# Affective Touch is encoded by pupil dilation as a comprehensive social phenomenon

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## Abstract

Affective Touch plays a pivotal role in regulating emotions, fostering social bonds and nurturing affiliations with others. The emotional and arousing dimensions associated to Affective Touch are linked to the activation of the CT- fibres system, an afferent pathway attuned to those specific features of tactile stimulations which characterize gentle human caresses, such as touch velocity and the nature of the stroking source. While previous research has examined the physiological responses in relation to these individual features of Affective Touch, no study has explored how they interact to shape autonomic activity. In this study, we investigated whether and how touch velocity (CT-optimal vs. CT-suboptimal) and the nature of the touching effector (Human hand vs. Artificial hand) influenced the participants' pupil dilation and their subjective experience during tactile stimulation. We observed a higher pupil dilation when touch was delivered simultaneously at CT-optimal speed and by a human hand. This kind of touch invoked a supralinear enhancement of pupil dilation indicating that the combination of these two features induced a significantly stronger autonomic activation than the summed effects of each delivered separately. Moreover, this specific type of touch was perceived as the most pleasant compared to all other tactile stimulations. Therefore, pupil dilation appears to map the positive and pleasant experience of human-to-human tactile interactions. Collectively, our results support the notion that the autonomic nervous system encodes the emotional and hedonic aspects associated with Affective Touch as a complex and holistic social experience, rather than solely responding to its low-level sensory properties.

## INTRODUCTION

Social interaction is a fundamental aspect of human life, and interpersonal touch plays a crucial role in shaping relationships and encouraging social connections (Cascio et al., 2019). Notably, social touch refers to the physical contact or tactile exchanges occurring between individuals during social engagements. It serves as a means of conveying greetings, affection, support, and comfort across diverse social scenarios (Hertenstein et al., 2006). A specific kind of social touch is Affective Touch, characterized by a gentle and enjoyable tactile stimulation capable of triggering profound emotional reactions and positive emotional states (Morrison et al., 2010; Morrison, 2016a). This form of touch can foster sentiments of care, intimacy, closeness, and trust among individuals (Field, 2010; Gulledge et al., 2007; Robinson et al., 2015).

Recent studies have shed light on the distinctive attributes of Affective Touch, revealing the existence of dedicated neural pathways and supporting its *sui generis* nature (Gallace and Spence, 2016; Morrison, 2016b; Olausson et al., 2008). A specialized somatosensory system, referred to as the CT-afferent system, stands out as it is selectively activated by soft and gentle strokes. Specifically, CT-fibers are sensitive to slow-moving caresses (1-10 cm/s) and exhibit heightened activation in response to touch stimuli with a temperature that closely aligns to human skin (i.e., 32°C) (Ackerley et al., 2014a; Löken et al., 2009). These two unique characteristics lend support to the notion that CT-fibers are finely tuned to warm and gentle human contact, effectively distinguishing Affective Touch from other kinds of touch exchange. Moreover, gentle stimulation of CT-innervated skin triggers the activation of the posterior insula (Gordon et al., 2013), coupling it with both somatosensory and reward processing regions (Sailer et al., 2016). The posterior insula plays a pivotal role in autonomic regulation and interoception by integrating sensory, affective, and rewarding aspects of tactile stimulation (Morrison et al., 2010). Its direct connection with CT-fiber stimulation (Kirsch et al., 2020) further underscores the distinctiveness of Affective Touch as a fundamental mechanism for emotion regulation and social-affective processing (Björnsdotter et al., 2009).

The complex interplay between Affective Touch, emotions, and the autonomic nervous system has been extensively investigated through psychophysiological responses. Notably, Affective Touch has been shown to induce an increase in skin conductance (Olausson et al., 2008): a response that can be influenced by salient contextual factors both in the person receiving the touch (Nava et al., 2021) and in the person promoting it (Mazza et al., 2023a). In line with the notion that Affective Touch can also serve as a potential buffer against stressful situations (Mazza et al., 2023b; Morrison, 2016a) it has been linked to reductions in blood pressure (Grewen et al., 2005; Lee and Cichy, 2020), stress hormone levels (Heinrichs et al., 2003; Henricson et al., 2008) and heart rate (Pawling et al., 2017; Triscoli et al., 2017) along with an increase in heart rate variability (Triscoli et al., 2017). Although skin conductance and heart rate have been extensively explored as markers of physiological modulation induced by Affective Touch, pupil dilation, a well-established indicator of physiological activation (Gusso et al., 2021), remains relatively unexplored in this context. Indeed, Affective Touch by engaging the sympathetic nervous system leads to the release of norepinephrine, a neurotransmitter involved in the regulation of pupil dilation (Aston-Jones and Cohen, 2005). Heightened pupil responses have been previously noted for both positive and negative arousing stimuli in visual (Basile et al., 2021; Dal Monte et al., 2015; Pagliaccio et al., 2019) and auditory (Partala and Surakka, 2003) domains. Understanding the relationship between Affective Touch and pupil dilation will provide important insights into the physiological responses evoked by this kind of tactile stimulation.

