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**Investigating the Social Softness Illusion in Autism Spectrum Disorder: A Comparative Study**

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**Relatrice**

Dal Monte Olga

**Candidato**

**Curatelo Moreno**

Matricola 958904

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*Grazie* ♥

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# Abstract

The **Social Softness Illusion (SSI)** [[1]](#footnote-2)is a consistent tactile perceptual phenomenon whereby individuals tend to perceive other people’s skin as softer than their own when giving a gentle caress. While initial findings in the general population have established the robustness of the effect through empirical studies, its manifestation, and physiological correlates in the context of neurodiversity remain largely unexplored. This study investigates the presence and modulation of the SSI in **Autism Spectrum Disorder (ASD)** adults, comparing subjective reports and **autonomic nervous system** responses with those of a Typically Developing (TD) control group.

Participants (ASD: N=13; TD: N=14) performed controlled touch interactions under two conditions: touching their own skin and either an unfamiliar person’s forearm or a human-skin-like object. After each touch, participants rated perceived softness, pleasantness, and comfort; **electrodermal activity (EDA)** was simultaneously recorded to assess physiological arousal.

Results confirmed the presence of the SSI across both groups: participants systematically perceived others’ skin as softer than their own. However, only the TD group exhibited corresponding increases in EDA, suggesting intact autonomic engagement. The ASD group showed a significant reduction in physiological embodied responsiveness, despite reporting comparable softness perception and, paradoxically, higher pleasantness when touching an unfamiliar person. These findings indicate a dissociation between explicit perceptual judgements and implicit physiological signals in the ASD group.

The inclusion of a human-skin-like object condition further highlighted the social specificity of the illusion, as the SSI effect was markedly attenuated in this non-social context. Taken together, the findings support the interpretation of the SSI as a socially grounded perceptual effect, shaped by embodied and predictive mechanisms rather than stimulus-driven sensory input alone.

### Keywords

Social Softness Illusion (SSI), Autism Spectrum Disorder (ASD), affective touch, social touch, social neurosciences, sensory phenomena

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# Chapter 1 – Theoretical Grounding

This dissertation explores whether touch is pivotal in humans’ lives and interaction with the world. It then narrows its focus to a specific form of **social touch**, **affective touch**, and introduces the Social Softness Illusion (SSI), examining how these concepts apply to individuals on the autism spectrum.

To clarify the scope of this investigation, it is first essential to define the key social tactile phenomena under examination. Social touch refers generally to any physical contact occurring between individuals that carries social meaning, playing a vital role in non-verbal communication and the establishment of interpersonal bonds. Within this broader category, affective touch represents a specific form of gentle, slow tactile interaction, typically perceived as pleasant and mediated by a dedicated neurobiological pathway involving C-Tactile (CT) afferents, crucial for social bonding and emotional well-being. A peculiar perceptual outcome of such affective interactions is the Social Softness Illusion (SSI), a phenomenon in which individuals tend to perceive another person's skin as significantly softer than their own when delivering a caress.

## The Fundamental Nature of Touch

The skin, the organ responsible for the sense of touch, marks the boundary between the body and the external world. This physical demarcation plays a crucial role in the development of the fundamental sense of one’s own body as a distinct and autonomous entity, either concerning other people, environment, and external objects (Elias, 2008).

Touch plays a foundational role in early human development, serving as one of the primary channels through which infants begin to form bonds with their caregivers. It is considered the earliest sensory modality available to the newborn, and it facilitates the establishment of the infant–caregiver relationship through physical contact, warmth, and soothing interactions (Field, 2010). In this sense, touch is not only a medium for exploring the external world, but also a vital component of early communication and emotional regulation. Through repeated tactile exchanges, such as holding, caressing, or skin-to-skin contact, infants develop the first building blocks of **attachment** and a **sense of bodily self**, which in turn supports the emergence of self–other differentiation (Gallace & Spence, 2010; Stack & Muir, 1992). As such, the study of touch is particularly relevant in developmental contexts, especially when considering conditions characterized by differences in sensory processing and social interaction.

