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**PAPER FOR SCIENTIFIC STUDENT ASSOCIATIONS
CONFERENCE**

**THE POWER OF EXPECTATION: HOW ANTICIPATION PREDICT THE
PHYSIOLOGICAL RESPONSE TO AFFECTIVE TOUCH**

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0. Abstract

Touch is the first sense to develop in humans and remains important throughout our lives (Arabin, 1996). Affective touch, which involves gentle stroking of the skin, plays a key role in emotional well-being, reducing stress, and helping form social bonds as well (Hertenstein, 2006; Fleming, 1994). This study explores how expectations predict both perceived and actual physiological responses—specifically changes during affective touch. In an experiment with the participation of 71 young individuals, expectations and actual and perceived heart rate, finger temperature, and respiratory rate were recorded in three experimental conditions, i.e., fast stroking, slow stroking, and attention. While expectations predicted perceived changes in heart rate, respiratory rate, and finger temperature in the slow and fast stroking condition, they did not align with actual physiological measurements. Also, no significant association between actual and perceived physiological changes was found. This suggests that cognitive processes, such as anticipations, play a role in the development of subjective experience, i.e., our beliefs can significantly influence how we interpret bodily sensations even when there is no corresponding physiological change.

Keywords: affective touch, physiological responses, expectations, heart rate, emotional regulation, social bonding, perceived versus actual changes

1. Introduction

Touch is the initial sensation to emerge in the embryo and is the last to diminish as we age (McGrath, 2009). Affective touch, i.e., the gentle stroking of the hairy surface of the skin, is assumed to play a crucial role in emotional regulation, including the alleviation of negative affective states and the stress response, and social bonding in humans as well as other animals, such as apes. It has been shown to reduce feelings of social exclusion and buffer the effects of interpersonal threats such as ostracism (von Mohr, 2017). The pleasantness of affective touch is significantly higher when it is exchanged between partners compared to strangers, highlighting its role in intimate relationships (von Mohr Ballina, 2019). It also helps convey emotions such as love, gratitude, and compassion, and is essential for establishing and maintaining close relationships (Hertenstein, 2006). It informs us about others' emotions and intentions, thereby sustaining intimacy and protecting against loneliness and psychological distress (von Mohr Ballina, 2019).

AT is perceived as a marked positive (i.e., pleasant) skin sensation by the vast majority of the population (Löken et al., 2009). Such internal experiences are the results of perception, i.e., the processing of sensory input in the light of so-called top-down factors, such as previous experiences and knowledge. For example, expectation substantially influences perception by changing how we interpret sensory inputs from both the outside world and within our bodies (Morrison, 2010). Our brain is continuously predicting sensory outcomes based on previous experiences, and these predictions -or expectations -can either improve or distort the perception of actual events (Friston, 2009). Perception is thus an active, inferential process, rather than a passive reception of information. This is most evident in the sense of body states, known as interoception, where expectations frequently shape what we consciously perceive (Köteles, 2024). For example, the brain may predict a biological change and generate sensations that correspond to that expectation, even if there are no corresponding actual changes (Körmendi et al., 2021, Köteles and Babulka, 2014). In this way, expectations might lead us to experience sensations that are based on our concepts and predictions rather than actual sensory information. Moreover, people tend to focus on sensory information that supports their expectations. For example, even when actual skin temperature fluctuated (getting warmer, then cooler), participants focused only on changes that matched their expectations and ignored opposing data in a study (Pennebaker and Skelton, 1981). This dynamic is evident in studies in which subjective sensations of body states, such as reported heartbeats or changes in alertness, were discovered to be predominantly impacted by participants' expectations rather than real physiological responses. Thus, expectation substantially alters our external and internal sensory worlds, influencing our view of reality, well-being, and health (Köteles, 2024).

In summary, affective touch is a vital component of our bodily well-being; it is assumed to evoke psychological and peripheral physiological changes. In this paper, we investigate the associations between expectations, and perceived and acute physiological changes evoked by AT. More specifically, we assumed that expectations of certain physiological changes (heart rate, finger temperature, and respiratory rate) would be positively associated with perceived but not with actual physiological changes.

2. Theoretical background

2.1. The phenomenon of affective touch

The skin is not merely a protective barrier; it is our largest organ that plays a pivotal role in our

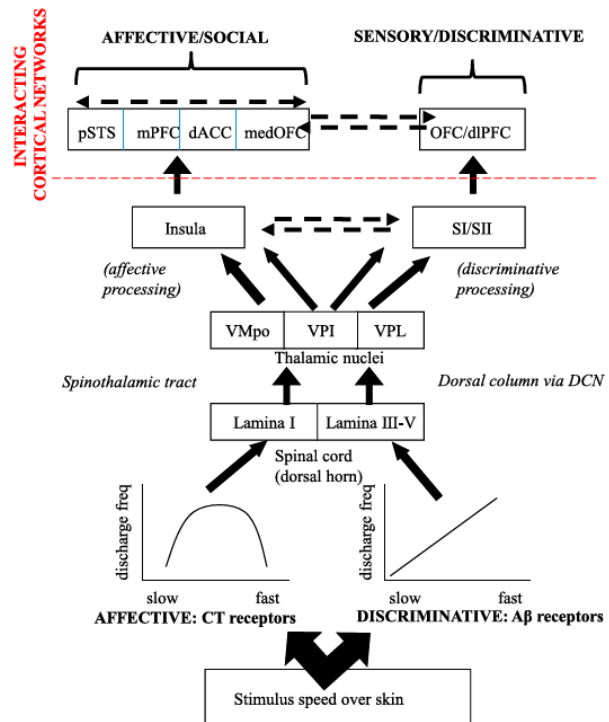
ability to perceive touch. It contains various types of receptors that respond to different stimuli, such as pressure, temperature, and pain. These receptors send signals to the brain, allowing us to interpret and respond to our external and internal environment. Specialized nerve endings are responsible for detecting light touch and deep pressure at the same time. This complex network enables us to experience a wide range of tactile sensations (Kalat, 2018).