Earlier research has indicated that pupil dilation is influenced by the speed of touch rather than its pleasantness (van Hooijdonk et al., 2019), concluding that pupil responses primarily encode the sensory characteristics of tactile stimulation and do not distinctly respond to the emotional aspects of touch. However, the majority of the studies investigating Affective Touch employed brushes or mechanical tools to deliver tactile stimuli (Bertheaux et al., 2020; Pawling et al., 2017; Triscoli et al., 2017; van Hooijdonk et al., 2019). This might have restricted the possibility of targeting the hedonic effects associated with an actual human touch. Building on this premise, a few investigations have discovered that the pupil dilates more in response to human touch compared to artificial touch, particularly when Affective Touch is accompanied by the presentation of images displaying a positive facial expression (Ellingsen et al., 2014). This observation implies that pupil response can discern between distinct types of tactile interactions and potentially even capture the emotional experience accompanying touch. Thus, a touch promoted by a human hand, as opposed to artificial means, appears to be a pivotal factor in evoking distinct pupillary responses that are aligned with the emotional aspect of touch.

Although previous studies have made strides in understanding the significance of specific attributes of Affective Touch, such as the stroking velocity and the nature of the touching effector, they have largely focused on investigating these features individually, examining one characteristic at a time. Thus, this approach has made it challenging to draw comprehensive conclusions on the intricate interplay between these distinct characteristics and how those contribute to eliciting a physiological response. The current study aims to bridge this gap by exploring whether and how the nature of the stroking effector and the speed of touch interact to shape pupillary responses. Our investigation delves into how touch velocity (CT-optimal vs. CT-suboptimal) and the nature of the hand promoting the touch (Human vs. Artificial) influence both pupil dilation and the subjective experience in the person receiving tactile stimulations. We seek to ascertain whether pupil size can distinctly encode Affective Touch, by preferentially reacting to CT-optimal touch promoted by a Human hand. Our hypotheses encompass several scenarios. If pupil size indeed encodes the nature of the hand promoting the touch, we expect to observe greater pupil responses during Human-initiated touch compared to Artificial-initiated touch, irrespective of velocity. Conversely, if pupil size merely tracks stroking speed, as hinted by prior research (van Hooijdonk et al., 2019), we anticipated to find greater pupil responses during the CT-optimal velocity condition compared to the CT-suboptimal velocity condition, regardless of the nature of the hand promoting the touch (Human vs. Artificial). Finally, if pupil size has the capacity to encode Affective Touch as a whole, we hypothesize that pupil responses to CT-optimal touch will be further influenced by the nature of the hand promoting the touch. This would be reflected in larger pupil dilation when touch is promoted by a Human hand, but exclusively under CT-optimal velocity conditions.

## MATERIALS and METHODS

### *Participants*

Thirty right-handed volunteers (16 females and 14 males, mean age 23.9 ± 2.3 and 24.6 ± 2.8 respectively) took part to this study. Most of the participants were undergraduate students at the Department of Psychology (University of Turin) and were recruited from a participants' database or through flyers posted on the University website. All experimental subjects gave written informed consent to participate, which was approved by the local ethics committee and performed in accordance with the Declaration of Helsinki. At the end of the experiment, all participants were informed about the aims and the scopes of the experiment and did not receive any compensation for participation in this research study.