Classical attachment theories emphasise the necessity of a secure bond between children and caregivers (Cassidy et al., 2013), lacking in the inspection of the role of touch during development (Duhn, 2010). Recent research, such as Carozza & Leong (2020), and Ardiel & Rankin, (2010), show how unique and vital it is the role of the caregiver’s affective touch: it regulates the development of the infant’s **somatosensory**, autonomic, and immune systems, and is essential in the establishment of social affiliative bonds and early psychosocial behaviour.

The intrinsic connection between touch and sociality can be traced from the earliest stages of development, even in automatic reflexes such as the grasp reflex (Futagi et al., 2012). Although it is an involuntary response, this reflex, which makes newborns grab everything that touches their palm, typically a caregiver’s fingers, assumes a profound social valence in the interactive context. It allows the child to establish a direct physical contact, maintaining proximity essential for survival and strengthening the bond. It is this interaction, eased by the reflex but activated socially, that reinforces the emotional bond and attachment, and is considered a component of affiliative behaviour (Falkson & Bordoni, 2025).

Studies on the impairments in the sense of touch, like hypoesthesia, show how the deprivation of touch may have a negative impact on daily functioning: there might be compromised fine motor tuning, awareness of potentially dangerous stimuli, or the ability to fully experience the richness of social and affective tactile interactions, creating potential difficulties both in physical orientation and in social commitment (Magerl and Treede, 2004). It is also interesting to note that, while the tactile discriminative ability may decline with ageing, the pleasantness perceived of slow and gentle caresses (CT targeted) seems to persist or even amplify (Sehlstedt et al., 2016).

## The Social Sense: Touch as a Multimodal Communicative Tool

Social touch is crucial in interpersonal communication, operating largely at a non-verbal level to convey complex emotional states such as affection, empathy, or even fear, potentiating and modulating both verbal and non-verbal communication among human individuals (Dolin and Booth‐Butterfield, 1993; van Erp and Toet, 2015). Its role exceeds the simple transmission of information, actively influencing social dynamics, as shown by the “Midas touch” effect, in which a brief, casual contact can increase trust and cooperation (Crusco and Wetzel, 1984), and proving essential for psychophysiological well-being.

It is also important to note that, in daily life interactions, touch acts rarely as an isolated channel. More often, touch is typically integrated in a **multimodal** context that involves the speech, the eyes’ gaze, the posture, the gestures, etc. (Suvilehto et al., 2023). Parallel to studies about tactile perception in social contexts, research in other sensory modalities confirmed the close bond between sensory inputs, emotional states, and empathic processes. An indicative example comes from studies regarding thermal perception. As IJzerman and Semin (2009) and Suhonen et al. (2012) pointed out, temperature (hot/cold) is linked to emotional valence (positive/negative): “hotter” messages were used to put emphasis on positive feelings and pleasant experiences, and to express empathy, emotional comfort, closeness, care, agreement, gratitude, and moral support. “Cold” feedback was consistently associated with negative experiences. While these studies focussed on temperature, they reinforce the idea that physiological and perceptual responses are susceptible to social influence, potentially through empathic mechanisms (Cooper et al., 2014). They offer an interesting link to the hypothesis of the Social Softness Illusion (SSI), where the perception of tactile softness might be influenced by the social valence of the interaction.

Studies about interpersonal physical contact indicate its role in regulating vital physiological parameters such as heart rate, blood pressure, and stress-related hormonal responses (Coan et al., 2006; Ditzen et al., 2007; Grewen et al., 2005; Whitcher and Fisher, 1979), with evidence suggesting even a hormonal modulation of tactile perception itself (Scheele et al., 2014). Such modulation provides ground for hypothesising that sensory perception is an experience involving both top-down and bottom-up processes, suggesting that touch is not a unilateral process from the sensory stimulation to the central processing. Still, it is bilateral and reciprocal, in which central states (expectations, emotions, etc.) also actively influence the elaboration and the interpretation of sensory signals coming from the periphery.