Traditionally, touch has been viewed as serving an exclusively discriminative role, helping us identify and react to external stimuli (Mountcastle, 2005). So-called low-threshold mechanoreceptors (LTM) are connected to myelinated A β afferent nerves, allowing quick (33-75cm/sec) signal transmission and fast reactions. This means that stimulation of these receptors can elicit an immediate response, informing the brain about the sensory-discriminative characteristics of touched objects. The hairy skin contains comparatively fewer LTMs than the glabrous skin; however, it also contains unmyelinated C fibers which are essential for a wide range of feelings (McGlone, 2014).

Affective touch refers to a specific type of personal touch that is characterized by its gentle, caressing nature (Pawling, 2017). Specific nerve fibers were connected in the sensation of affective touch, particularly focusing on a group of unmyelinated mechanoreceptors known as C tactile afferents (CT afferents). These fibers, located in the hairy skin of the body, are part of a subgroup of slowly conducting (0.5-2 cm/sec), low-threshold C fibers. They are uniquely tuned to respond to slow, gentle stroking, ideally at speeds between 1 to 10 cm/s and at a skin temperature of around 32°C (Croy et al, 2016; Löken et al, 2009). When the stroking is too slow (0.3 cm/s or slower) or too fast (30 cm/s or faster), the pleasantness of the sensation diminishes (Croy et al, 2016). This sensitivity to light touch is crucial for convey social and emotional information, allowing for the formation of bonds through tactile interaction. That being said, traditionally, the skin is viewed as an organ that provides external sensory information (exteroception). However, the skin also plays an important role in conveying interoceptive signals, which are related to emotions and bodily states (Crucianelli and Ehrsson, 2023).

Soft brush stimulation activates somatosensory areas (S1 and S2) as well as the insular cortex, which is responsible for interoceptive and emotional processing. Individuals with specific nerve deafferentation, particularly complete denervation of A β afferents, had no activation in somatosensory areas but do in the insular cortex, indicating a separate processing pathway for affective touch (Björnsdotter, 2010). C-tactile (CT) afferents respond to the velocity gentle touch in a way that resembles an "inverted U" curve with a peak at 3-5 cm/s, meaning they are most sensitive to touches that have emotional significance, like affectionate or comforting

touches (see 1. Figure). In contrary, A β fibers respond steadily as the speed of touch increases, focusing on the physical aspects of the stimulus. Within the brain, areas such as the posterior insula and secondary somatosensory cortex work together to process both sensory and emotional aspects of touch. The connections from these areas also reach parts of the brain involved in social processing, particularly in areas like the orbitofrontal cortex (OFC) (Craig, 2002). This suggests that our experiences of touch are influenced by both sensory input and emotional context. Affective touch prioritizes the pleasantness of the experience, emphasizing emotional connections rather than merely the sensory details.



1. Figure Schematic Representation of Affective and Discriminative Pathways for Touch on Hairy Skin

2.2. Functional hypotheses of CT signaling: social touch, interoception, and thermoregulation

It is now obvious that the sensation of soft touch, relying on the activation of CT fibers, is more than a neutral body feeling. It has a substantial impact on our emotional and physical well-being. Morrison (2016) proposed three major ideas on the functional role of CT fibers: (1) The Social Touch Hypothesis; (2) The Interoceptive Hypothesis; and (3) Thermoregulatory Hypothesis.

The Social Touch Hypothesis contends that CT fibers are essential for social bonding because they respond to touch that is essentially pleasant and rewarding. This type of emotive contact can improve social relationships by encouraging intimacy and bonding among individuals. This approach proposes that touch may act as a signal of connection and safety, influencing behaviors that promote social cohesion. However, not just any contact provides these benefits; it is the quality of the touch that is most important (Jean et al, 2009).

The Interoceptive Hypothesis emphasizes the physiological effects of affective touch on the body. It suggests that gentle touch via CT fibers helps regulate internal bodily states, such as reducing stress. When someone experiences a comforting touch, it signals to the brain that they are in a safe environment, which can alleviate anxiety and promote relaxation. This perspective highlights the connection between sensory experiences and emotional regulation, suggesting that CT fibers play a role in our overall physiological well-being.

Thermosensation and affective touch are both skin-based interoceptive modalities that contribute to bodily awareness, social connection, and emotional regulation. The Thermoregulatory Hypothesis offers a different perspective by proposing that CT fibers may have originally evolved as part of thermoregulatory behavior. When people engage in social interactions like hugging, snuggling, or other forms of gentle touch, these physical acts serve not only as expressions of affection but also as mechanisms for regulating bodily temperature and reducing stress. This type of contact helps regulate physiological states and maintain emotional stability, particularly in challenging situations. From infancy, individuals rely on caregivers to meet their interoceptive needs, such as regulating temperature and ensuring comfort (Crucianelli and Ehrsson, 2023). This hypothesis suggests that the functions of CT fibers might have evolved from these thermoregulatory mechanisms to facilitate social bonding. As such, CT fibers not only signal warmth but also promote social interactions that enhance survival and well-being.

2.3. Interoception

Understanding the distinction between exteroception and interoception is important for comprehending how we interact with both our internal and external worlds. Exteroception will allow us to navigate our environment and respond to external threats or opportunities, while interoception helps us maintain our physical and emotional well-being by providing vital information about our body's internal conditions (Morrison, 2010). The interplay between these two systems is essential for holistic sensory processing, as they work together to inform our decisions, behaviors, and emotional responses.

Affective touch, mediated by specialized unmyelinated fibers known as C-tactile (CT) afferents, exemplifies the integration of interoceptive and exteroceptive processes. These fibers respond to gentle, slow stroking and are linked to emotional and physiological regulation. The unique role of CT fibers highlights the importance of tactile input in shaping interoceptive awareness and promoting well-being (Crucianelli and Ehrsson, 2023).

2.4.The role of touch in development

The skin, as the largest sensory organ, shares an ontogenetic link with the nervous system, making it a critical mediator of touch and its associated emotional and physiological effects. Human fetus reacts to gentle stroking around the mouth area by 8.5 weeks of development. This was later confirmed by Arabin and others in 1996, using studies on living embryos. These early touch responses happen even before specialized touch receptors - called low-threshold mechanoreceptors - have fully formed because the nerve endings in the skin are still developing and are below the surface of the skin at this embryonic developmental stage.