### *Experimental setting and design*

Participants were invited to sit in a comfortable position, place their left arm on a table with their palm facing down, and lean their chin and forehead on a headrest to ensure stability and reduce any unintentional movement (**Figure 1a** ). Given that in this study we recorded pupillary dilation, the experimental session started with a 9-point grid system calibration. Each trial started with a 2-second fixation cross (baseline) followed by a 10-second grey square (stimulus) presented in the center of the screen, during which the participant received a tactile stimulation. We used two types of touch velocity: a CT-optimal [i.e., a dynamic stroking at 3 cm/s; (Löken et al., 2009); CT-optimal condition] and a CT-suboptimal (i.e., a static touch; CT-suboptimal condition). Both types of touch were delivered by either a Human hand (i.e., the experimenter's hand; Human condition) or an Artificial hand (i.e., a wooden hand; Artificial condition) (**Figure 1b** ), over either the dorsal side of the hand or the dorsal side of the forearm, two CT-rich sites mostly involved in interpersonal touch (Pyasik et al., 2022; Suvilehto et al., 2015). Given that pupil dilation recording is sensitive to eye movements and blinks, participants were instructed to keep their gaze fixed on the target stimulus and blink as little as possible. A 10-second period of tactile stimulation was followed by a 2-second ITI where subjects were allowed to rest. Before the beginning of the next trial participants were asked to rate the pleasantness of the touch received, on a scale from 0 to 10. Participants' subjective ratings were recorded by the experimenter as an indicator of the pleasantness associated with each touch. Each participant received 4 tactile stimuli per condition (i.e., CT-optimal_Human, CT-optimal_Artificial, CT-suboptimal_Human, and CT-suboptimal_ Artificial) for a total of 16 tactile stimulations. For each condition, the touch was delivered twice on the dorsal side of the hand and twice on the dorsal side of the forearm; the order of conditions presentation was randomized. The task was implemented on Psychtoolbox (MATLAB©, The Mathworks Inc.), and pupil size was recorded at a 1000 Hz sampling rate using an Eyelink®-1000 monocular-arm (SR Research, Osgoode, ON, Canada Tobii TX300).

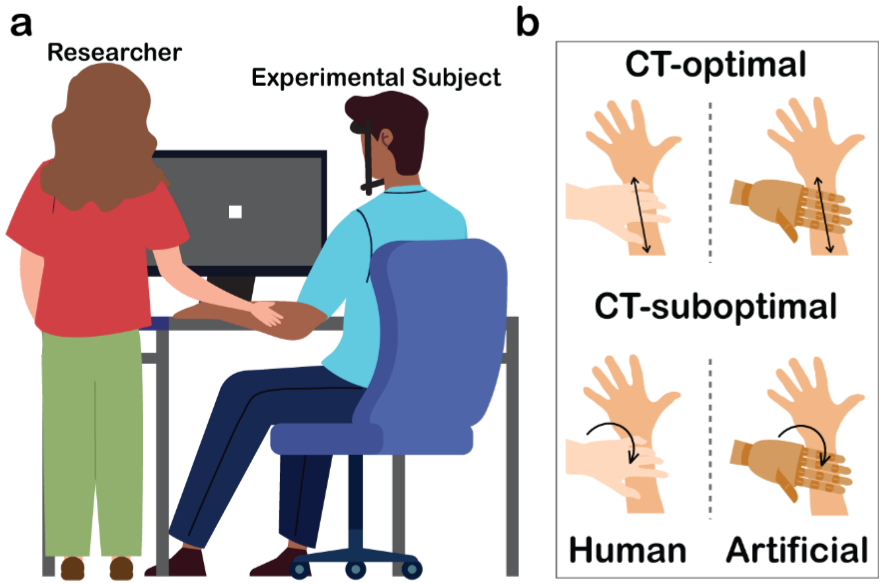


**Figure 1: Experimental setting, variables, and spatial location control.**

**a)** Experimental setting: the participants sat facing a computer monitor with their chin and forehead on a headrest to ensure stability and reduce any unintentional movement during pupil recording. They were invited to place their left arm on the table with their palm facing down. The researcher standing on the left side of the experimental subject performed different types of touch on either the dorsal side of the hand or the dorsal side of the forearm of the participant.**b)** Experimental variables: participants received a CT-optimal touch stroke velocity (a dynamic stroking with a speed of 3 cm/s) and CT-suboptimal touch velocity (a static touch). The nature of the stroking effector promoting the touch was either a Human hand or an Artificial hand.

*Data analysis*

*Spatial location control analysis*

Spatial location control analysis allowed us to ensure that participants kept their gaze centered on the center of the screen while receiving tactile stimulations, and that pupillary measures were not biased by eye movements. Heatmaps in **Figure 2a** represent the spatial distribution of fixations during tactile stimulations. Axes represent pixels coordinates calculated according to standard Eyelink®-1000 1024x768 screen resolution.

*Pupillometry analysis*

Pupillary changes were first baseline corrected on a trial-by-trial basis by subtracting the mean change in pupil diameter 1000ms before the beginning of tactile stimulations. Next, to control for inter-individual variability, pupil data were Z-scored for each subject across all conditions (Basile et al., 2021; Rudebeck et al., 2014). In each trial, missing samples due to blinks or loss of the eye-tracking signal during the tactile stimulation period were interpolated via spline interpolation using the nearest valid adjacent samples. Pupil responses were then averaged across trials for each condition. Based on visual inspection of the average response profile, the mean change in pupil diameter was extracted for the time window ranging from 0-4 seconds after stimulus onset (**Figure 2a** ). Data were analyzed via a 2-way repeated-measures ANOVA with Touch type (CT-optimal vs. CT-suboptimal) and Hand type (Human vs. Artificial) as within subject factors. Post-hoc analyses following significant main effects and interactions were performed by running two-tailed pairwise t-tests, and multiple comparisons were corrected by means of false discovery rate (FDR; Benjamini & Hochberg, 1995). All p values $< 0.05$ were considered significant.