Starting from these grounds, touch, and particularly social touch mediated by the C Tactile afferent system (Vallbo et al., 1993), plays a key role in shaping critical aspects of our lives: influencing social reward mechanisms, nurturing attachment bonds, impacting cognitive capabilities, easing communication, and supporting emotional regulation across the entire human life span (Cascio et al., 2019). The profound importance of social touch in our emotional, social, and cognitive lives provides the essential context for understanding why a perceptual phenomenon such as the social softness illusion, which arises specifically from that type of tactile interaction, might exist and have certain characteristics.

Social touch, mainly in grooming, is fundamental for establishing, maintaining, and repairing social relationships and group cohesion in non-human primates (Franz, 1999). It supports individual emotional stability and fosters group unity (Troisi et al., 1989). Comforting behaviour through touch (such as **allogrooming** addressed to stressed-out partners) is furthermore observed in other social mammals (Franz, 1999; Mota Filho et al., 2022), suggesting that neural mechanisms may be phylogenetically preserved to promote affiliative touch (Gothard & Fuglevand, 2022; Martin et al., 2023). The profound impact of social touch on communication, physiology, and social bonding highlights the need to understand its underlying mechanisms, particularly the specialised system processing its affective qualities.

## Shaping Affective Touch: the Interaction of Innate Mechanisms and Experience

As previously discussed, social touch permeates human existence, deeply influencing development, relationships, and daily well-being (Cascio et al., 2019). Its social function helps us place specific perceptive phenomena, like the Social Softness Illusion (SSI), in context. This illusion arises from how the physical aspects of touch interact with its social and emotional meaning.

In parent-child dyads, it has been shown that there is a significant interaction between behaviour and heart rates, showing a fine-tuned mechanism that regulates the speed of the caresses. This mechanism guarantees individual consistency, and the flexibility required for a dynamic parent-child relationship (Bytomski Anika et al., 2020). This might seem to suggest the existence of biologically rooted mechanisms entangled with the shaping of social-affective responses and the tactile perception of the developing child.

During infancy, social touch, especially within caregiver-infant exchanges, serves as a dynamic and reciprocal process that supports the development of a stable attachment relationship. The child and the caregiver play an active role in this tactile communication, which requires mutual responsiveness. Gentle caresses are consistently associated with rewards, delving deeply into the neural circuits of the “social brain” (Glozman and Krukow, 2013) through networks and mechanisms suited for learning how to successfully exploit the environment and linked to specific neurotransmitter pathways, such as **oxytocin** (Li et al., 2022) and cortisol (Dreisoerner et al., 2021). Such a rewarding component may play a leading role in the emergence of the Social Softness Illusion, where social-affective touch is perceived as intrinsically more pleasant. This mechanism could explain why giving gentle strokes to others is intrinsically perceived as more pleasant and softer than self-administered touch, which does not elicit the same circuits in the same way.

Studies like Mantis et al. (2019) and Crucianelli et al. (2019) have shown that factors such as post-partum maternal depression or reduced emotional synchrony in caregivers can influence both the frequency and the contingency of tactile exchanges with infants. These findings suggest that the quality of early tactile experiences may shape the development of social touch perception, as also pointed out by Cascio et al. (2019).

The distinction between innate and experience-dependent mechanisms within the affective touch paradigm is particularly relevant for understanding sensory interactions in neurodevelopmental conditions such as ASD (Gliga et al., 2019). On one side, there is evidence in favour of genetically specified mechanisms. Findings about C-tactile fibres, optimised in a specific range of the velocity of the touch delivered and their early responsivity in human newborns suggest an innate basis for the identification and the appreciation of the social touch (Tuulari et al., 2019). The multimodal experience also seems to have a role. Keizer *et al.* (2017) showed that the hedonic aspect of the touch increased if participants were able to see the hand performing the stroke, suggesting that the association with other sensory experiences (like vision) contributes to the social and affective valence of the tactile stimuli.