The sense of touch in the fetus starts developing even before birth, when it moves around in the amniotic fluid, tiny soft hairs on the fetus's skin (lanugo) are stimulated by this also the stimulate CT afferents are activated what is sending signals to the brain regions such as the hypothalamus and insular cortex (Bystrova, 2009). These signals help develop the parts of the brain responsible for understanding touch and building a sense of self. For instance, this early development is suggested to be connected to eating disorders like anorexia nervosa (AN) (Strumia, 2005). In people with AN, the soft hairs on their skin often grow back in the same areas where they were present while they were still in the womb.

The physical stimulation of touch is quite important for emotional expression and communication; it often expresses more feeling than words can (Dunbar, 2004). Tactile signals, which are connected to specialized nerve fibers called CTs and possibility A β -mediated touch may also play a key role in activating feelings of closeness and reward (Fleming, 1994). The early phase of life, particularly shortly after birth, is critical for social connections and cognitive development. During this stage, the quality and kind of social contacts have a significant impact on how social behaviors develop and are showed. According to research on rats by Flemings (1994), when mother rats lick and groom their pups, it has long-term impacts on how those pups handle stress as they grow older. According to studies, this nurturing behavior effects both the pups' behavior and their brain responses to fear later in life. This licking-grooming behavior focuses on certain body regions on the pup, such as the dorsal back and head/ears, where CLTMs are highly concentrated (Liu, 1997). In other words, the level of affectionate touch between mother and child can have a substantial impact on how the child behaves and responds to stress as an adult (Fleming, 1994).

2.5. Physiological responses to affective touch

When newborns were subjected to non-affective contact, their heart rate variability (HRV) reduced compared to their resting state. This decrease implies vagal withdrawal, indicating that their bodies were probably experiencing a minor stress response or increased arousal. This shows that non-affective contact may communicate to the newborn's body that it is time to prepare for sensory processing, as it is less soothing and may not provide the same level of security. In contrast, when newborns were receiving affective touch, there was no significant change in HRV. This stability shows that emotive contact contributes to a calm physiological state without causing tension or excitation (Della et al, 2021). In another study executed with adults, affective touch has been shown to enhance heart rate variability (HRV), indicating increased parasympathetic activity and suppression of sympathetic responses in cardiac regulation (Candia-Rivera et al, 2024).

A study conducted by Puyvelde et al. (2019) looked at how different types of touch from mothers -gentle stroking versus just holding-affected both infants and mothers. When mothers stroked their infants, it caused a calming effect, resulting increased heart rate regulation and decreased breathing rate in the infants. However, non-stroking touch did not have the same effect, and in some cases, the infants' heart regulation measures even decreased. These results suggest that gentle stroking stimulates a part of the nervous system that helps calm the body, and it seems that mothers naturally stroke their infants at the optimal speed to achieve this effect. This type of touch may be especially important for helping infants develop healthy stress regulation early in life.

In a study made by Pawling et al., 2017 it was showed that when slow stroking touch (3 cm/sec) was applied to the forearm, there was a significant slowing down of the heart rate compared to faster strokes (30 cm/sec). This heart rate deceleration suggests that slow stroking is more pleasant and triggers a relaxation response. Interestingly, this slowing down also happened when slow strokes were applied to the palm, which does not have CT fibers, meaning that the relaxing effect of the slow touch was similar for both the forearm and palm.

2.6. Dissociation Between Perception and Physiology

Anatomically, CT activation may have both short-term and long-term stress-buffering effects through a number of possible brain pathways. Like other C-type afferent fibers, CTs enter the

brain through the spinothalamic tract, and their projections to the amygdala and hypothalamus offer possible routes for their input to influence HPA axis function (Kidd, 2023).

The stress response is largely characterized by a discrepancy or dissociation between perceived and actual physiological changes. Perceived stress may not necessarily correspond with physiological stress indicators, such as heart rate. People's expectations and beliefs can have a considerable impact on how they react to stress, even if their bodies display evidence of physiological activation. (Nagy et al., 2024). This discrepancy, where individuals either do not perceive actual visceral events or perceive changes that do not occur, can impact health through behavioral factors and adherence issues (Köteles, 2024). The adaptiveness and original function of this discrepancy can be approached from evolutionary, cognitive development, and predictive processing perspectives.

Evolutionarily, it may have been advantageous to have a heightened sensitivity to certain bodily changes to respond quickly to threats, even if this sometimes resulted in false alarms. However, increased precision would require more resources, which could be allocated to other fitness-enhancing functions (Köteles, 2024).

Cognitive explanation is this matter that adults' poor interoceptive accuracy is a result of learning and habituation. Internal cues that are repeated over time lose their ability to be consciously perceived since they do not convey new or emotionally salient information. Because it frees up brain resources for outside dangers, this is adaptive. Under specific conditions, sensory information from internal organs can reach conscious consciousness; nevertheless, most of the time, people filter out the vast majority of internal stimuli because continuous perception would deplete their limited attentional capacity (Köteles, 2024).

Explanation of the active inference model states that in order to make sense of sensory information, the brain creates and tests hypotheses. Energy and capacity are conserved when there is no difference between expected (predicted) and actual sensory input. This is because no additional information is processed. Top-down processes predominate in interoception, meaning that previous expectations have a significant impact on our internal experience. An internal event is only consciously represented when physiological regulatory processes are unable to resolve the discrepancy (Köteles, 2024).

In consequence, as our ability to detect bodily signals is generally poor, expectations significantly shape the perception of physiological changes. For instance, in the context of inhaled essential oils, participants' expectations predicted changes in alertness but did not affect

cardiovascular variables (Köteles and Babulka, 2014). This indicates that subjective experiences can be heavily influenced by what individuals expect to feel, rather than by actual physiological changes. Similarly, in the mental heartbeat tracking task, performance was strongly related to expectation, suggesting that individuals with high expectations might misinterpret vague sensations as heartbeats, leading to inflated scores (Körmendi et al, 2021). This demonstrates that expectations can lead to the categorization and counting of non-specific sensations as specific physiological events, thereby shaping perception.

