fearful attachment scores were associated with higher ratings of negative emotions and intentions than secure attachment scores ( $p < .001$ ), while there was no difference between secure and anxious attachment scores. Furthermore, avoidant and fearful attachment scores were associated with lower ratings for positive emotions and intentions than secure attachment, while anxious attachment scores were associated with higher ratings for positive emotions and intentions than secure attachment scores (all  $p < .001$ ). Thus, part 1 of the hypothesis was partially supported for avoidant and fearful but not anxious attachment sub-types of insecure attachment. Notably, findings for anxious and avoidant/fearful attachment went in opposite directions. We repeated the analysis with the same steps for only the people who thought of their partner (exploratory question in pre-registration). Results fully mirrored those in the full sample (see Supplementary Table 7).

To examine the discriminability question, we computed a ‘distinctiveness’ score. This particular outcome measure was not pre-registered but was needed to be able to address the ‘distinct’ part of the hypothesis. Separately for emotions and intentions, we computed absolute difference scores for the different emotions/intention categories (e.g., love vs. happiness, love vs. desire, love vs. annoyance, love vs. anger, love vs. fear and repeated for all combinations) and took the average of all these absolute differences as the outcome. Greater scores therefore denoted greater differences, that is, distinctions between emotion categories and intention categories. As the outcome variables were negatively skewed, we ran a multiple regression analysis with bootstrapping (1000 replications). For both emotions and intentions, attachment anxiety and avoidance (but not their interaction) were significantly associated with distinctiveness – but in opposite directions (see Table 4 for full model results). While higher attachment avoidance was associated with lower distinctiveness (partial  $\eta^2 = .020$  for emotions and  $.007$  for intentions), supporting this part of the hypothesis, attachment anxiety was associated with greater distinctiveness of categories (partial  $\eta^2 = .003$  for emotions and  $.002$  for intentions). This finding is thus in contrast with this part of the hypothesis, but in line with results for part 1; that is, anxiety and avoidance showed opposite patterns. When examining these associations only in participants who had thought of their partner, results were very similar (see Supplementary

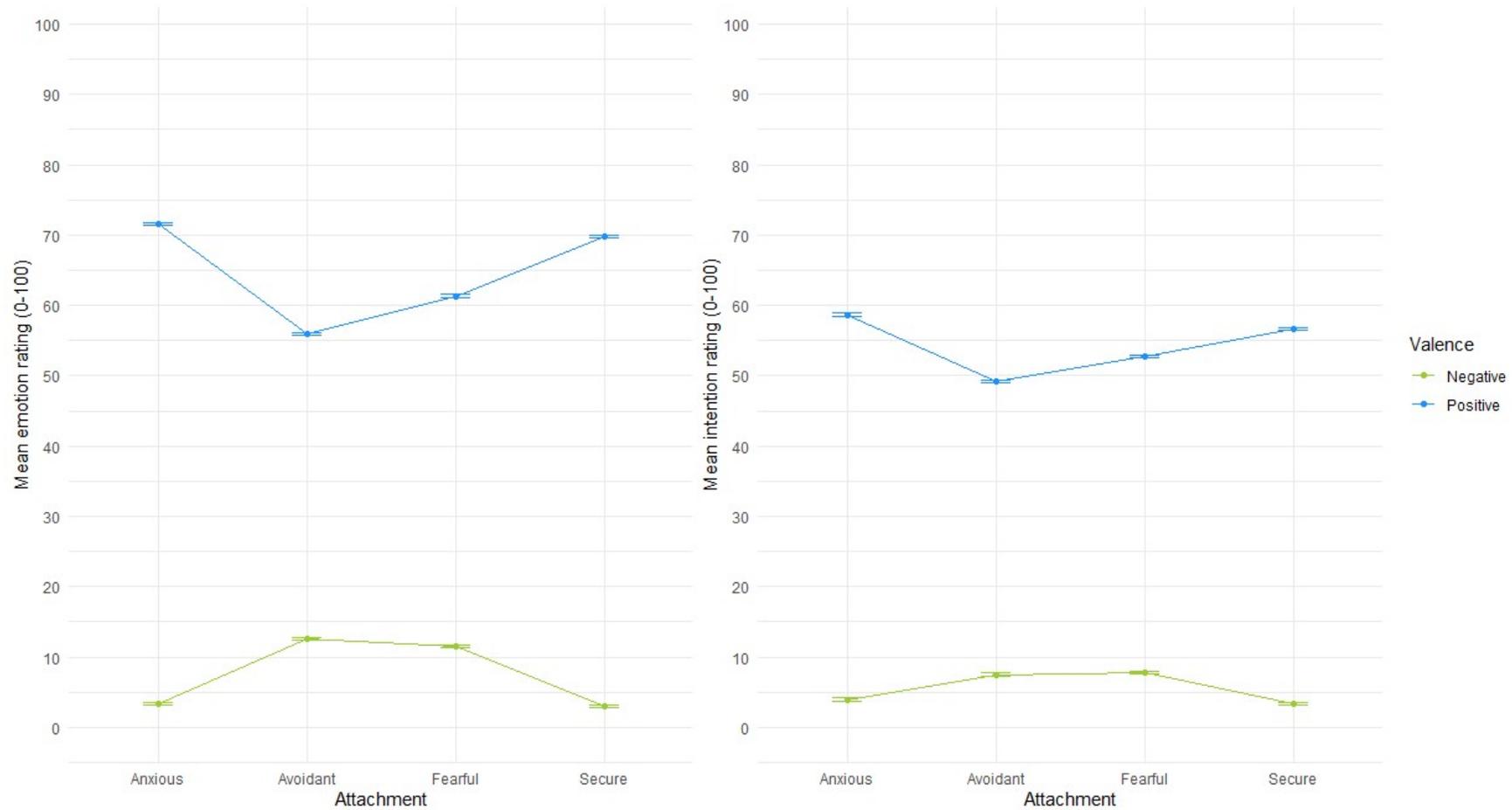
**Table 3.** Interaction between valence, attachment anxiety, and attachment avoidance on ratings for emotions and intentions.