To test the hypothesis that CT-optimal_Human touch alone induced a larger pupil size than CT-optimal_Artificial plus CT-suboptimal_Human touch, supralinearity was quantified by contrasting, for each participant, the average pupil size in the CT-optimal_Human condition against the sum of the average pupil size in the CT-optimal_Artificial plus CT-suboptimal_Human conditions. The effect of CT-optimal_Human condition was then compared with the added CT-optimal_Artificial and CT-suboptimal_Human condition with a paired-sample t test to determine significance.

*Subjective Rating*

To test whether different kinds of tactile stimulations impacted the perceived pleasantness, subjective ratings were analyzed by means of a 2-way repeated-measures ANOVA with Touch type (CT-optimal vs. CT-suboptimal) and Hand type (Human vs. Artificial) as within subject factors. Post-hoc analyses following significant main effects and interactions were performed by running two-tailed pairwise t-tests, and multiple comparisons were corrected by means of FDR. All p values $< 0.05$ were considered significant.

## RESULTS

*Pupil size*

We found a main effect of Hand type [$F_{(1,119)} = 10.196$, $p = 0.002$, $\eta^2 = 0.079$], indicating a stronger pupil dilation when participants received a touch from a Human hand compared to an Artificial hand [$t_{(119)} = 3.193, p = 0.002$]. Crucially, we also found a significant Hand type by Touch type interaction [$F_{(1,119)} = 7.402$, $p = 0.007$, $\eta^2 = 0.059$], indicating that the magnitude of increase in pupil dilation during the touch promoted by a Human hand differed depending on the type of touch. Specifically, post-hoc t-tests showed that only during CT-optimal touch participants exhibited a stronger pupil dilation when receiving a touch from a Human hand compared to an Artificial hand [$t_{(119)} = 4.023; p < 0.001$], indicating that pupil dilation specifically encodes CT-optimal stimulation only when promoted by a Human hand. Furthermore, we observed that a touch promoted by a Human hand elicited a significant increase in pupil dilation for CT-optimal condition compared to CT-suboptimal touch [$t_{(119)} = 2.966$; $p = 0.006$]. During CT-suboptimal touch participants did not show any difference between a Human and Artificial hand [$t_{(119)} = 0.213$; $p = 0.832$]. Similarly, we did not observe any difference in pupil dilation between CT-optimal and CT-suboptimal conditions when the touch was promoted by an Artificial hand [$t_{(119)} = 1.079$; $p = 0.283$] (**Figure 2b and 2c** ). Supralinearity analyses showed that 70% (n=21) of participants displayed a supralinear effect, that is a larger pupil size in the CT-optimal_Human condition alone than in the CT-optimal_Artificial plus CT-suboptimal_Human conditions summed together [$t_{(29)} = 1.781$, $p = 0.043$] (**Figure 2d** ).

Our results show a stronger pupil dilation when touch was delivered simultaneously at CT-optimal speed and by a human hand. This kind of touch invoked a supralinear enhancement of pupil dilation indicating that the combination of these two features induced a significantly stronger physiological activation than the summed effects of each delivered separately.

*Subjective ratings*

In line with pupil dilation findings, we observed a main effect of Hand type [$F_{(1,119)} = 32.062$, $p < 0.001$, $\eta^2 = 0.212$], indicating that participants preferred to receive a touch from a Human hand than from an Artificial hand [$t_{(119)} = 5.662$, $p < 0.001$]. Also, we found a main effect of Touch type [$F_{(1,119)} = 15.087$, $p < 0.001$, $\eta^2 = 0.113$], indicating that participants preferred to receive a touch with a CT-optimal than a CT-suboptimal speed [$t_{(119)} = 3.884, p < 0.001$]. Finally, we also found a significant Hand type by Touch type interaction [$F_{(1,119)} = 7.402, p = 0.044$, $\eta^2 = 0.034$], which showed that participants preferred to receive a CT-optimal touch from a Human hand. Indeed, post-hoc pairwise comparisons showed that the CT-optimal touch from a Human hand condition received the highest ratings compared to all other conditions [CT-optimal_Human vs. CT-optimal_Artificial: $t_{(119)} = 3.657$, $p < 0.001$; CT-optimal_Human vs. CT-suboptimal_ Human: $t_{(119)} = 2.343$, $p = 0.021$; CT-optimal_Human vs. CT-suboptimal_ Artificial: $t_{(119)} = 7.070$, $p < 0.001$] (**Figure 2e** ). These results, in line with physiological findings, indicate that a touch is perceived as the most pleasant when is promoted by a Human hand and with CT-optimal speed.