3. Research question and hypotheses

The major question behind the current study concerns the potential role of expectations in shaping the perception of physiological changes presumably evoked by AT. The study included the assessment of three physiological modalities: heart rate, respiratory rate, and temperature of the finger. With respect to these modalities, the following hypotheses were tested.

Hypothesis 1 (H1) - The anticipated physiological change predicts the perceived physiological change.

Hypothesis 2 (H2) - The anticipated physiological change predicts the actual physiological change.

Hypothesis 3 (H3) - The actual physiological change predicts the perceived physiological change.

4. Methodology

4.1. Participants

Sample size calculation for a medium level correlation ($r = 0.3$), $\alpha = .05$, $1-\beta = 0.8$ indicated a minimum sample size of $n = 84$. The current paper, being part of an ongoing project, relies on the data obtained from 71 participants (81% females, 28.7 ± 9.4 yrs). Recruitment was conducted through convenience sampling, specifically targeting KRE university students enrolled in the courses “Psychological Experiments” and “Biological Foundations of Psychology 1-2.” Data collection was through personal laboratory assessments. It is important to highlight that while

the data collected will be shared with other students for collaborative purposes, this paper only focuses specifically on the physiology-related assessments. Inclusion criteria for participants will require them to declare that they do not suffer from any untreated neurological disorders. Conversely, individuals were excluded from participation if they have had injuries to the right hand or are experiencing acute or chronic pain, regardless of the affected area. All participants were fully informed about the study's objectives and procedures, and written informed consent was obtained before their participation. Participants were assured of their rights, including the freedom to withdraw from the study at any time without penalty. Confidentiality will be and was maintained throughout the research process to protect participant data. The study was approved by the Research Ethics Board of Institute of Psychology, KRE (BTK-PI/408-1/2024).

4.2. Physiological measurements

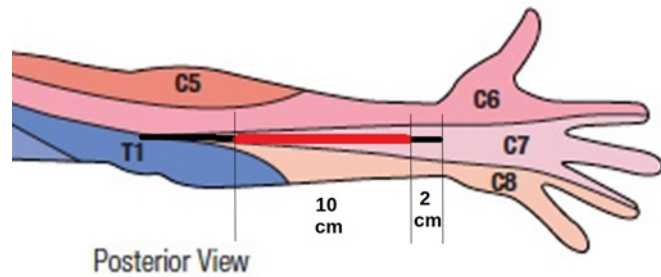
The NeXus system (NeXus-10 Mark II, Version 1.02 device and BioTrace + Software for NeXus-10 v2018A1; Mind Media BV, Herten, the Netherlands) was utilized to record various physiological data. ECG was recorded using a modified Lead II electrode arrangement, with electrodes placed on the right clavicle and the lower part of the left ribcage. The sampling rate for ECG was set at 1024 Hz, and a notch filter was applied at 50 Hz to eliminate electrical noise. For the assessment of electrodermal activity, two electrodes were positioned on the palmar surface of the second digit of the right index and middle fingers, with a sampling rate of 64 Hz. Respiratory activity was measured using a strain gauge inserted on the chest at a sampling rate as well of 64 Hz. Before analysis, every data set was visually checked for artifacts. Heart rate (HR), respiratory rate (RR), and skin conductance level (SCL) were calculated by the BioTrace+ software after artifact removal.

4.3. Procedure

Upon arrival, participants were briefed on the experimental procedure and provided informed consent by signing the necessary forms. They then filled out a battery of questionnaires. To

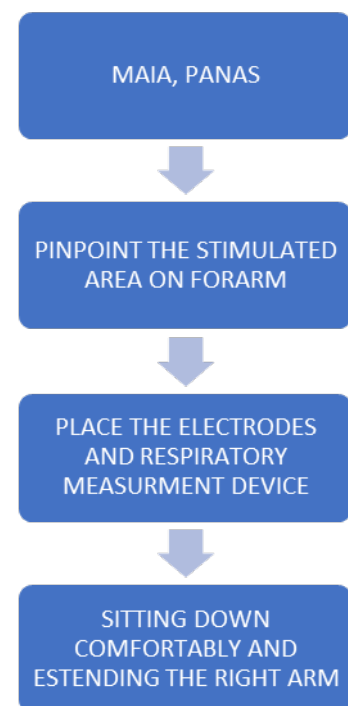
start with the experiment, a 10 cm line was then drawn on the dorsal surface of each participant's right forearm, within the C7 dermatome (see 2. Figure).

2. Figure The red line indicates the stimulated area on the dorsal surface of the right forearm. C5..8 and T1 refer to different dermatomes.



The experimenter then affixed the electrodes and sensors for the physiological measurement. In the experimental room a cardboard divider separated the participant and the experimenter while they were seated on different sides of a table. The subject's right arm was comfortably lying on the table after being extended through an opening in the divider (see 1. Picture). Participants were instructed to keep sitting in a comfortable position for five minutes in order to record their baseline physiological values (see 3. Figure)