		Emotions					Intentions				
		<i>b</i>	<i>SE</i>	<i>p</i>	95% CI		<i>b</i>	<i>SE</i>	<i>p</i>	95% CI	
<i>Intercept</i>		-11.84	0.90	< .001	-13.61	-10.07	-7.76	1.02	< .001	-9.75	-5.77
<i>Covariates</i>											
Last time touched	>1 month ago	-0.59	0.87	.499	-2.29	1.11	-0.52	0.98	.594	-2.43	1.39
(Over a year ago = ref category)	≤ last month	-1.13	0.81	.161	-2.72	0.45	-1.24	0.91	.172	-3.03	0.54
	≤ last week	-0.64	0.76	.397	-2.13	0.85	-0.83	0.86	.335	-2.51	0.85
	≤ last day	0.08	0.75	.912	-1.39	1.55	-0.12	0.85	.884	-1.78	1.54
	Last hour	0.60	0.76	.434	-0.90	2.09	0.32	0.86	.712	-1.37	2.00
Ability to empathise		0.20	0.02	< .001	0.15	0.24	0.21	0.02	< .001	0.16	0.26
Attitudes to intimate touch		3.74	0.09	< .001	3.56	3.92	2.21	0.10	< .001	2.01	2.42
Week since start of 2020		0.06	0.03	.053	0.00	0.12	0.06	0.03	.074	-0.01	0.13
Interoceptive sensibility		0.17	0.10	.068	-0.01	0.36	0.30	0.11	.004	0.10	0.51
<i>Predictor of interest</i>											
Valence		57.04	0.11	< .001	56.83	57.25	48.64	0.10	< .001	48.44	48.84