This might be highly relevant for ASD, where hypo/hyper-sensitivity (Tomchek and Dunn, 2007) or difficulties in social interactions might lead to histories of atypical or reduced tactile experiences (Voos et al., 2013). This altered empirical “training” might directly influence how the pleasantness of others’ touch is perceived and can consequently modulate SSI.

On the other hand, different studies suggest that experience plays a crucial role in defining the valence and the pleasantness of social touch. A reduction in exposure to social touch may modulate how tactile stimuli are experienced. Sailer & Ackerley (2019), for instance, found that individuals with lower levels of social touch experience showed a stronger preference for caresses delivered at CT-optimal velocity. While such preference is observed broadly in the population, these findings suggest that individual differences in touch exposure might modulate the affective appraisal of social touch. Although the authors also acknowledged the possibility of genetic factors influencing the propensity for social contact, their results open the door to the hypothesis that affective touch perception is shaped, at least in part, by prior tactile experience.

While such variations in early input can stem from environmental conditions, it is equally important to consider how neurodevelopmental conditions like ASD may involve intrinsic sensory processing differences that affect the perception and **integration** of affective touch (Neufeld et al., 2021). These differences likely arise from genetically influenced atypical responses to sensory stimuli (Falcão et al., 2024), which may contribute to a distinct trajectory in social-affective development and tactile perception.

## Affective Touch and C-Tactile Afferents: The Neurobiology of Pleasant Touch

Affective touch is a specific category characterised by gentle and slow caresses on the skin, typically perceived as **pleasant** (Kidd et al., 2023), that promotes sensations linked to social bonding and wellness (Chatel-Goldman et al., 2014). Physiologically, affective touch is strictly correlated to activating a specific class of nervous fibres called C-tactile (CT) afferents (Vallbo et al., 1993).

The sense of touch is mediated by distinct sensory receptors found in the skin, each specific for detecting diverse aspects of the tactile experience. Each receptor is connected to the Central Nervous System (CNS) through diverse kinds of fibres, which vary by velocity of conduction and functional specialisation (Zotterman, 1939). Myelinated A-β and A-δ primary sensory afferents provide the discriminative touch (McGlone et al., 2007), i.e., the physical information about the stimulus (pressure, vibration, slip, and texture). C-tactile afferents are linked to the affective processing of the touch aspect (Vallbo et al., 1993). This type of fibre is found all over the body skin while highly concentrated in the hairy skin (Ackerley et al., 2014).

CT fibres are a specific low-threshold class of unmyelinated mechanoreceptors (slower in response compared to myelinated fibres but also phylogenetically more ancient), which are uniquely tuned to respond to slow/light tactile stimuli (Löken et al., 2009). CT afferents are available in copious quantities in the face, specifically on the infraorbital and supraorbital nerves, as well as in parts of the skin of the limbs holding hair follicles. C-tactile afferents optimally respond at 32°C, a typical temperature for the skin, while not firing at lower or higher temperatures. Specific characteristics of speed and temperature of the stroke delivered induced Ackerley and colleagues to suppose that CT afferents are sensitive to tactile stimuli resembling human-to-human caressing (Ackerley et al., 2014; Olausson et al., 2002).

Velocity is fundamental. CT fibres respond optimally to stroking with a **velocity** between 1 and 10 cm/s (Löken et al., 2009). Notably, their firing rate is directly correlated to the pleasantness of the touch received, suggesting that they are fundamental mediators of affective touch. Conversely, when the stroking is administered at speeds either lower or higher than the indicated range, or when given a static touch without relative motion, a reduced CT afferent firing occurs (Gentsch et al., 2015).