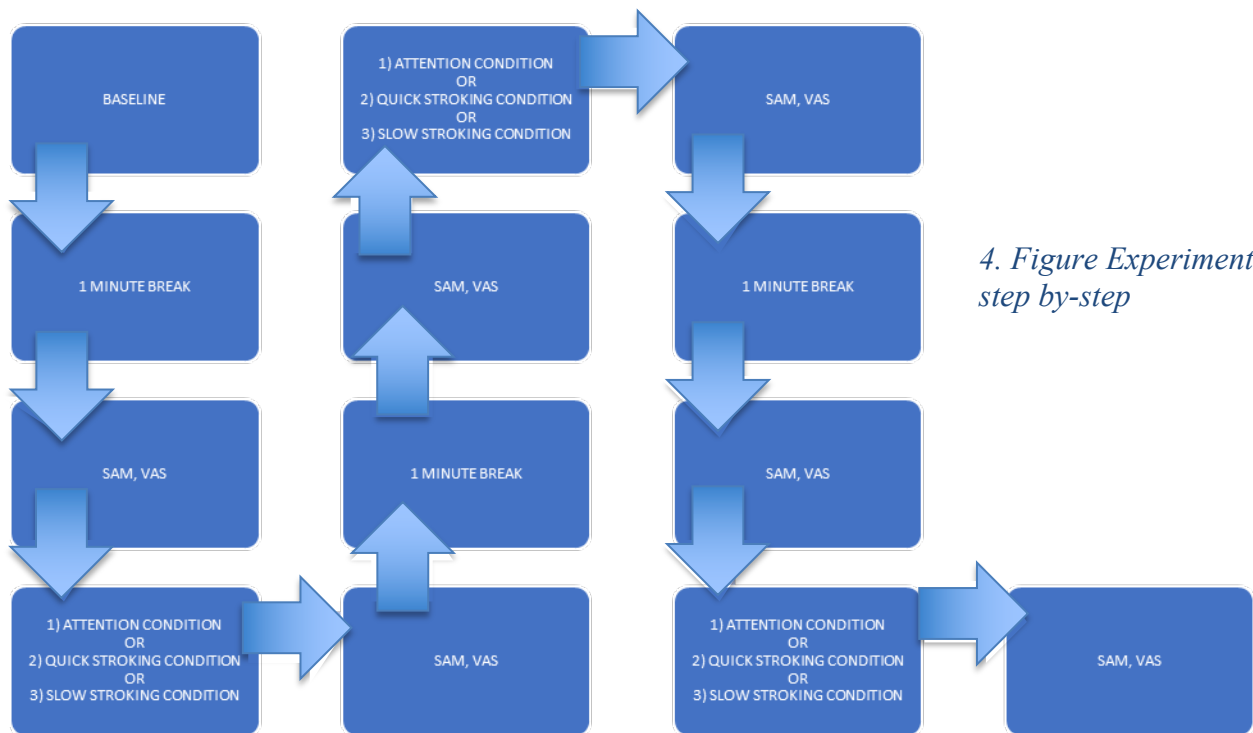
During the experiment, three different stimuli were applied to a 10 cm zone on the dorsal middle forearm (C7 dermatome) in a randomized order, each lasting 2 minutes. The stimuli were as follows: 1) The participants focused and fixed their attention on the marked zone (attention condition). 2) The experimenter brushed the designated area rapidly (30 cm/sec) with a watercolor brush (quick stroking condition). 3) The experimenter brushed the same area slowly (3.3 cm/sec) with the same brush (slow stroking condition).



3. Figure Preparation for the experiment

The two touch stimulations were presented by the experimenter on his/her own forearm to the participant. An audio guide, listened to by the experimenter through headphones, ensured accurate timing for each stimulus. Prior to each 2-minute stimulation period, there was 1 minute break. Then participants were asked to rate their current mood (valence and arousal) using self-assessment manikin scale (SAM), and their expectations regarding mood, skin sensation pleasantness, and physiological changes (HR, RR, and finger temperature) using VAS. After each 2-minute period, participants again rated their mood and skin sensation (valence and arousal) using SAM,

and their perceived physiological changes (HR, RR, and finger temperature) using VAS. The process is illustrated on 4. Figure



4. Figure Experiment step by-step

1. Picture The setup with the experimenter and the participant



4.4. Questionnaires

Self-report measurements

At baseline, participants completed several questionnaires, including the Edinburgh Handedness Inventory, the Multidimensional Assessment of Interoceptive Awareness (MAIA), and the Positive and Negative Affect Schedule (PANAS). However, the data from these questionnaires will not be used in this study.

Expected and perceived changes in skin sensation, mood state, HR, RR, and skin temperature were assessed using a 10-cm visual analogue scale (VAS) during the experiment. As only physiology-related variables are used in the present paper, scales assessing mood state and skin sensation are not described here. The survey included the following questions: Participants were also asked about the expected heart rate change with the question: "*What do you think will happen to your heartbeat in response to the stimulation?*" They could choose between anchor points as following "*It will be much slower*", "*It will not change*", or "*It will be much faster*". The expected breathing change was assessed with the prompt: "*What do you think will happen to your breathing in response to the stimulation?*" Participants were given the same anchor points options as for heart rate. To gauge their perception of temperature, participants answered the question: "*What do you think will happen to the temperature of your fingers in response to the stimulation?*" The anchor points options included "*It will be much lower*", "*It will not change*", or "*It will be much higher*."

Participants were asked similar questions after the stimulation to evaluate how their heart rate, breathing, and finger temperature actually changed. For heart rate, the question was, "*What happened to your heartbeat in response to the stimulation?*" with the same response anchors as for expected changes. The same structure applied to the questions about breathing and finger temperature perception, where they rated the changes they felt during the experiment.

For all VAS, value of 50 indicated no expected/perceived change, larger values showed expected/perceived increases, whereas lower values expected/perceived decreases

5. Statistical analysis

Statistical analysis was carried out with the JASP v0.19.1 software (The JASP Team, 2024). For measures of physiological activity (HR, RR, temperature), the mean value obtained from the first 30-second period of the 2-minute stimulation sessions was subtracted from the respective mean of the last 30-second periods, i.e., a change score were calculated for each variable for each condition. Differences across the three conditions with respect to the three physiological change scores were investigated with separate repeated-measures analyses of valiance (ANOVA) with Greenhouse-Geisser correction if required. In the *post hoc* tests, $p_{\text{Holm}} < 0.05$ was the accepted threshold. The hypotheses of the study were checked with Kendall tau-b coefficients due to the violation of normality for multiple variables. Beyond the frequentist analysis, Bayesian correlation analysis was also used for testing the hypotheses. In these analyses, Bayes factor (BF_{10}) > 3 was considered supporting the alternative hypothesis, $\text{BF}_{10} < .33$ was considered supporting the null hypothesis, whereas the $.33 - 3$ domain was regarded as inconclusive.