Meaning of touch: Context and person matters

Attachment anxiety	-0.16	0.07	<b>.022</b>	-0.30	-0.02	0.15	0.07	<b>.042</b>	0.01	0.29
Attachment avoidance	3.60	0.09	<b>&lt; .001</b>	3.43	3.76	1.62	0.09	<b>&lt; .001</b>	1.44	1.80
Valence x Attachment anxiety	1.44	0.08	<b>&lt; .001</b>	1.29	1.59	0.83	0.07	<b>&lt; .001</b>	0.69	0.97
Valence x Attachment avoidance	-8.46	0.09	<b>&lt; .001</b>	-8.64	-8.29	-4.33	0.08	<b>&lt; .001</b>	-4.49	-4.16
Attachment anxiety x Attachment avoidance	-0.20	0.05	<b>&lt; .001</b>	-0.30	-0.10	-0.05	0.05	.368	-0.15	0.06
Valence x Attachment anxiety x Attachment avoidance	0.70	0.06	<b>&lt; .001</b>	0.59	0.81	0.27	0.05	<b>&lt; .001</b>	0.16	0.37
Participant (random intercept)	61.86	1.21		59.53	64.28	97.23	1.51		94.32	100.23
Intercept residual	630.46	2.00		626.56	634.38	554.80	1.75		551.38	558.24

Note: For emotions, full model  $ICC = .089$ ,  $SE = .002$ , 95%  $CI = .086 - .093$ , Log-likelihood = -1017836.9,  $AIC = 2035712$ ,  $BIC = 2035907$ ; model with covariates:  $ICC = 1.75e-16$ ,  $SE = 0$ , 95%  $CI = 1.75e-16 - 1.75e-16$ , Log-likelihood = -1111763.2,  $AIC = 2223550$ ,  $BIC = 2223674$ ; intercept-only model:  $ICC = .005$ ,  $SE = .001$ , 95%  $CI = .003 - .007$ , Log-likelihood = -1360813.1,  $AIC = 2721632$ ,  $BIC = 2721664$ . For intentions, full model  $ICC = .149$ ,  $SE = .002$ , 95%  $CI = .145 - .153$ , Log-likelihood = -1014025.5,  $AIC = 2028089$ ,  $BIC = 2028285$ ; model with covariates:  $ICC = .035$ ,  $SE = .001$ , 95%  $CI = .032 - .037$ , Log-likelihood = -1096085,  $AIC = 2192194$ ,  $BIC = 2192318$ ; intercept-only model:  $ICC = .043$ ,  $SE = .001$ , 95%  $CI = .041 - .046$ , Log-likelihood = -1341257.1,  $AIC = 2682520$ ,  $BIC = 2682552$ .



**Figure 5.** Mean touch ratings for positive and negative emotions (left panel) and intentions (right panel), by attachment scores. Error bars show  $\pm 1$  standard error of the mean. Note. Secure attachment =  $-1SD$  on anxiety and  $-1SD$  on avoidance dimension; avoidant attachment =  $-1SD$  on anxiety and  $+1SD$  on avoidance dimension; anxious attachment =  $+1SD$  on anxiety and  $-1SD$  on avoidance dimension; fearful attachment =  $+1SD$  on anxiety and  $+1SD$  on avoidance dimension.

**Table 4.** Bootstrapped regression analysis for effects of attachment anxiety and attachment avoidance on distinctness of emotions and intentions.

	<b>Emotions</b>						<b>Intentions</b>				
		<i>b</i>	<i>SE</i>	<i>p</i>	95% CI		<i>b</i>	<i>SE</i>	<i>p</i>	95% CI	
<i>Intercept</i>		16.56	1.19	< .001	14.24	18.88	16.65	1.13	< .001	14.44	18.86
<i>Covariates</i>	Last time touched										
	>1 month ago	-0.81	1.11	.469	-2.99	1.38	0.81	1.10	.460	-1.34	2.96
	(Over a year ago = ref category)										
	≤ last month	-1.06	1.05	.310	-3.12	0.99	1.26	1.05	.228	-0.79	3.32
	≤ last week	0.24	1.03	.817	-1.78	2.26	2.01	0.99	.043	0.07	3.95
	≤ last day	0.78	1.02	.444	-1.21	2.77	2.79	0.99	.005	0.86	4.73
	Last hour	1.49	1.02	.143	-0.51	3.49	3.27	1.00	.001	1.32	5.22
	Ability to empathise	0.26	0.02	< .001	0.22	0.30	0.32	0.02	< .001	0.28	0.36
	Attitudes to intimate touch	4.30	0.10	< .001	4.10	4.50	2.59	0.10	< .001	2.40	2.78
	Week since start of 2020	0.31	0.03	< .001	0.26	0.36	0.17	0.03	< .001	0.12	0.23
	Interoceptive sensibility	0.75	0.10	< .001	0.55	0.95	0.62	0.10	< .001	0.43	0.81
<i>Predictors</i>	Attachment anxiety	0.17	0.06	<b>.003</b>	0.06	0.28	0.37	0.06	< <b>.001</b>	0.26	0.48
<i>of interest</i>	Attachment avoidance	-1.14	0.08	< <b>.001</b>	-1.29	-1.00	-0.86	0.08	< <b>.001</b>	-1.01	-0.71
	Attachment anxiety x Attachment avoidance	-0.01	0.05	.806	-0.11	0.08	0.07	0.04	.102	-0.01	0.16