Despite CT fibres delivering the affective component of the touch sensation, selective stimulation of the CT system is not enough to evoke the naturalistic and complete feeling of a pleasant caress. Hence, the whole experience is delivered through the myelinated (Aβ) and unmyelinated (CT) afferents. The intensity and the quality of the emotional response to a tactile stimulus are not fixed, individually nor as a species. Instead, it has been proposed that it may depend on the circumstantial individual need of affection (McGlone et al., 2007).

Affiliative touch appears to be rooted in neurobiology. While CT fibres play a central role, pleasant social touch is also associated with the release of neurotransmitters like endogenous opioids and oxytocin, which contribute to the strengthening of social bonding and mediate the rewarding effects of the contact, encouraging social behaviours (Charbonneau et al., 2024; Dunbar, 2010; Jablonski, 2021a; Suvilehto et al., 2015).

Information broadcast through the CT fibres is elaborated through a network of brain areas involved in social perception and cognition: in addition to the somatosensory cortices and the amygdala, stimuli are processed by the posterior insula, the right posterior superior temporal sulcus, the medial prefrontal cortex, and the dorsoanterior cingulate cortex. Anterior cingulate and prefrontal cortices, along with the amygdala, are components of the reward (or **meso-cortico-limbic**) system (Gordon et al., 2013). This system, central in human interaction with the environment, is fundamental to incentive-based learning to pursue adaptive behaviours, given its direct connection to areas involving motor planning, and it seems that its main role is to produce or facilitate emotional, hormonal, and behavioural responses springing from species-specific skin-to-skin contact (Haber and Knutson, 2010).

This dedicated neurobiological system for processing affective touch, involving specific fibres, pathways, and neurochemicals, forms the likely substrate for perceptual phenomena related to pleasant social interactions, such as the SSI.

## The Social Softness Illusion (SSI): Examining Affective Touch Perception

The SSI arises when people are asked to administer a soft caress to other people’s skin and then compare their skin softness and smoothness to the skin of the receiver. This kind of stimulation is typical in affective social touch (Schirmer et al., 2023), such as gentle stroking within romantic partners and between parents and children (Croy et al., 2016), or even social grooming in animals (Jablonski, 2021b).

La sezione (a) mostra due figure stilizzate che si abbracciano, etichettate come 'ricevitore' (a sinistra) e 'mittente' (a destra). Il mittente ha un'espressione sorridente e una nuvoletta di pensiero sopra la testa che dice 'intento emotivo: non intendo far male. Andrà tutto bene.' Il contatto tra le due figure è etichettato come 'canale' e 'veicolo'. Sono indicate frecce che rappresentano le direzioni di input: 'TOP-DOWN e.g. interazioni multisensoriali' (frecce blu che scendono verso il ricevitore) e 'BOTTOM-UP CT + Aβ input' (frecce rosa che salgono dal ricevitore). Una freccia rosa in basso indica la direzione della comunicazione da 'mittente' a 'ricevitore'.

La sezione (b) presenta un diagramma circolare che descrive la relazione tra 'mittente' e 'ricevitore' in termini di 'espressione' e 'riconoscimento'. In alto a destra c'è il 'mittente' e in basso a sinistra il 'ricevitore'. Una freccia va dal mittente all'espressione del mittente, che poi porta al riconoscimento del ricevitore. A sua volta, una freccia va dal ricevitore all'espressione del ricevitore, che poi porta al riconoscimento del mittente. Le frecce indicano una relazione bidirezionale, dinamica e reciproca tra questi processi.Fairhurst, McGlone and Croy schematised affective touch as an expressive complex process that involves at least two individuals, which comprises specific components (sender, receiver, vehicle, signal, and a channel), is dynamic and reciprocal, and is based on the activation of specific tactile neural systems (CT-afferents) integrated with several sensory and contextual data (Fairhurst et al., 2022).