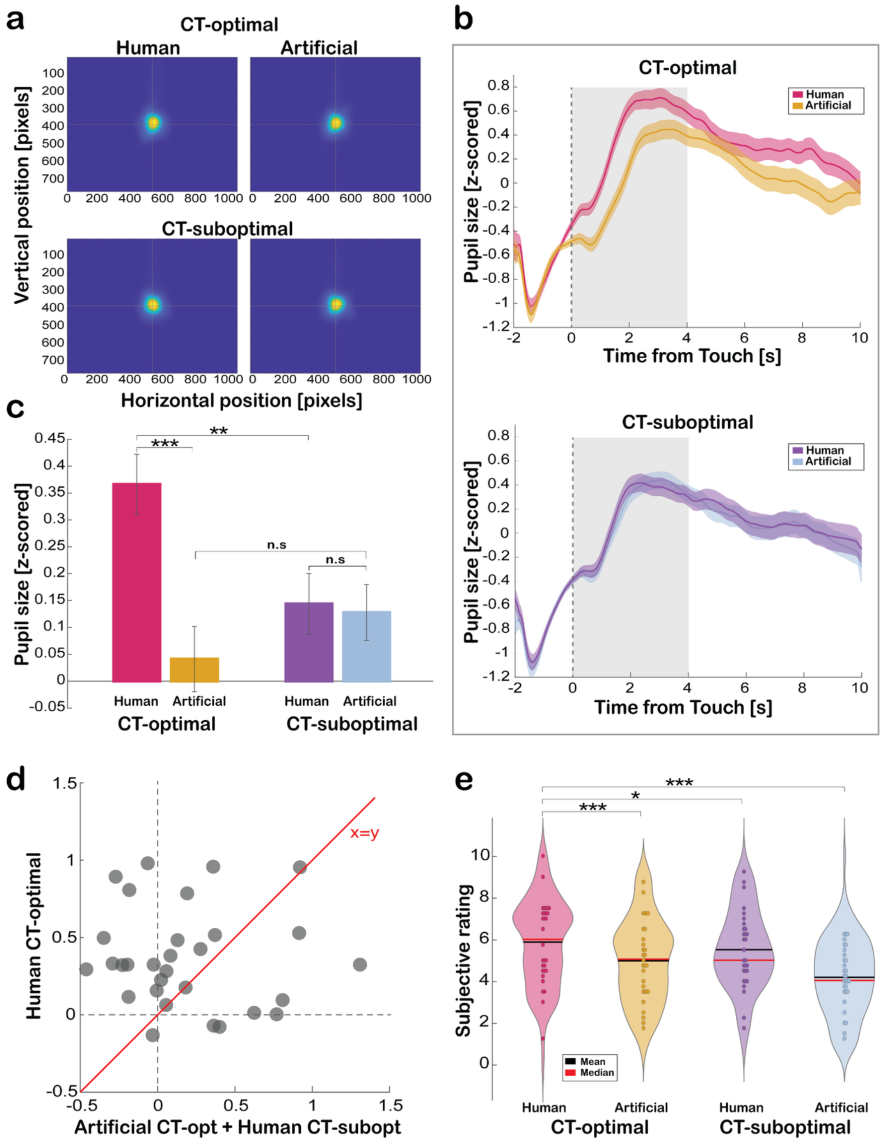


**Figure 2: Pupil Dilation responses and subjective rating**

**a)** Spatial location control: heatmaps show the gaze position during a 10-second grey square (stimulus) in which the participant received a tactile stimulation. None of the four heat maps (depicting the 4 experimental conditions) showed any meaningful eye movements deviation from the stimulus presented on the center of the screen.**b)** On the top, pupil dilation traces aligned to the time of CT-optimal touch promoted by a Human hand (pink) and Artificial hand (yellow). The shaded traces represent ± s.e.m. centered around the mean. Vertical dotted grey line indicates the beginning CT-optimal touch (10-second duration). The grey shaded area represents the analyzed epoch. On the bottom, pupil dilation traces aligned to the time of CT-suboptimal touch promoted by a Human hand (purple) and Artificial hand (light blue). **c)** Bar plot shows the Z-scored mean pupil size values normalized to baseline during CT-optimal and CT-suboptimal touch promoted by a Human hand and Artificial hand. **d)** Scatter plot shows the supralinearity effect by contrasting participants' pupil size in CT-optimal_Human condition alone (y-axis) against CT-optimal_Artificial plus CT-suboptimal_Human conditions summed together (x-axis). **e)** Violin plots show the mean subjective ratings reported by participants in the four conditions: CT-optimal touch promoted by a Human hand (pink), CT-optimal touch promoted by an Artificial hand (yellow), CT-suboptimal touch promoted by a Human hand (purple), and CT-suboptimal touch promoted by an Artificial hand (light blue). Data points overlaid on top show each subject. In black it is depicted the mean and in red the median. ***, $p < 0.001$; **, $p < 0.01$; *, $p < 0.05$; n.s., not significant.