6. Results

1. Table Descriptive statistics (means and standard deviations) of the recorded variables

Variable	Condition	M	SD	Shapiro-Wilk	p
Expected HR change	Attention	51.58	12.32	0.94	0.001
	Slow Stroking	48.52	13.29	0.98	0.184
	Fast Stroking	57.37	12.51	0.98	0.365
Perceived HR change	Attention	48.99	9.26	0.90	<.001
	Slow Stroking	49.86	13.56	0.98	0.183
	Fast Stroking	54.41	10.40	0.97	0.092
Actual HR change (bpm)	Attention	2.10	4.65	0.89	<.001
	Slow Stroking	2.27	5.36	0.73	<.001
	Fast Stroking	1.80	3.30	0.98	0.193

Expected respiratory rate change	Attention	48.34	10.79	0.91	<.001
	Slow Stroking	47.01	13.62	0.98	0.490
	Fast Stroking	54.45	12.42	0.97	0.114
Perceived respiratory rate change	Attention	48.45	10.38	0.94	0.001
	Slow Stroking	46.79	14.04	0.98	0.461
	Fast Stroking	50.97	10.56	0.93	0.001
Actual respiratory rate change (1/min)	Attention	0.16	3.58	0.95	0.012
	Slow Stroking	-0.59	3.26	0.91	<.001
	Fast Stroking	0.16	2.79	0.97	0.141
Expected finger temperature change	Attention	56.79	10.96	0.92	<.001
	Slow Stroking	56.21	11.01	0.98	0.215
	Fast Stroking	60.13	11.13	0.92	<.001
Perceived temperature change (°C)	Attention	56.66	11.47	0.89	<.001
	Slow Stroking	59.37	14.90	0.97	0.080
	Fast Stroking	59.10	12.33	0.96	0.021
Actual temperature change	Attention	0.16	0.54	0.92	<.001
	Slow Stroking	0.03	0.45	0.99	0.731
	Fast Stroking	0.07	0.51	0.96	0.039

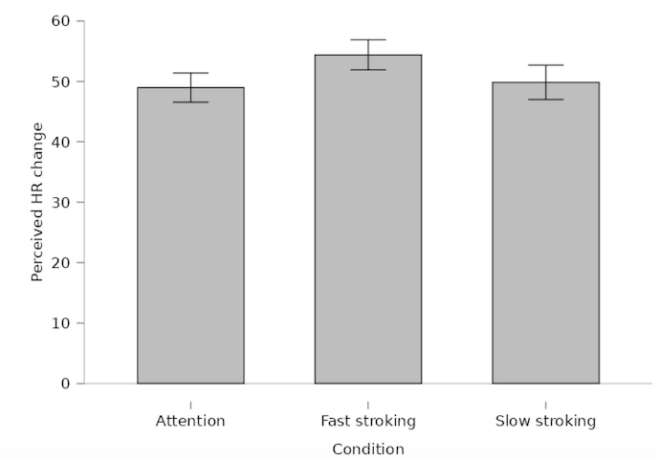
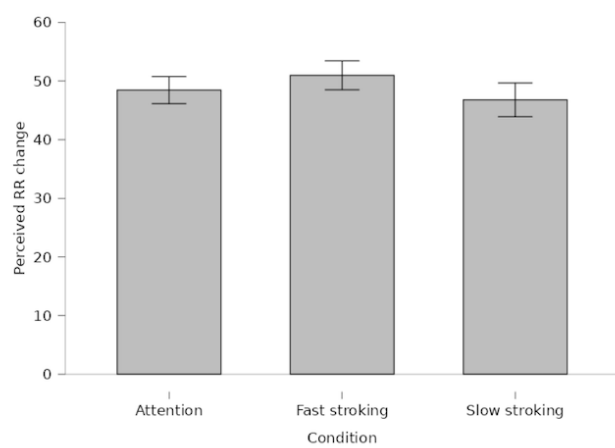
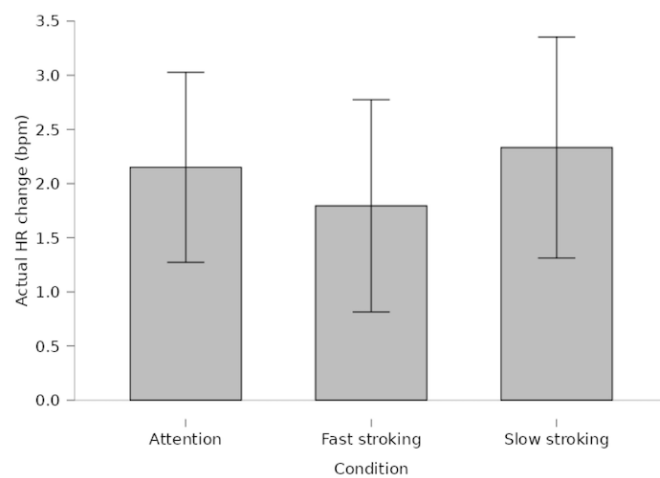
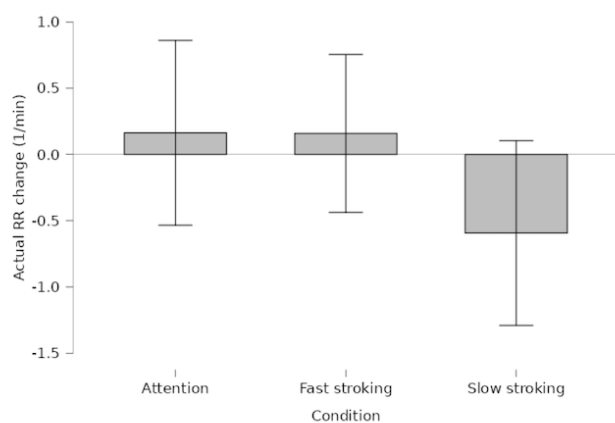
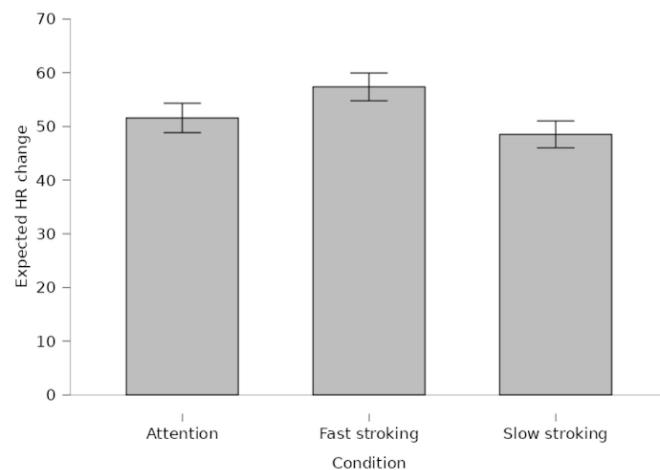
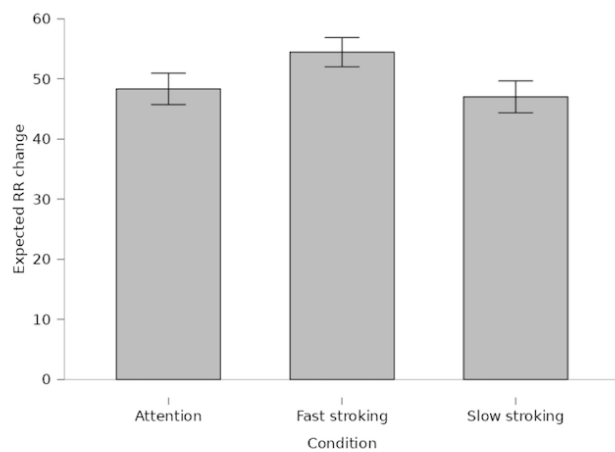
6.1. Expected, perceived, and actual changes

