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The influence of duration, arm crossing style, gender, and emotional closeness on hugging behaviour

Anna L. Dueren [a,*], Aikaterini Vafeiadou [a], Christopher Edgar [b], Michael J. Banissy [a,c,*]

[a] Department of Psychology, Goldsmiths, University of London, London SE14 6NW, UK
[b] Birkbeck, University of London, Malet Street, Bloomsbury, London WC1E 7HX, UK
[c] University of Bristol, Beacon House, Queens Road, Bristol, BS8 1QU, UK

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ABSTRACT

Hugging is one of the most common types of affective touch encountered in everyday life. However, little is known about the factors that influence hugging evaluation and behaviour. Here, we aimed to assess how different hugs would be evaluated and whether they can affect mood. Furthermore, we aimed to investigate what kind of arm crossing is common in a naturalistic setting and whether arm crossing style could be predicted from gender, emotional closeness, and the height difference of huggers. We conducted two studies addressing these questions. In study 1, participants hugged a confederate for 1 second (s), 5 s or 10 s with two different arm crossing styles and reported how pleasant, arousing and under control the touch felt. Additionally, participants were asked about their mood ("self-ratings") immediately after, 3 minutes (min) after and 6 min after each hug. In study 2, participants were approached on campus and asked to share a hug, with arm crossing style being the dependent variable. The height difference, gender and self-rated emotional closeness to the hug partner were recorded as possible predictors for arm crossing style. Results from study 1 indicate that duration matters more than arm crossing style for hug pleasure, arousal, and control, with 1 s hugs being rated as least pleasant and under control than 5 s and 10 s hugs. Accordingly, 1 s hugs also resulted in lower pleasure self-ratings immediately post hug than 5 s and 10 s hugs. Arousal self-ratings were higher immediately post hug than several minutes after a hug. In study 2, gender was linked to arm crossing style, with male-male hug dyads exhibiting a different hugging style from female-female dyads. These findings are discussed in relation to previous hug research and gender differences in touch behaviour.

1. Introduction

Despite the high prevalence of hugs in everyday life, hugs have not been widely studied in adult experimental research. The research that has been conducted suggests that hugs can provide emotional support and might function as a stress buffer (Cohen et al., 2015; Light et al., 2005; van Raalte & Floyd, 2020). Some predominantly correlational studies found that frequent hugging is associated with decreased physiological measures of stress, such as lower blood pressure (Light et al., 2005), lower levels of proinflammatory cytokines (van Raalte & Floyd, 2020), or improved immune system response to a cold virus (Cohen et al., 2015). However, such studies have mainly investigated the overall frequency of hugs that a person experiences; hence it remains unclear whether the type of hug matters for the association between hugging and positive emotional and health outcomes. Here, we aimed to assess whether there are preferences for different types of hugs and whether certain types of hugs are more common than others.

Relevant features of a hug that may influence their perception, consequences and prevalence are thought to include hand placement, duration, body position, pressure, and whether torsos touch (Forsell & Åström, 2012; Straker, 2002). Floyd (1999) let students watch videos of hugs that varied on three factors: arm crossing (criss-cross style, neck-waist style, engulfing style, described in Section 2.1.3), duration (1 s (1 s), 3 s and 5 s), and gender of huggers. Participants were asked to rate the interactions on a range of dimensions such as positivity, egalitarianism, expectedness, and intimacy. Regarding arm crossing, results indicated that criss-cross hugs were rated as more egalitarian, intimate, and positive than neck-waist hugs (however, note that the difference in positivity was not statistically significant when analysed with pairwise comparisons; Floyd, 1999).

* Corresponding authors.
E-mail addresses: aduer001@gold.ac.uk (A.L. Dueren), m.banissy@gold.ac.uk (M.J. Banissy).

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The relevance of arm crossing in hugs has further been addressed by studies investigating hug lateralisation. Such studies observed which arm is dominant, e.g. right lateralisation is defined as huggers embracing in such a manner that their heads rest to the right of each other (Ocklenburg et al., 2018;Packheiser et al., 2019; Turnbull et al., 1995). These studies reported an overall right lateralisation bias when observing people hugging each other (Packheiser et al., 2019; Turnbull et al., 1995), which was modulated by gender and emotional context (Packheiser et al., 2019). However, whether participants used a criss-cross hug, or a neck-waist hug was not reported, and participants were not asked whether they preferred one type of arm crossing over the other.