Figure 1. A hybrid communication model of affective touch. Extracted from Fairhurst et al., 2022.

In their six-experiment study, Gentsch and colleagues (2015) examined the Social Softness Illusion (SSI) across different dimensions. The first two experiments confirmed the basic effect and assessed whether it was specific to body regions innervated by CT afferents and to stroking velocities optimal for their activation. The following three experiments explored potential confounds: one avoided direct self-other comparisons to rule out social bias, another manipulated spatial distance on the forearm to exclude proximity or salience effects, and a further condition evaluated whether mere approach without skin contact could elicit the illusion. Finally, the sixth experiment investigated the contribution of sensory attenuation mechanisms, assessing how motor control over touch modulated the experience. Together, these studies not only demonstrated the robustness of the SSI but also outlined its sensory, cognitive, and motor constraints.

Pyasik *et al.* (2022) furthered the exploration of the role held by the spatial perspective taken by the participants. The experiment explored the effects of three variables: the site of the delivered touch (palm, i.e., glabrous skin, or forearm, i.e., hairy skin) to investigate whether, effectively, there was a significant difference in hairy vs. glabrous skin in that specific sample; the ability to see the touched body part; and the spatial perspective (**egocentric vs. allocentric**). The variables assessed were the Social Softness Illusion, the **sense of ownership**, and the effect of vision. Gentsch *et al.*’s (2015) SSI hypothesis was confirmed for both the forearm and the palm. The allocentric perspective increased significantly with the perceived softness of others’ skin and the sense of ownership, especially for the palm. It has been observed that the chance of seeing the body part involved did not significatively influence the evaluation of the softness (and therefore the social softness illusion), probably because the illusion is mainly driven by the affective value of the touch itself. On the contrary, sight significantly improved the sense of ownership perceived towards the other’s body part. This disassociation, where sight does not alter the tactile perception of softness but influences the sense of ownership, highlights the multimodal nature of the social perceptual experience: different sensory channels contribute to distinct aspects of the overall experience (Suvilehto et al., 2023).

These findings collectively suggest that social touch is not just a passive physical perception, but a complex and multifaceted experience shaped by psychological and social factors, in which the **peripheral nervous system (PNS)**, and especially CT fibres, plays an active role in constructing the perception of the self and others.

## Touch Processing in Autism Spectrum Disorder (ASD)

ASD is a condition of neurodevelopment characterised by differences in both verbal and nonverbal communicative behaviours, social-emotional reciprocity, and by the presence of restricted and repetitive patterns of interests, behaviours, and activities (DSM-V, American Psychiatric Association, 2013). The necessity to refer to a spectrum arises from the assumption that neurological differences are natural variations of human neurology, not pathologies to be treated or corrected. This approach moves the focus from the deficits to the differences of the individuals, acknowledging both the challenges and unique strengths associated with these diverse ways of approaching the self and the world. Difficulties encountered by neurodivergent people are often a result of a maladjustment between the individual’s needs and the environment (physical, social, and sensory), mainly built on neurotypical measures (Chapman, 2021).

Affective touch elaboration in ASD is complex and, sometimes, may show apparent contradictory aspects. Studies that use **self-reported scales** suggest that the hedonic experience, i.e. the pleasantness perceived in receiving affective touch, might be similar between ASD and Typically Developing (TD) individuals (Cascio et al., 2016). However, neurophysiological inquiries showed a different framework. fMRI studies showed that, regarding affective tactile stimuli with pleasant or neutral textures, ASD participants showed less activation than TD controls in brain regions key to affective processing, such as the insula and somatosensory areas. On the contrary, these areas were more activated in ASD individuals when the touch was delivered to unpleasant textures (Cascio et al., 2012).