## DISCUSSION

In the present study, we investigated whether Affective Touch is encoded as a comprehensive social phenomenon by the autonomic nervous system. We measured participants' pupil responses and pleasantness ratings while manipulating two key features characterizing Affective Touch, that are the stroking velocity and the sensory characteristics of the stroking hand. Overall, we observed a notable increase in pupil dilation when the touch received fell within the CT-optimal stroking range (3 cm/s; Löken et al., 2009) and was administered by a human hand. Additionally, participants' self-reports consistently indicated that this type of touch was perceived as the most pleasant in comparison to all other touch conditions. This outcome aligns with existing research suggesting that C-tactile afferents, the neural pathways responsible for the emotional and rewarding aspects of touch (McGlone et al., 2014), exhibit a preference for slow, caress-like touch (Löken et al., 2009) and are finely attuned to touch that mimics human skin temperature(Ackerley et al., 2014b). Thus, these findings emphasize the pivotal role of human contact in evoking positive emotional responses.

In line with the well-documented positive effects of Affective Touch on human well-being, other studies investigating the autonomic responses to Affective Touch reported positive effects on both cardiovascular (Grewen et al., 2005; Lee and Cichy, 2020; Triscoli et al., 2017) and hormonal systems (Heinrichs et al., 2003; Henricson et al., 2008) of individuals receiving a touch. Also, physiological coupling has been observed among dyads during interpersonal touch (Chatel-Goldman et al., 2014), further highlighting its pivotal role in social bonding. However, it is noteworthy that most of these studies employed artificial tools to reproduce Affective Touch at a CT-optimal speed (Bertheaux et al., 2020; Triscoli et al., 2017; van Hooijdonk et al., 2019). While this approach is valuable for precisely controlling stroking velocity, it may lack ecological validity as it does not account for the nuances of human-to-human tactile interactions. Our results add knowledge to this body of work by revealing that pupil responses are generally more pronounced when the touch is administered by a human hand compared to an artificial hand. This observation aligns with a previous study by Ellingsen and colleagues (2014), which similarly found that pupil dilation is more responsive to human touch than machine touch. Pupil dilation is associated with salient and rewarding stimuli (Beatty, 1982; Laeng et al., 2012) and reflects social interest in others (Laeng and Falkenberg, 2007): this suggests that touch promoted by a real human hand may be perceived as more rewarding, thereby eliciting a stronger pupil response.

Moreover, we found that the stroking speed is also another crucial element for eliciting a high pupil dilation, but only when the touch is promoted by a human hand. Van Hooijdonk and colleagues (2019) investigated and compared the impact of different stroking velocities on autonomic parameters, including pupil dilation. They reported, in line with our findings, that pupil dilation increased as a function of stimulation velocity. Thus, our findings not only corroborate previous research but also expand on the concept that pupil response depends on the interaction between stroking velocity and low-level characteristics of the stroking effector. Both the temperature and the softness of the touching hand might be responsible for the strong modulation observed in pupil dilation. Indeed, the greatest pupil dilation occurred when the touch resembled a soft stroke that activated CT-system fibers at both optimal temperature and velocity. CT-fibers are known to convey feelings of pleasure and comfort (von Mohr et al., 2017), and the soothing and beneficial effects of this pleasant touch provide evidence supporting a direct connection between CT-fiber stimulation and autonomic modulation (Fotopoulou et al., 2022; Triscoli et al., 2017). Taken together, our results consistently support the idea that Affective Touch is linked to autonomic regulation and that pupil size encodes Affective Touch not only for the speed or the effector features, but as a holistic experience. Indeed, we observed a higher pupil dilation when touch was delivered simultaneously at CT-optimal speed and by a human hand. Also, the observation of supralinear enhancement of pupil dilation in this kind of touch further supports the idea that the combination of these two features can induce a significantly stronger autonomic activation than the summed effects of each delivered separately.