Descriptive statistics of the assessed variables in the three conditions are presented in 1. Table.

For heart rate (HR) expected changes, ANOVA indicated significant differences across conditions ($F(2,140) = 11.750, p < .001, \eta^2 = .14$), with fast stroking being significantly ($p_{\text{Holm}} < 0.05$) larger than the other two conditions. For actual HR differences, no significant effect of condition was found ($F(2,140) = 0.323, p = .725, \eta^2 = .005$). For HR perception, a significant difference was found between conditions ($F(2,140) = 5.014, p = .008, \eta^2 = .067$); *post hoc* tests indicated that the fast stroking condition was characterized by significantly ($p_{\text{Holm}} < 0.05$) larger values than the other two. (See 2. Bar Plot HR Change- Expected, Actual, Perceived)

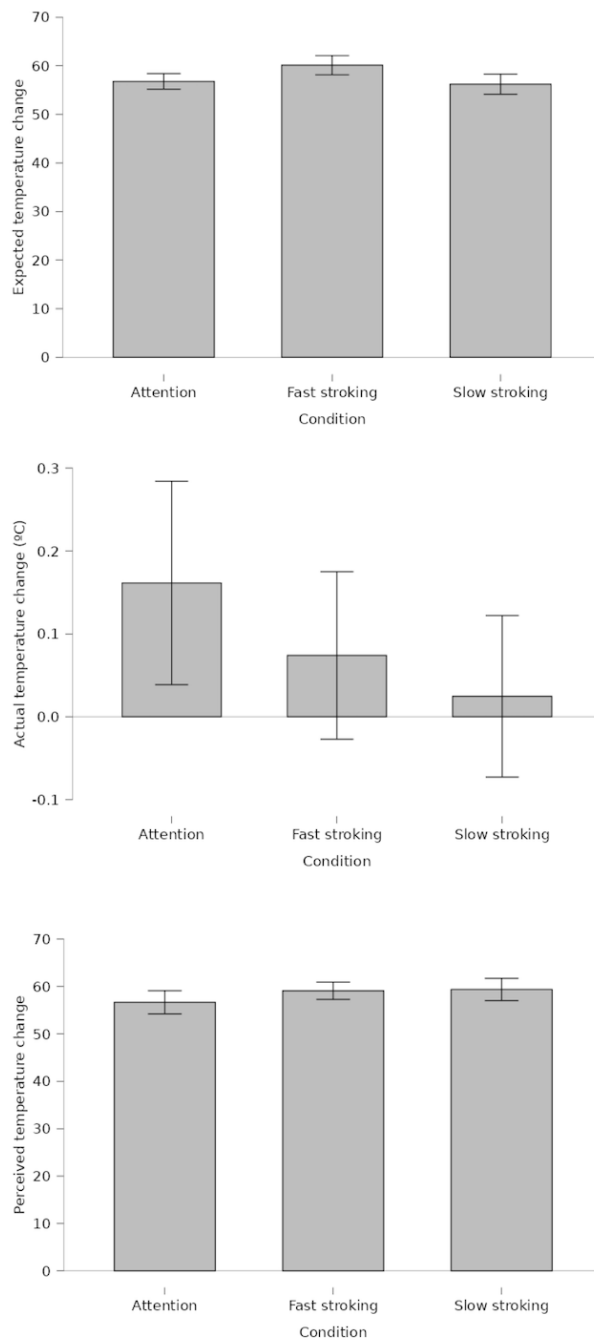
For respiratory rate (RR) expectation, significant differences were found across conditions ($F(2,140) = 9.486, p < .001, \eta^2 = .119$), with fast stroking being significantly ($p_{\text{Holm}} < 0.05$) larger than the other conditions. For actual RR differences, no significant effects were observed ($F(2,140) = 1.705, p = .186, \eta^2 = .024$). For perceived RR, there were no significant differences across conditions ($F(2,140) = 2.682, p = .072, \eta^2 = .037$). (for details, see 1. Table) (Also see 1. Bar Plot RR Change- Expected, Actual, Perceived)