Regarding hug duration, one observational study reported that the average hug between athletes winning a competition is 3 s (Nagy, 2011). In Floyd's (1999) study, duration did not appear to have a linear effect on hug evaluation. Interestingly, the 1 s hug was the most positively evaluated and most expected, followed by the 5 s hug and then by the 3 s hug. However, extrapolating from this study is difficult because the difference between hug durations was restricted to 2 s and because participants watched the hugs rather than experienced the touch themselves. Recently, further evidence on the importance of hug duration has emerged from the field of social robotics. Block and Kuchenbecker (2019) conducted an experiment in which a hugging robot's physical properties and hugging behaviour were manipulated. Three hug durations were tested: 1) the "too short" condition, which lasted for 1 s, 2) the "immediate release" condition in which the hug lasted until the participant let go their arms from the robot's back, and 3) the "too long" condition in which the hug lasted until 5 s after the participant let go. After each hug, participants were asked to judge the robot on several dimensions. Following the immediate release condition and the too-long condition, the robot was considered more social, caring, happy and comforting in comparison to the too-short condition. Here, we addressed the questions of whether arm crossing style and hug duration influence hug ratings.

Gender (e.g. same-gender vs different-gender hugging dyads) and the relationship between huggers has also been suggested to influence hugging behaviour (Forsell & Åström, 2012). In Floyd's (1999) study, gender composition of the hugging dyad had a significant effect on hug expectedness, with hugs between women being rated as more expected than hugs between men. However, gender did not significantly influence how positively the hugs were evaluated (Floyd, 1999). The role of gender in hugging preferences and outcomes, therefore, remains equivocal and requires further investigation. In the broader literature on affective touch, which includes gentle stroking, gender emerged as a consistent predictor of touch behaviour and evaluation (e.g. Bendas et al., 2017; Harjunen et al., 2017; Hertenstein & Keltner, 2011; Miller et al., 2014; Stier & Hall, 1984; Suvilehto et al., 2015). Similarly, prior work suggests that the relationship between touch partners influences affective touch (Forsell & Åström, 2012; Suvilehto et al., 2015; Thompson & Hampton, 2011).

Here, we sought to address some of these gaps in the literature by conducting two studies. Study 1 sought to determine preferences for different types of hugs by manipulating hug duration and arm crossing style in a laboratory setting. As prior literature suggests that arm crossing and hug duration are relevant for hug evaluation (Floyd, 1999; Forsell & Åström, 2012), we predicted 1) that arm crossing style will impact hug preferences, with hugs with more egalitarian style (criss-cross hugs) expected to be rated as more pleasant. Based on prior work on hug duration (Block & Kuchenbecker, 2019), we predicted 2) that longer hugs would be rated as more pleasant than shorter hugs. In addition to hug preferences, we also sought to determine the impact of different hugs on mood several minutes after each hug. This was done by asking participants to rate their mood at various timepoints after receiving a hug ("self-ratings"). Given our expectations that hug duration and arm crossing style would impact hug ratings, we also expected these manipulations to influence self-ratings.

Study 2 built on Study 1 by moving our work from the laboratory to examine hugging in naturalistic settings. We sought to do this in order to: 1) address calls for more ecologically valid touch research (Schilbach et al., 2013) and psychological research more generally (Yarkoni, 2020); 2) to examine if arm-crossing style preferences found in previous literature extend to real-world settings (Floyd, 1999) and 3) to determine how differences in gender and emotional closeness of hugging partners may or may not relate to hugging behaviour. Based on prior work in the related domain of affective touch (Floyd, 1999; Miller et al., 2014; Suvilehto et al., 2015), we predicted: 1) that criss-cross hugs are the most common hugs in a naturalistic setting and 2) that gender and emotional closeness of hugging partners influence hugging style.

2. Study 1

In study 1, we assessed whether hug duration and arm crossing influenced the evaluation of hugs and self-ratings at several time points after each hug. Therefore, a fully factorial within-subject study was conducted with participants experiencing six hugs (three durations × two arm crossing styles). It was expected that: 1) hugs with a more egalitarian arm crossing style (like a criss-cross hug, described in Section 2.1.3.) would be rated as more pleasant and 2) longer hugs would be more rated as pleasant than shorter hugs. The assessment of self-mood ratings was exploratory, so while differences were expected depending on the type of hug, the directional nature of the effect was equivocal. Note that in this study, only females were examined due to resource constraints.

2.1. Methods

2.1.1. Participants

There were 48 female participants recruited (age $M = 20.27$, $SD = 3.16$). One participant was excluded from the analysis because they interrupted the 10 s neck-waist hug and requested to withdraw. Two more participants were excluded because they did not end the 1 s hugs in time, so the sample used for analyses consisted of 45 participants (age $M = 20.38$, $SD = 3.24$). The sample size was calculated using G*Power (Faul et al., 2007) and based on the effect size of hug duration on hug evaluation ($\eta^2p = 0.06$) in Floyd (1999). Alpha was set at 0.05 and power of 0.95. Power calculation resulted in a minimum required sample of 42. Participants were compensated with course credits or financial rewards. The experiment was approved by the local ethics committee.

2.1.2. Procedure

Upon arrival, participants provided written informed consent. Participants were seated in front of a computer and were familiarised with the rating scale. Participants were told to use the rating scale in a relative manner, i.e., to compare each rating to the ratings they gave in previous trials. Next, participants indicated their age and answered the baseline self-rating questions (see Section 2.1.3 and Table S1).