In our study, we also invited participants to rate the pleasantness of the touch they received. Consistent with prior research (Ali et al., 2023; Pfabigan et al., 2023; van Hooijdonk et al., 2019; von Mohr et al., 2017; Zheng et al., 2021), our participants reported higher levels of pleasantness when the touch was administered at the CT-optimal speed and when delivered by a human rather than an artificial hand. Crucially, self-reports mirrored pupil results by revealing that participants reported the highest ratings of pleasantness when tactile stimulation featured both CT-optimal speed and human contact simultaneously. These finding reinforce the notion that touch is perceived as more pleasant when it exhibits characteristics associated with human touch (Schirmer et al., 2023; Wijaya et al., 2020). It also underscores that real human-to-human interaction triggers a wide range of positive physiological, emotional, and behavioural effects that cannot be replicated by an artificial social touch (Willemse et al., 2017).

This is the first study investigating the combined effects of two key low-level features characterizing tactile interaction on both physiological activity and perceived pleasantness. Our results emphasize the uniqueness of Affective Touch as a standalone form of social interaction characterized by specific sensory attributes. Indeed, this type of social touch not only conveys positive emotions but also elicits feelings of support and affection (Bytomski et al., 2020; Croy et al., 2016; Lo et al., 2021). Collectively, our findings suggest that the connection between Affective Touch and pleasantness hinges on the sensory characteristics inherent to human-to-human tactile interactions. These features might be crucial for experiencing Affective Touch as a rewarding experience having a strong adaptive and evolutionary value central to our relational and social development.

It is important to acknowledge the possible limitations in our study and consider potential avenues for future research. Firstly, in our study, we only examined two different stroke speeds. Future investigations should explore a broader range of stroke-speed conditions while still using a human hand, as a touch promoted by a human hand is central for analysing the affective and social aspects of Affective Touch. Secondly, touch pressure and intensity, which have been identified as significant factors in other studies (Case et al., 2021; Iriki et al., 1996; van Hooijdonk et al., 2019; Wolfgang Ellermeier and Westphal, 1995), should also be investigated as essential features of Affective Touch. Furthermore, it would be valuable for future studies to consider participants' personal attitudes towards interpersonal touch by using targeted questionnaires. For instance, research has indicated that individuals who lacked tactile, enjoyable experiences with close family members during early development may perceive Affective Touch as less pleasant (Sailer et al., 2016). Lastly, our study focused exclusively on young subjects. Future research should expand upon these findings and explore the effects of age. A more diverse and heterogeneous sample could provide further insights into the hedonic and physiological responses related to Affective Touch throughout the lifespan (Cascio et al., 2019; Sehlstedt et al., 2016).

Summarizing, the present study investigated how two key features characterizing Affective Touch such as touch velocity and the nature of the hand promoting the touch influence both pupil dilation and the subjective experience in the person receiving a tactile stimulation. We not only replicated previous observations regarding each feature alone, but also unveiled, for the first time, that their combination is crucial in promoting a stronger physiological activation and an optimal hedonic experience. In fact, we found that both pupil dilation and degree of pleasantness were significantly higher when tactile stimulation was delivered by a human hand and with a speed resembling the one used during a caress. These combined sensory elements appear to be fundamental for experiencing Affective Touch as a comprehensive and rewarding phenomenon, one that holds central importance in our social lives.

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## IMPACT STATEMENT

Our research shows that physiological response and degree of pleasantness were significantly higher when participants received slow, caress-like touch administered by a human hand. These combined sensory elements (stroke velocity and human hand features) emerge as a pivotal factor for experiencing Affective Touch as a comprehensive and rewarding phenomenon, one that holds central importance in promoting social bonding and individual wellbeing.

## CREDIT STATEMENTS

**Greta Bonino:** Conceptualization, Methodology, Software, Formal Analysis, Investigation, Writing – Original Draft, Writing – Review & Editing, Visualization.

**Alessandro Mazza** : Software, Formal Analysis, Investigation, Data Curation, Writing – Original Draft, Writing – Review & Editing, Visualization.

**Francesca Capiotto** : Methodology, Investigation, Writing – Original Draft, Writing – Review & Editing, Visualization.

**Anna Maria Berti** : Conceptualization, Methodology, Writing – Review & Editing

**Lorenzo Pia** : Conceptualization, Methodology, Writing – Review & Editing

**Olga Dal Monte** : Conceptualization, Methodology, Validation, Formal Analysis, Investigation, Resources, Data curation, Writing – Original Draft, Writing – Review & Editing, Visualization, Supervision, Project Administration, Funding acquisition.