Materials and Supplementary Table 8): here, the attachment by avoidance interaction was significant, showing that avoidant/fearful attachment scores were associated with lower distinctness of emotions and intentions, while anxious and secure attachment scores were associated with greater distinctness.

*Positive childhood touch:* Valence, positive childhood touch, and their interaction, were examined as predictors of interest. We considered all touch rating and ran the analysis across type of touch. There was a significant interaction between valence and positive childhood touch for both emotions ( $f^2 = .009$ ) and intentions ( $f^2 = .004$ ; see Supplementary Table 9 for full model results). Although all planned contrasts (comparing positive vs. negative valence at  $-1SD$ , mean, and  $+1SD$  of positive childhood touch scores) were significant, greater positive childhood touch was related to higher ratings for positive and lower ratings for negative emotions and intentions, in line with the first part of the hypothesis (see Supplementary Figure 3). Furthermore, in the distinctiveness analysis, greater positive childhood touch was significantly associated with greater discrimination between emotion categories (partial  $\eta^2 = .004$ ) and intention categories (partial  $\eta^2 = .003$ ), supporting part 2 of the hypothesis (see Supplementary Table 10). Taken together, more positive reported childhood touch was associated with more positive emotions and intentions, and greater distinctiveness between emotion and intention categories when rating imagined social touch.

## Discussion

The present study sought to investigate how relational context and person variables shape the meaning associated with imagined prosocial touch. We found that, overall, gentle, caressing touch and hugs were rated as evoking and conveying more positive than negative emotions and intentions, supporting our first hypothesis (H1). Considering the relational context, specifically who participants had had in mind when rating the touch, we found that ratings of love and desire (emotions) and love and support (intentions) were higher when participants had had their partner (vs. someone else) in mind, supporting H2, and that these findings were moderated by gender: while both men and women rated love, support, and desire more strongly when they had their partner (vs. someone else) in mind, women gave lower ratings for desire than did men for emotions and intentions in general (partially supporting H2.1). Focusing on erotic arousal, specifically, we further found that desire ratings were higher for

gentle touch compared to hugs, particularly when participants had had their partner (vs. someone else) in mind, in line with H3. Lastly, considering individual differences, we found partial support for H4, in that results diverged for anxious and avoidant attachment: avoidant attachment scores were associated with lower ratings for positive emotions and intentions, and less distinctness between categories, compared to secure attachment scores, whereas anxious attachment scores were associated with higher ratings for positive emotions and intentions and greater discriminability between categories compared to secure attachment scores. Positive childhood touch was associated with more positive emotions and intentions, and greater distinctness between emotion and intention categories when rating imagined social touch.

Considering hugs and slow, gentle touch together, we first hypothesised that these forms of touch would generally be rated as conveying positive rather than negative emotions and intentions. Gentle stroking has previously been found to be decoded as the emotions love (Hertenstein et al., 2006; McIntyre et al., 2022) and desire (Kirsch et al., 2018), and the intention to communicate support (Kirsch et al., 2018). Hugging has been associated with positive mood (Packheiser et al., 2023) and holding or light squeezing has been associated with gratitude (McIntyre et al., 2022). We used the emotion and intention categories in Kirsch et al. (2018), and presented the same synonyms for each to help clarify concepts. Though we explored specific emotions and intentions in regard to different relational contexts, we were initially interested in general valence effects of gentle touch and hugs, rather than clarifying which specific emotions and intentions were associated with touch. We found that, across the two types of touch, participants gave significantly higher ratings for feeling positive (vs. negative) emotions when imagining the touch, and for positive (vs. negative) intentions being conveyed by this touch. Our findings support the idea that in general, hugs and gentle touch are associated with positive meaning.