The first trial started with participants standing up to receive the first hug. After the hug, participants sat down and were asked to give hug ratings and self-ratings. Additionally, they had the option to provide some qualitative information about the hug. Next, participants were asked to listen to a part of an audiobook and to concentrate on its content. After 3 min, the audiobook was interrupted, and self-ratings were retaken. Participants were also asked for some keywords about the content of the audiobook as an attention check. The self-ratings and audiobook questions were repeated after three more minutes of listening, after which participants were asked to stand up for the next hug (procedure illustrated in Fig. 1). This procedure was repeated six times.

After the last hug, participants were asked with a forced-choice question whether the height difference between them and the confederate influenced their hug experience and if so, in what way it mattered

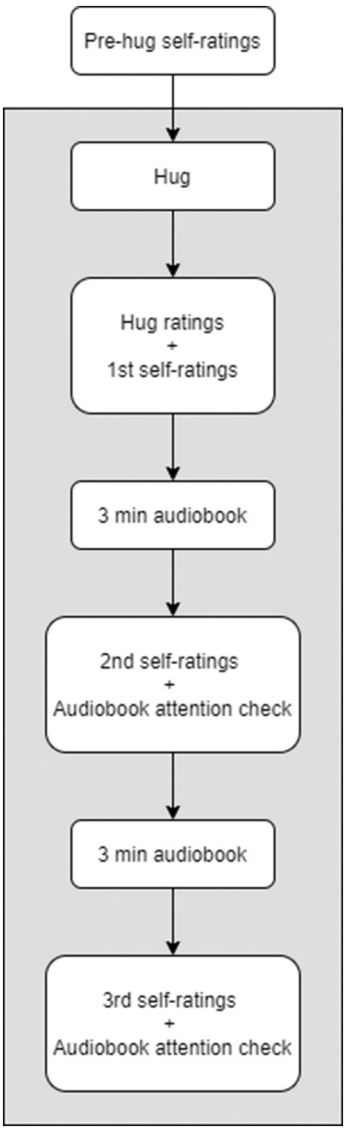

Fig. 1. Timeline of study 1. After each hug, participants were asked to evaluate the hug and give an immediate post-hug self-rating. Participants then waited for 3 min during which they listened to an audiobook and were subsequently asked to complete self-ratings and attention checks. This procedure was repeated so that three self-ratings were obtained after each hug. The procedure in the grey box was repeated for each hug (six times).

(Table S1). Finally, the participants' height was measured, participants were then debriefed and received compensation.

2.1.3. Measures and conditions

2.1.3.1. Hugs. The experiment was conducted by two female experimenters, one of whom shared hugs with participants (hereafter "confederate"). Participants were informed that they shared hugs with the same female experimenter throughout the experiment. Before each hug, participants were instructed to stand up and were handed a blindfold to cover their eyes to avoid visual feedback influencing touch perception (Kirsch et al., 2018; Noel et al., 2014). They were asked to stand with their arms stretched out to the sides so that the confederate could approach them easily and were instructed to reciprocate the hug. The confederate was seated in a separate part of the room and entered the testing area only when the participant wore the blindfold. Hugs were timed with auditory cues through the confederate's earphones, and the experimenter controlled for hug duration with a stopwatch. Timing started when the confederate's hands touched the participants' backs. Hugs lasted for 1 s, 5 s or 10 s and were administered in criss-cross style or neck-waist style (Floyd, 1999). During a criss-cross hug, the arms of hug partners A and B are crossed over each other's shoulder and waist (Fig. 2). During a neck-waist hug, person A hugs the shoulders of person B, who wraps their arms around the waist of person A (Fig. 2). These arm crossing styles were chosen because piloting revealed that they were most prevalent when spontaneously asking friends to share a hug. For the neck-waist hugs, the confederate always put their arms around the participants' waists.

2.1.3.2. Hug ratings. Following each hug, participants rated how pleasant and arousing the hug felt for them and how much control they felt over the hug (Table S1). These questions were rated on a scale from 0 to 100. Finally, participants were invited to write down additional thoughts after each hug (Table S1).

2.1.3.3. Self-ratings. Participants were asked how pleasant, aroused and in control of the situation they felt at the start of the experiment and at several timepoints after the hugs. Hence, self-ratings evaluated the same dimensions as hug ratings and were also rated on a scale from 0 to 100.

2.1.3.4. Audiobook. The audiobook used to separate the repeated self-ratings was "A Short History Of Nearly Everything" (Bryson, 2003), a book that has been used previously in studies investigating emotionally neutral states (Smallwood et al., 2009; Smilek et al., 2010).

2.1.4. Design

Hug duration and arm crossing were manipulated in a fully factorial 3 (hug duration) × 2 (arm crossing) design, so each participant experienced six different hugs (Table 1). Hugs were randomised in a balanced Latin Square design, i.e., every hug followed every other hug an equal number of times to reduce order effects.