## DISCLOSURES

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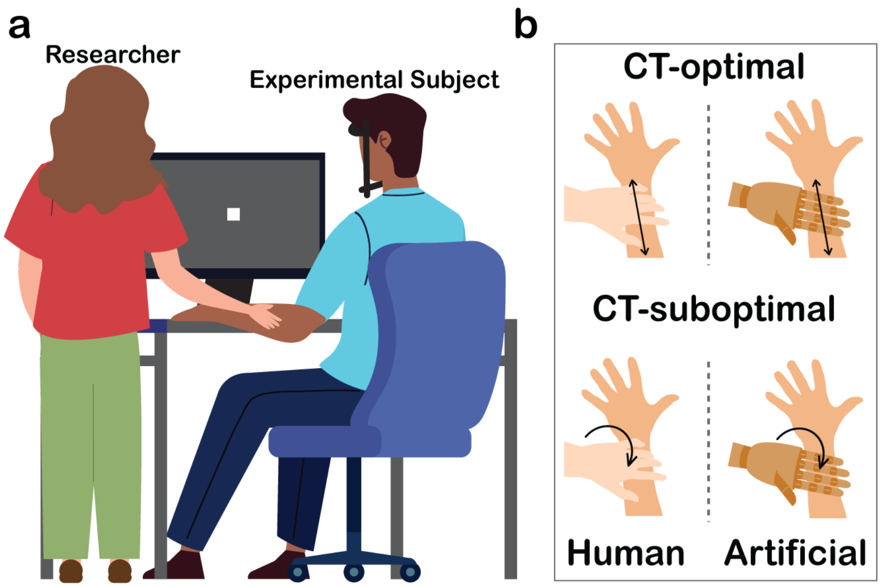
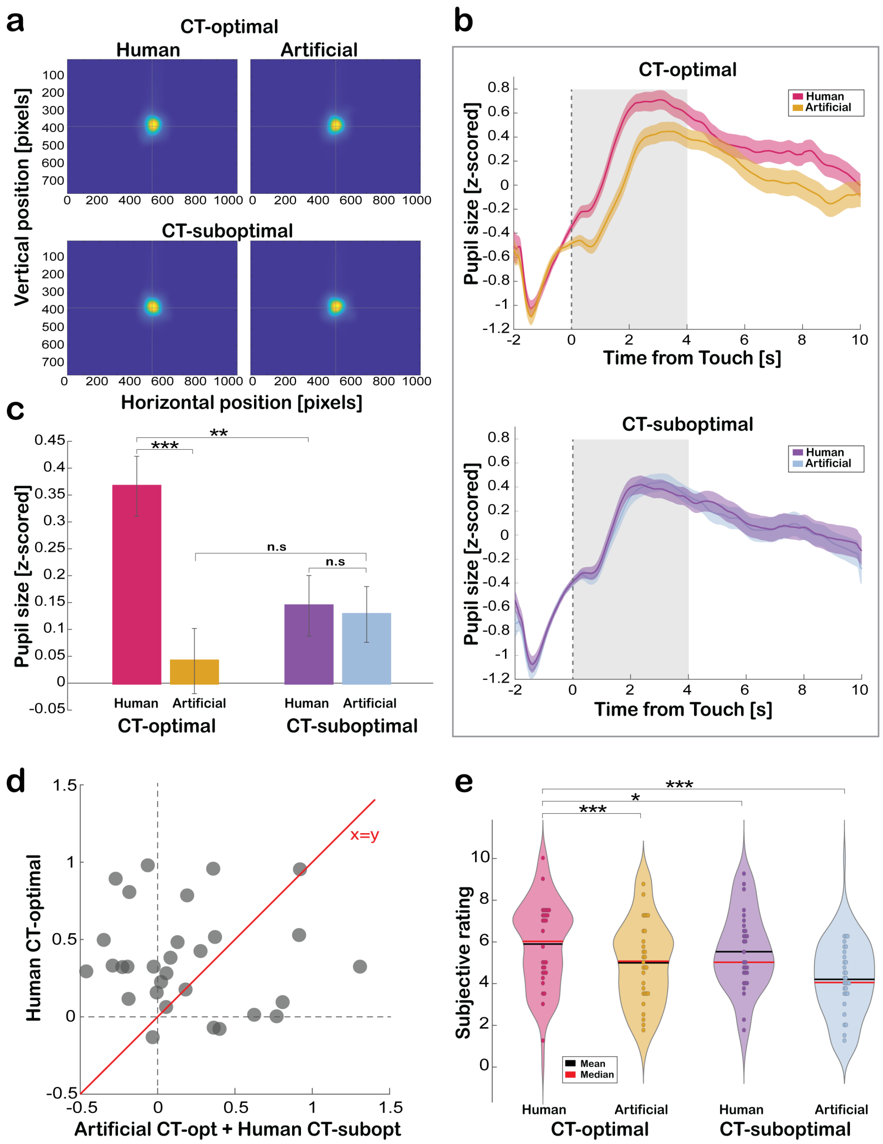
## DATA AVAILABILITY STATEMENT

The data and code of the present study are available from the corresponding author upon request.

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