This interpretation of touch as positive has been conceptualised as a critical pathway to wellbeing in close relationships (Jakubiak & Feeney, 2017). Jakubiak and Feeney (2017) propose that seeing touch as affectionate and prosocial leads to cognitive-relational changes, including increased felt security, which facilitates closeness and increases cognitions that support is available when needed. In

other words, this model highlights the link between the meaning associated with touch, secure attachment, and enhanced wellbeing. Jakubiak and Feeney's model does not contrast close relationships with other relationships, and indeed, when we contrasted partner, friend, and family member, touch imagined from all these close relationship contexts was similarly associated with support (and there were no gender differences). As participants were asked to indicate who they had had in mind *after* they completed the touch ratings, it is possible that people naturally chose to think of supportive and loving others. Furthermore, it is possible that people responded in ways that reflect social norms around recognising hugs and gentle touch as positive rather than how they themselves would feel or interpret such touch. However, varying imagined touch source more systematically by asking certain participants to imagine their partner (if they had one) and others to imagine somebody else, or probing touch norms more comprehensively, was beyond the possibilities of this large-scale survey. Indeed, it would not have been in keeping with the Touch Test's aims to explore naturally occurring attitudes towards touch and touch experiences in the general population.

We did find several effects that were strongest in partner contexts. Love and desire (the latter more so for men than women) were rated more highly when participants had their partner (vs. someone else) in mind, and this was still the case for love when we contrasted partner with friend and family member. Regarding desire, we examined hugs and gentle stroking touch separately because adult partners stroke each other at speeds which are optimal for activating CT fibres (Croy et al., 2016) and this CT-optimal, gentle touch (compared to non-CT-optimal touch) is perceived as erotically arousing (Bendas et al., 2017) in close relationship contexts (Panagiotopoulou et al., 2018). Building on the role of CT-mediated touch in shaping arousal, we found, in line with our hypothesis, that gentle touch was rated as significantly more erotic than hugs for both emotions and intentions. Furthermore, gentle touch was most arousing, and decoded as conveying desire, when participants had had their partner (vs. someone else) in mind. A limitation here is that previous research explored touch to erogenous vs. non-erogenous zones and, while dissociable from stroking speed in Panagiotopoulou et al. (2018)'s study, it would have been useful to ask which body parts participants were imagining being touched. Not asking participants to indicated imagined touch location is a more general limitation of the present

research. Touch meaning may vary depending on where touch is applied, and this may interact with relationship closeness (McIntyre et al., 2022; Suvilehto et al., 2015), and person factors such as attachment styles, especially if the location imagined is more or less intimate. Furthermore, arousal ratings for touch to one's own body have been found to correspond with arousal for touch when imagining one's partner's body (Maister et al., 2020), and examining meaning of touch in terms of evoking and conveying arousal would be interesting to explore in reciprocal interpersonal tasks. Nevertheless, our findings demonstrate that closeness and intimacy with an imagined toucher shape the meaning of slow, gentle touch and hugs, with differences for men and women in these effects.

Most previous research has investigated the role of person variables in shaping the affective quality of touch (e.g., perceived pleasantness; see Suvilehto et al., 2015; Sailer & Ackerley, 2019) or its effects in terms of reducing negative affective states (e.g., Krahe et al., 2016; von Mohr et al., 2018) and increasing wellbeing (Debrot et al., 2020). We examined both positive childhood touch and differences in adult attachment style as potential moderators of how touch is felt and interpreted from imagined social touch. Regarding the former, more positive childhood touch was linked to more positive emotions and intentions associated with touch, and more nuanced discrimination between emotion and intention categories. Of note, positive childhood touch was retrospectively reported, and the scale, though it had good internal consistency, comprised only two items taken from a longer, validated scale, and thus findings should be interpreted with caution.