2.2. Results

2.2.1. Hug ratings

2.2.1.1. Pleasure hug ratings. A two-way repeated measure ANCOVA with the factors hug duration (1 s, 5 s, 10 s), arm crossing (criss-cross, neck-waist), and height difference as a covariate was used. A significant main effect of hug duration was found; $F(1.617, 86) = 6.876$, $p = .002$, $\eta^2p = 0.138$. Bonferroni-corrected pairwise comparisons showed that 1 s ($M = 50.66$, $SD = 22.19$) hugs were rated as significantly less pleasant than 5 s hugs ($p < .001$, $M = 66.13$, $SD = 16.37$) and 10 s hugs ($p < .001$, $M = 64.37$, $SD = 14.8$). 5 s hugs and 10 s hugs were not rated as significantly different from each other ($p = .837$; Fig. 3). Arm crossing did not show a significant main effect (Table S2).

A statistically significant interaction between hug duration and arm crossing was found when controlling for the height difference between hug partners, $F(2, 86) = 3.882$, $p = .024$, $\eta^2p = 0.083$. For the criss-cross condition, there was no significant effect of hug duration, $F(2, 86) = 2.297$, $p = .107$, $\eta^2p = 0.051$. For the neck-waist condition, hug duration showed a significant main effect $F(2, 86) = 9.798$, $p < .001$, $\eta^2p = 0.186$. Bonferroni-corrected pairwise comparisons showed that this effect was caused by lower pleasure ratings for 1 s neck-waist hugs ($M = 50.71$, $SD = 23.95$) than for 5 s neck-waist hugs ($M = 66.84$, $SD = 19.12$; $p = .001$) and 10 s neck-waist hugs ($M = 70.64$, $SD = 17.4$; $p < .001$). The difference between 5 s neck-waist hugs and 10 s neck-waist hugs was not statistically significant (Table S2).

Within 1 s and the 5 s conditions, there was no significant difference between criss-cross and neck-waist hugs. For 10 s hugs, the effect of arm crossing was significant when height difference was taken into consideration; $F(1, 43) = 6.685$, $p = .013$, $\eta^2p = 0.135$, with neck-waist hugs being rated as more pleasant than criss-cross hugs ($M = 66.98$, $SD =$

Fig. 2. Criss-cross hug left and neck-waist hug right.

Table 1
All hugs tested in study 1. Each participant experienced each hug.

Arm crossing style	1 s	5 s	10 s
Criss-cross hug	1 s criss-cross	5 s criss-cross	10 s criss-cross
Neck-waist hug	1 s neck-waist	5 s neck-waist	10 s neck-waist

19.19). Means and standard deviations for hug ratings are presented in Table 2. Participants' answers to the open-ended questions were analysed using thematic analysis and are reported in the Supplemental material (see "Qualitative hug evaluation").

2.2.1.2. Arousal and control hug ratings. For arousal ratings, a two-way repeated measure ANCOVA with the factors hug duration (1 s, 5 s, 10 s), arm crossing (criss-cross, neck-waist), and height difference as a covariate found no statistically significant main effect of hug duration or arm crossing. Furthermore, no interaction between hug duration and

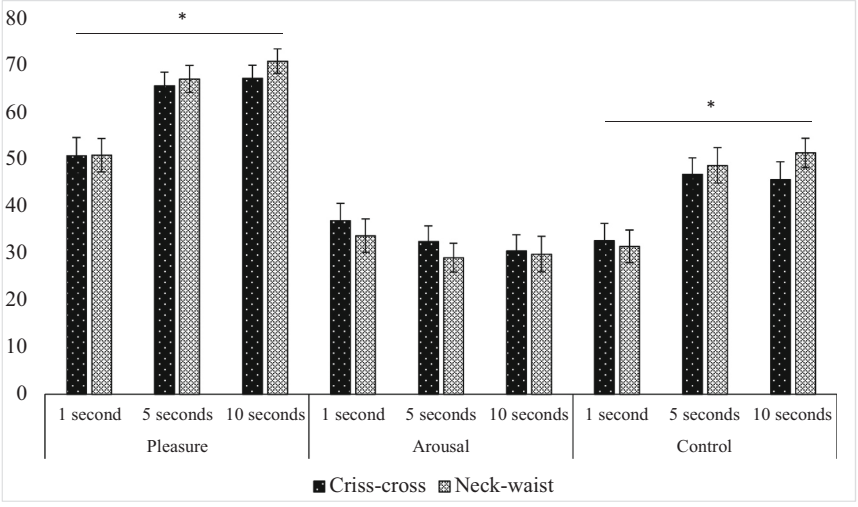

Fig. 3. Mean hug evaluations for pleasure, arousal and control for all tested hug types, bars denote standard error. Asterisks indicate statistically significant main effects of duration at $p < .05$.

Table 2
Mean (*M*), standard deviation (*SD*) and 95% confidence interval (CI) for hug pleasure, arousal, and control ratings for all hugs. Index values indicate the arm crossing type (neck-waist: NW; criss-cross: CC) and duration (1, 5, 10 s) of hugs.