Regarding temperature expectation, significant differences were found across conditions ($F(1.844,129.053) = 4.964, p = .008, \eta^2 = .066$), with significant ($p_{\text{Holm}} < 0.05$) differences between fast stroking and the other two conditions (the latter two being lower see 1. Table). For actual temperature differences, no significant differences were observed ($F(1.834,126.518) = 1.646, p = .197, \eta^2 = .023$). For temperature perception, there were no significant differences between conditions ($F(1.798,125.892) = 1.789, p = .171, \eta^2 = .025$). (See on 3. Bar Plot Temperature Change- Expected, Actual, Perceived)



1. Bar Plot RR Change- Expected, Actual, Perceived

2. Bar Plot HR Change- Expected, Actual, Perceived



*3. Bar Plot Temperature Change-
Expected, Actual, Perceived*

6.2. Hypothesis tests

Results of frequentist and Bayesian correlation analyses are summarized in 2. Table. Overall, expectations were not significantly associated with actual changes and Bayesian analysis indicated the superiority of the null hypothesis (i.e., independence) for the majority of the cases (H2). In contrary, expectations predicted perceived changes in the fast and slow stroking

conditions for all three modalities, with the possible exception of HR in the fast stroking condition (H1). Finally, actual and perceived changes were not associated in any of the conditions for any modality, and the null hypothesis (i.e., lack of association) was more probable than the alternative hypothesis for many cases (H3).

2. Table Associations (Kendall tau-b correlation coefficients [BF10 values]) between expectations, perceived changes and actual changes in HR, respiratory rate, and finger temperature in the three conditions.

	Attention	Fast stroking	Slow stroking
HR change – expected x perceived (H1)	.049 [0.185]	.18* [1.765]	.46*** [846387.1]
HR change – expected x actual (H2)	.07 [0.213]	-.02 [0.163]	-.11 [0.159]
HR change – actual x perceived (H3)	.13 [0.494]	.02 [0.164]	.11 [0.352]
Respiratory rate change – expected x perceived (H1)	-.01 [0.157]	.31*** [244.161]	.37*** [5192.132]
Respiratory rate change – expected x actual (H2)	.12 [0.412]	.12 [0.469]	.10 [0.303]
Respiratory rate change – actual x perceived	-.11 [0.369]	.10 [0.324]	-.05 [0.189]
Finger temperature change – expected x perceived (H1)	.21* [3.932]	.40*** [18921.153]	.41*** [55497.698]
Finger temperature change – expected x actual (H2)	-.10 [0.309]	.01 [0.159]	-.04 [0.175]
Finger temperature change – actual x perceived (H3)	.07 [0.214]	.01 [0.159]	-.10 [0.273]

Note: *: $p < .05$; ***: $p < .001$

7. Discussion

In an experimental study with the participation of 71 university students, paying attention to, and slow and fast stroking of the hairy skin of the forearm showed no significant group-level differences in HR, RR, and finger temperature. Actual changes were not positively associated with expected and perceived changes; however, expectations predicted perceived changes for all three physiological variables in the two stroking conditions.

Our first hypothesis was that the anticipated physiological change predicts the perceived physiological change. Our findings support this hypothesis, in the fast and slow stroking condition, where expectations predicted perceived changes in heart rate (HR), respiratory rate (RR), and finger temperature. This aligns with previous research indicating the strong influence of expectations on subjective experiences (Köteles, 2024; Körmendi et al., 2021). The impact of anticipation on perception suggests that top-down cognitive processes significantly shape our sensory experiences, as highlighted in predictive processing theories (Köteles, 2024). The relative impact of top-down factors is particularly strong if the bottom-up sensory input is vague and noisy.

The second hypothesis, i.e., the anticipated physiological change predicts the actual physiological change, was not supported by our findings, as expectations were uniformly unrelated to actual physiological changes. This discrepancy highlights the distinction between perceived and actual physiological responses, a phenomenon well-documented in interoception research (Craig, 2002; Köteles, 2024). The lack of association suggests that while expectations can influence perceived changes, they do not necessarily alter physiological states, which is consistent with findings in the context of placebo effects and interoceptive accuracy (Körmendi et al., 2021).

The third hypothesis assumed that the actual physiological change predicts the perceived physiological change. This hypothesis was not supported, as actual changes did not significantly correlate with perceived changes across conditions. This finding underscores the complex interplay between physiological signals and their subjective interpretation, as discussed in interoception research (Köteles, 2024; Morrison, 2016). The observed dissociation may reflect the brain's tendency to filter and prioritize certain sensory inputs over others based on context and prior experiences (Morrison et al., 2010).

Several limitations of the study should be noted. First, the sample size was relatively small and primarily consisted of university students, which may limit the generalizability of the findings. Second, the study's design did not allow for the exploration of potential moderating factors, such as individual differences in interoceptive sensitivity or prior experiences with touch, which could influence the observed effects. Finally, no conclusion on causal relationships (e.g. between expected and perceived changes) can be drawn as expectations were not systematically manipulated, only assessed.

Future research should consider larger and more diverse samples to enhance the generalizability of the findings. Additionally, incorporating objective measures of perception, such as neurophysiological indicators, could provide a more comprehensive understanding of the mechanisms underlying the observed effects. Further exploration of individual differences, such as personality traits, attachment styles or prior experiences with touch, may help to make clear the variability in responses to affective touch. Finally, longitudinal studies could investigate the long-term effects of affective touch on emotional and physiological well-being, potentially informing interventions aimed at enhancing social connection and emotional regulation. Additionally, while the study assessed expectations regarding touch, it did not include systematic manipulations of expectancy, which could provide deeper insights into the relationship between expected and perceived changes.

Our study looks at how what we expect affects how we feel, especially regarding affective touch that evokes emotions as well. It's clear that anticipation plays a strong role in shaping how we experience things. While we recognize the complexities and limits of our findings, we also see opportunities for further research. By connecting ideas from cognitive neuroscience, psychology, and physiology, we can gain a better understanding of the human experience. This understanding shows that gentle, purposeful (affective) touch can go beyond just physical contact; our results show that expectation is more than just a mental state- it's a powerful force that can shape the way we perceive even the most basic physical sensations.

Declaration of AI Usage

The author hereby declare that no artificial intelligence tools or applications were used in the preparation of this paper. All content is the result of the author's own research, analysis, and writing.

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