Examining attachment styles (the development of which is undoubtedly influenced by positive childhood touch, although the correlation between the two constructs was weak in the present study), we hypothesised that insecure attachment would be associated with less positive and distinct emotions and intentions. Higher attachment avoidance is linked with higher levels of mistrust in others, maintaining interpersonal distance and – as research also using Touch Test data showed – a greater tendency to avoid tactile treatments in health settings (Vafeiadou, Bowling, Hammond, & Banissy, 2022). Higher attachment anxiety is related to a more ambivalent stance, namely simultaneously desiring closeness and fearing rejection and abandonment (Mikulincer et al., 2003). Higher attachment anxiety has also been associated with reduced discrimination between 'affective' CT-optimal stroking touch

and more ‘neutral’ non-CT-optimal touch when rating pleasantness (Krahé et al., 2018). In this paper, our prediction regarding attachment avoidance was confirmed, but attachment anxiety was linked to more positive emotions and intentions and greater discrimination between categories. It is possible that hypervigilance and ‘hyperactivating strategies’ (Mikulincer et al., 2003) associated with greater attachment anxiety makes social signals especially salient and facilitate a more nuanced interpretation of them, even when imagined. While this finding is at odds with research examining the affective quality of touch, it can be explained in relation to Sailer and Leknes (2022)’s model, in which touch meaning is compared with goals to impact affective experience. In this sense, positive touch meaning and the relational goal to seek closeness and reassurance may reduce differences in perceived pleasantness between what are ultimately two forms of social touch.

In contrast to previous research in which participants indicated which emotions and intentions they thought were conveyed by the toucher (Kirsch et al., 2018), the Touch Test asked participants to indicate which emotions *they themselves felt* when imagining social touch. While we have conceptualised both emotions (evoked) and intention (communicated) ratings as interpreting and ascribing meaning to touch, it could be argued that emotion ratings reflect affective quality of touch rather than meaning per se. However, as we have discussed, these concepts inform each other in likely reciprocal ways (Sailer & Leknes, 2022) and are difficult to untangle from survey data. Given that emotion and intention results mirrored each other for most analyses, and intention categories included concepts such as praise and support, which are not emotion terms, it is unlikely that participants approached emotions and intentions in entirely different ways. However, the similarities between the two do indicate that participants might not have distinguished between emotions and intentions in the way it was intended.

Too few participants from outside the United Kingdom completed the survey to address differences across countries or world regions, and so only participants resident in the United Kingdom were included in the current study. Fascinating research is emerging on regional and cultural factors, such as regional temperature and collectivism, in shaping touch behaviour (Sorokowska et al., 2021) and it would be invaluable to study such factors in relation to touch meaning. Furthermore, this study

was cross-sectional in nature, and so we cannot make any claims regarding causality. In addition, all measures were self-reported and some measures were unvalidated, as they were shorter versions of existing scales. These are limitations of the present research and reflect the compromises inherent in designing large-scale surveys. Lastly, while we studied imagined touch rather than directly experienced touch, which comes with obvious limitations, imagined touch likely draws on memories, and is perhaps even more susceptible to individual differences than first-hand touch would be (Cao et al., 2018).

Recruiting a big sample from the general population, with a large age range (especially compared to laboratory studies often conducted in student samples), allowed us to explore contextual and person variables emerging from research on experienced touch with more power and statistical rigour than is sometimes possible in laboratory settings. We were able include relevant covariates and examine complex interaction effects, including gender differences. We confirmed certain findings (the overwhelmingly positive meaning ascribed to gentle touch and hugs), and discovered novel insights regarding attachment styles, showing that attachment anxiety and avoidance are differentially associated with discriminability of specific emotions and intentions elicited and conveyed by imagined touch. These findings can now inform studies systematically exploring the influence of contextual and person variables on directly experienced touch to enhance our understanding of the meaning of touch in social interactions, and the promotion of wellbeing through touch.

**Statements and declarations**

The authors declare no conflict of interest. MJB is author of *When We Touch / Touch Matters* published by a commercial publisher.

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