Hug	Pleasure				Arousal				Control			
	M	*SD*	95% CI		*M*	*SD*	95% CI		*M*	*SD*	95% CI	
			Lower	Upper			Lower	Upper			Lower	Upper
NW1	50.711	23.946	43.517	57.905	33.622	23.6	26.532	40.713	31.378	23.505	24.316	38.439
CC1	50.6	25.437	42.958	58.242	36.8	24.538	29.428	44.172	32.578	24.199	25.308	39.848
NW5	66.844	19.117	61.101	72.588	28.956	20.335	22.846	35.065	48.533	25.098	40.993	56.074
CC5	65.422	18.926	59.736	71.108	32.378	22.227	25.7	39.056	46.667	22.97	39.766	53.568
NW10	70.644	17.404	65.416	75.873	29.711	25.152	22.155	37.268	51.178	21.566	44.699	57.657
CC10	66.978	19.187	61.213	72.742	30.4	22.964	23.501	37.299	45.511	25.452	37.865	53.158

arm crossing was found (Table S2).

For control ratings, a two-way repeated measure ANCOVA with height difference as covariate showed a main effect of hug duration $F(1.64, 70.28) = 3.715$, $p = .037$, $\eta^2p = 0.080$. Bonferroni corrected pairwise comparisons showed that this was due to lower control ratings for 1 s hugs ($M = 31.98$, $SD = 21.32$) than for 5 s hugs ($M = 47.6$, $SD = 21.49$, $p < .001$) and 10 s hugs ($M = 48.34$, $SD = 19.73$; $p < .001$; Fig. 3, Table 2). No other main effects or interactions were significant (Table S2).

2.2.2. Self-ratings

To assess whether rating timepoint, hug duration and arm crossing influence self-ratings, ANOVAs with the factors rating timepoint (immediately post hug, 3 min post hug, 6 min post hug), hug duration (1 s, 5 s, 10 s) and arm crossing (criss-cross, neck-waist) were conducted. These ANOVAs were conducted separately for each self-rating (pleasure, arousal, and control). Means and standard deviations of self-ratings are indicated in Tables S3–S5.

2.2.2.1. Pleasure self-ratings. For pleasure self-ratings, a statistically significant main effect of hug duration was found; $F(2, 88) = 5.455$, $p = .006$, $\eta^2p = 0.110$. Bonferroni-corrected post-hoc tests revealed that this effect was driven by lower pleasure self-ratings following 1 s hugs ($M = 60.45$, $SD = 14.43$) compared to 5 s hugs ($M = 64.62$, $SD = 16.86$; $p = .013$) and by lower pleasure self-ratings following 1 s hugs compared to 10 s hugs ($M = 64.17$, $SD = 15$; $p = .037$). There was no significant difference between 5 s hugs and 10 s hugs (Table S6). No other main effects or interactions were statistically significant (Table S6).

2.2.2.2. Arousal self-ratings. For arousal self-ratings, a statistically significant main effect of rating timepoint was found; $F(1.151, 50.665) = 8.620$, $p = .004$, $\eta^2p = 0.164$. Bonferroni-corrected post hoc tests showed that the main effect was caused by higher arousal ratings immediately post hug ($M = 28.33$, $SD = 18.05$) than 3 min post hug ($M = 21.94$, $SD = 16.6$; $p = .004$) and 6 min post hug ($M = 21.88$, $SD = 17.75$; $p = .025$). The difference between arousal ratings 3 min post hug and 6 min post hug was not significant (Table S6). No other main effects or interactions were statistically significant (Table S6).

2.2.2.3. Control self-ratings. For control self-ratings, a significant main effect of hug duration was found; $F(2, 88) = 3.498$, $p = .035$, $\eta^2p = 0.074$. However, Bonferroni corrected post-hoc tests showed no significant differences between control self-ratings following the 1 s ($M = 55.72$; $SD = 19.83$), 5 s ($M = 60.06$; $SD = 20.57$) and 10 s hugs ($M = 60.99$; $SD = 20.67$; Table S6). Still, means indicate that the significant main effect was caused by slightly lower control self-ratings following 1 s compared to 5 s and 10 s hugs (Table S5). No other main effects or interactions were statistically significant (Table S6).

2.3. Discussion

The results from study 1 indicate that hug duration can influence hug experience, while arm crossing has no or only a small effect on hug valence, arousal, and control ratings. Specifically, 1 s hugs were rated as less pleasant and less controllable than 5 s and 10 s hugs, supporting our hypothesis that longer hugs would be rated as more pleasant than shorter hugs. The hypothesis that criss-cross hugs would be rated as more pleasant than neck-waist hugs was not supported. Furthermore, hug duration was found to influence the pleasure participants experienced after the hugs. Specifically, the pleasure experienced was higher following 5 s and 10 s hugs than following 1 s hugs. Additionally, participants indicated higher arousal immediately post hug compared to 3 min and 6 min post hug.

There are some limitations to these findings. Firstly, we tested only women; however, affective touch perception is gender dependent (e.g. Bendas et al., 2017; Harjunen et al., 2017; Struckman-Johnson & Struckman-Johnson, 1993), so our findings are not generalisable to men. Also, the confederate hugging the participants was a woman; thus, the interpretation of the hug experience in a lab-based design is restricted to female-female dyads. Secondly, we did not control pressure, which has been argued to affect embrace perception (Block & Kuchenbecker, 2018, see also qualitative reports in the Supplemental material). Pressure will be important to consider in future investigations. Furthermore, from study 1, it is not clear why participants were indifferent to arm crossing style. This unexpected finding could be specific to the lab setting where participants hugged an unknown confederate or potentially to the exclusively female sample. Also, further research on hugs might benefit from using a hug that is common in everyday life in addition to being judged as pleasant in the lab.

Hence, in study 2, we aimed to assess what type of arm crossing participants preferred when asked to hug another person spontaneously. Particularly, gender and emotional closeness have been shown to influence affective touch behaviour in previous research (Hertenstein & Keltner, 2011; Packheiser et al., 2019; Suvilehto et al., 2015; Thompson & Hampton, 2011), but these variables were not experimentally manipulated in study 1. Therefore, we aimed to explore the association between gender composition of hugging dyads, the emotional closeness of huggers and preferred arm crossing style in a naturalistic setting.

3. Study 2

In study 2, we asked people on campus to share a hug and recorded arm crossing style, gender, and self-reported emotional closeness between hug partners. Furthermore, a large height difference can make it cumbersome to hug, especially when attempting to hug in a criss-cross style. Therefore, we additionally recorded participants' height. Based on previous literature, it was expected that criss-cross hugs would be the most prevalent arm crossing style and that gender of the hugging partners and emotional closeness would relate to arm crossing style (Floyd, 1999; Packheiser et al., 2019; Rabinowitz, 1991; Suvilehto et al., 2015).

3.1. Methods

3.1.1. Participants

In total, 206 participants aged between 18 and 43 ($M = 23.47$, $SD = 4.80$) were recruited, i.e., 103 hugs were observed. Out of the 103 observed hugs, the experimenters recorded different arm crossing styles in three cases. These hugs were excluded from the analysis, resulting in 100 hugs analysed when assessing which arm crossing style was most prevalent (age $M = 23.55$, $SD = 4.84$). For the analysis of factors predicting hug arm crossing, 17 more dyads were excluded from the analysis for various reasons: Six participants indicated non-binary gender, and one preferred not to answer the gender item. Hugs with these participants were excluded from the analysis due to small sample sizes. For 10 dyads, one or both emotional closeness ratings were missing. After removing these dyads, the final sample for the regression predicting arm crossing type included 83 dyads (age $M = 23.08$, $SD = 4.5$).

As the research question and the design were novel, the power calculation was based on a medium effect size (odds ratio (OR) = 3.47; Chen et al., 2010). Using G*Power (Faul et al., 2007), with alpha set at 0.05 and a power of 0.8, the sample required to detect a medium effect would be 101.

3.1.2. Procedure

Participant dyads were approached on campus and in public spaces. Once participants gave written informed consent, they were asked to share a hug with the person they were socialising with on campus. Two experimenters observed the hug and recorded the arm crossing style. Once participants completed a hug, they indicated their age, gender, and sexual orientation. Then, they were asked to rate emotional closeness to the other participant on a continuous 0–100 scale. Consent and answers were recorded via Qualtrics XM on Amazon Fire tablets. Lastly, participants' height was measured. The study was approved by the local ethics committee.

3.2. Results

A chi-square goodness-of-fit test was conducted to assess whether there were differences in the overall number of criss-cross versus neck-waist hugs. Out of these 100 hugs included in the test, 66 were criss-cross hugs and 34 neck-waist hugs. The chi-square goodness-of-fit test confirmed that the observed distribution of arm crossing styles was statistically different from the expected distribution of 50 for each arm crossing style; $\chi^2(2) = 10.24$, $p = .001$.

A hierarchical logistic regression was performed to evaluate the influence of dyad gender, average emotional closeness, the difference in emotional closeness, and height difference on arm crossing style. Dyad gender was entered as a categorical variable with three levels: female-female, female-male, and male-male; male-male dyads served as the reference category. Dyad emotional closeness was calculated by averaging the emotional closeness ratings of hug partners. The difference in emotional closeness ratings was calculated by subtracting emotional closeness scores of hug partners. This measure was included to evaluate whether large differences in emotional closeness would influence arm crossing style.

When dyad gender was entered as a predictor in step 1, the Wald X^2 test of overall model fit was statistically significant; $\chi^2(2) = 7.348$, $p = .025$, $R^2_{CS} = 0.085$, $R^2_N = 0.116$, indicating that dyad gender predicted arm crossing style better than a model without predictors. Both female-female and female-male dyads were significant predictors ($OR = 4.271$, $p = .020$ and $OR = 3.987$, $p = .026$, respectively); illustrating that these dyads were more likely to share a neck-waist hug than male-male dyads. Height difference was added as a predictor in step 2, and overall model fit remained statistically significant; $\chi^2(3) = 9.118$, $p = .028$, $R^2_{CS} = 0.104$, $R^2_N = 0.142$. However, change in model fit was not statistically significant ($\chi^2(1) = 1.769$, $p = .183$), indicating that adding height difference did not explain additional variance in arm crossing style. Emotional closeness and the difference in emotional closeness were entered as predictor variables at step 3. Neither overall model fit ($\chi^2(5) = 10.583$, $p = .06$, $R^2_{CS} = 0.12$, $R^2_N = 0.163$) nor change in model fit was statistically significant ($\chi^2(2) = 1.465$, $p = .481$). See Table 3 for hug frequencies by dyad gender and Table 4 for regression parameters.

3.3. Discussion

In agreement with our hypothesis, study 2 indicated that criss-cross hugs were the most common type of arm crossing in the young adult university sample tested. In addition, the gender composition of hugging dyads predicted hugging style, and it was found that criss-cross hugs were more common between men than between women or mixed dyads. Height difference, emotional closeness and difference in emotional closeness were no significant predictors of arm crossing style. Hence, the more parsimonious model using only dyad gender as predictors is the preferred model for predicting arm crossing style.

Our results align with previous studies reporting gender effects on hugs, specifically in that male-male dyads hug differently than female-female dyads (Turnbull et al., 1995). Here, we cannot conclude whether men would prefer a criss-cross hug in the lab, as we tested only women in study 1. The criss-cross hug has been argued to be more egalitarian than other hugging forms (Floyd, 1999). Based on this argument, it seems likely that male-male dyads express recognition of equality when hugging. Touching prevalence in public has been previously linked to gender-dependent power relations by Henley (1973), a suggestion which has raised controversy (e.g. Stier & Hall, 1984). The data presented here indicate that hugging style may be influenced by gender.

Height difference did not influence hugging style significantly in study 2. This is surprising in that a criss-cross hug between two people with height differences is rather cumbersome. However, only six dyads had a height difference larger than 20 cm in the current study sample. Thus, the study might not have had sufficient variability to detect the effect of height on hugging style. Likewise, emotional closeness was not a significant predictor for hugging style.

4. General discussion

In the current investigation, we conducted two studies to examine: 1) how hug duration and arm crossing style influence hug experience; 2) how hug duration and arm crossing style influence self-ratings at several timepoints after hugging; 3) which arm crossing style is most common in a naturalistic setting; and 4) whether it is possible to predict arm crossing style from dyad gender, emotional closeness, and height difference. In study 1, it was found that 5 s and 10s hugs were rated as more pleasant and under control than 1 s hugs. Also, the pleasure experienced immediately post hug was influenced by hug duration, with greater pleasure following 5 s and 10s hugs than following 1 s h hugs. Participants furthermore experienced higher arousal immediately post hug than 3 min or 6 min post hug.

Our findings on hug pleasure align with research indicating that robots are evaluated less positively after a "too short" hug (Block & Kuchenbecker, 2019), indicating that very short hugs are less pleasant than longer hugs. Moreover, as we found no difference in pleasantness ratings between 5 s and 10s hugs, our findings imply that the relationship between hug duration and hug enjoyment is not linear. Instead, there might be a plateau in pleasantness. Interestingly, our results

Table 3
Frequency table for dyad arm crossing split by dyad gender.

	Female-female	Female-male	Male-male	Total
Criss-cross	14 (51.9%)	15 (53.6%)	23 (82.1%)	52 (64.5%)
Neck-waist	13 (48.1%)	13 (46.4%)	5 (17.9%)	31 (35.5%)
Total	27	28	28	83

Table 4
Hierarchical logistic regression predicting likelihood of dyads sharing a neck-waist hug rather than a criss-cross hug. Reference categories are criss-cross hugs and male-male dyads. Confidence interval (CI), odds ratio (OR), standard error (SE).

Predictor	B	SE	Wald	OR	*p*	95% CI for OR	
						Lower	Upper
Step 1							
Constant	−1.526	0.493	9.565	0.217			
Dyad gender							
Female-female	1.452	0.626	5.380	4.271	.020	1.252	14.568
Female-male	1.383	0.622	4.941	3.987	.026	1.178	13.495
Step 2							
Constant	−1.902	0.581	10.724	0.149			
Dyad gender							
Female-female	1.482	0.632	5.500	4.400	.019	1.276	15.180
Female-male	1.277	0.631	4.089	3.585	.043	1.040	12.356
Height difference	0.049	0.037	1.726	1.050	.189	0.976	1.130
Step 3							
Constant	−3.343	1.396	5.740	0.035			
Dyad gender							
Female-female	1.320	0.649	4.134	3.742	.042	1.049	13.351
Female-male	1.242	0.638	3.784	3.462	.052	0.991	12.095
Height difference	0.059	0.039	2.280	1.060	.131	0.983	1.144
Emotional closeness	0.017	0.015	1.344	1.017	.246	0.988	1.048
Difference closeness	0.012	0.019	0.377	1.012	.539	0.975	1.050

contrast with Floyd's (1999), which reported that 1 s hugs were evaluated more positively than 3 s and 5 s hugs. A reason for the equivocal findings could be that in our study, participants experienced hugs, whereas previously, hugs were merely viewed by the participants (Floyd, 1999). Further studies are necessary to define at which rating timepoint physically experienced hugs become "too long".

Regarding hug ratings of control, prior literature suggests that participants report an increased sense of agency when the outcome of an action is expected rather than when it is not (Gentsch & Schütz-Bosbach, 2011). Given that the average hug is thought to last approximately 3 s (Nagy, 2011), receiving a shorter hug (e.g. 1 s) might not be anticipated by the person reciprocating the hug. Consequently, the mismatch between the expected outcome (release of the hands only after 3 s) and the actual outcome (release of the hands earlier than 3 s) might result in a decreased feeling of control over the hug. In line with this, control ratings were lower for 1 s hugs than 5 s and 10 s hugs.

In study 2, participants were asked to share a hug, and arm crossing style was analysed in relation to gender, height difference and emotional closeness of hugging partners. It was found that criss-cross hugs are overall more common. Furthermore, female-female dyads and female-male dyads were more likely than male-male dyads to share a neck-waist hug in steps 1 and 2 of the regression models. Emotional closeness and height difference did not significantly predict embrace style.

The finding that gender composition of hugging dyads influences arm crossing style is in line with previous research suggesting that affective touch behaviour is gender-dependent (e.g. Bendas et al., 2017; Harjunen et al., 2017; Struckman-Johnson & Struckman-Johnson, 1993). As criss-cross hugs have been argued to be more egalitarian than neck-waist hugs, our finding that male dyads were more likely to share criss-cross hugs than mixed or female hugging dyads might suggest that demonstration of equality is particularly important for male hugging partners. Note that previous observational research found male-male touch to be less common than female-female or mixed-gender touch (Stier & Hall, 1984). This finding has even been extended to hugs (Packheiser et al., 2019; Rabinowitz, 1991). The method employed here allowed us to test approximately equally sized groups instead of relying on observation of publicly displayed hugs alone. However, as the final regression model was not statistically significant, further research is necessary to further disentangle the relationship between different arm crossing styles and dyad gender.

One of our motivations to conduct the studies reported here was to identify a hug that can be applied in affective touch research. Based on our findings, we advise using a 5 s criss-cross hug to model a familiar and pleasant type of experience. Despite our finding that both 5 s and 10 s hugs are similarly pleasant, 5 s hugs might be preferable whenever researchers want to induce a common touch experience, as previous research has shown that hugs are relatively brief (Nagy, 2011). Special care should be taken to avoid extremely brief hugs, as both our quantitative findings and the subjective answers reported in the Supplemental material indicate that they do not constitute the same kind of experience as longer hugs - a finding in concordance with recent research on robot hugs (Block & Kuchenbecker, 2019). An additional result relevant for further hug research emerged from the analysis of qualitative statements in study 1, reported in the Supplemental materials. Many participants explained that they got used to the unusual hugging situation over time, habituating to the experience of hugging an unseen stranger over trials. These qualitative results indicate that further hug studies might benefit from a "warming up" period if hugs take place between strangers. Further research is necessary to define all parameters previously defined as relevant for hugs, including aspects such as pressure and surface of torso contact (Forsell & Åström, 2012; Straker, 2002).

The pleasure experienced by participants was increased after 5 s and 10 s hugs compared to 1 s hugs. Further, participants indicated higher arousal levels immediately post hug compared to 3 min post hug and 6 min post hug, whereas the experienced pleasure and control did not change with time. These findings suggest that hugs might influence arousal for a short period but that this change in arousal ceases in up to 3 min post hug. Together, the findings on self-ratings indicate that researchers looking to induce changes in pleasant mood or feelings of control should use 5 s hugs or 10 s hugs rather than 1 s hugs, and that hugs may be used to increase short-term feelings of arousal.

Summarised, because of the lack of research on what makes a good hug, we conducted two studies assessing hug evaluation and hugging style. Our findings suggest that longer hugs are more pleasant than very short hugs and criss-cross hugs are more common than neck-waist hugs. We anticipate that the studies presented here will provide a foundation for future research on pleasant touch, especially for research on hugs, which are highly prevalent but still widely understudied.

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CRediT authorship contribution statement

Studies were designed by ALD and MJB, testing was conducted by ALD and AV. Statistical analysis was conducted by ALD with advice from CE. The manuscript was written by ALD with supervision from MJB, all authors contributed equally to the final manuscript.

Declaration of competing interest

None.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.actpsy.2021.103441.

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