A complementary theoretical perspective is offered by Quattrocki & Friston (2014), who argue that impairments in affective and social perception in ASD may stem from early disfunctions in the oxytocin system, which plays a crucial neuromodulatory role in assigning precision to interoceptive signals (Fotopoulou & Tsakiris, 2017). Within a **predictive coding** framework, oxytocin is thought to influence the salience of socially relevant tactile and interoceptive inputs, shaping how these signals are integrated into generative models of the self. Disruptions in this modulation process could therefore contribute to the formation of atypical embodied representations of affective touch and help account for the dissociation often observed between explicit hedonic ratings and implicit autonomic responses in ASD (Bufo et al., 2022; Capiotto et al., 2024). These insights reinforce the need to examine how social touch is encoded not only at the perceptual level, but also in terms of interoceptive inference and autonomic integration.

Extending the investigation to implicit physiological responses, recent studies started to examine Autonomous Nervous System (ANS) responses, such as pupillary dilation, galvanic response, and heart rate, evoked by affective touch in TD individuals (Bonino et al., 2024; Chatel-Goldman et al., 2014; Gusso et al., 2021; A. Mazza et al., 2023; Triscoli et al., 2017). Nonetheless, research about autonomic responses in ASD individuals is still limited. As of today, one specific study reported a general ANS hypoactivation in ASD children (Bufo et al., 2022), and one confirmed for the adult ASD population (Capiotto et al., 2024). Scarcity of studies on autonomic feedback in the ASD population, together with the already observed dissociation between explicit results (self-administered evaluations) and implicit ones (ANS activation) in this population, also present in other sensory modalities (M. Mazza et al., 2020), emphasises the necessity of further investigation to clarify how affective touch is elaborated both at behavioural and physiological levels by ASD individuals.

Since the quality of touch has such important communicative, social, and physiological effects, studying the SSI in the ASD is particularly relevant given the peculiarities of this condition in sensory processing, communication, and emotional/physiological regulation (Bufo et al., 2022; Thye et al., 2018). Understanding how the SSI functions in ASD may clarify the mechanisms underlying social interaction and well-being in this population, with possible therapeutic implications. Tactile experience has already been applied in psychotherapy (Phelan, 2009) and nursing (Bush, 2001; Chang, 2001; Gleeson and Timmins, 2005), with positive effects.

Consistent with the view of ASD as a neurodevelopmental condition, research indicates differences in early neurological maturation trajectories, such as the observed persistence of certain primary reflexes (e.g., snout and visual rooting reflex) beyond the typical developmental period in children with ASD (Healy et al., 2024).

All these studies set the groundwork for the question of whether the SSI is altered in individuals within the autism spectrum.

## An Integrated View of Touch: Beyond Simple Stimulus-Response Frameworks

Traditionally, the nervous system has been partitioned into a central processing branch, the central nervous system (CNS), and the peripheral nervous system (PNS), which connects the nerves lying in the rest of the body to the central structures. However, considering recent neuroscientific outlooks, it is possible to question this rigid subdivision of the nervous system, deeply rooted in classical neuroanatomy (Banik et al., 2024).

For phenomena like the Social Softness Illusion (SSI), especially when considering diverse populations such as individuals with ASD, a deeper understanding of means moving beyond basic stimulus-response models of touch perception.

As previously stated, social touch highlights the importance of the interaction between top-down modulations (the role of expectations, emotions, and social context) and bottom-up processes (the direct collection of inputs) (Cascio et al., 2019). Studies like the ones about the SSI (Gentsch et al., 2015) show how the PNS (particularly CT fibres) is responsible not only for transmitting sensation but also in playing an active role in the construction of body perception and its social interactions. Pyasik et al. (2022) investigated whether the ability to see the body part being touched influenced the emergence of the SSI. They found that visual access did not affect the perception of softness. Still, they did influence ownership ratings, i.e., the extent to which participants felt that the touched body part belonged to them.

This line of study connects with the embodied cognition field, which emphasises that cognitive processes are deeply grounded in the body’s interaction with the environment (Kiverstein and Miller, 2015). From this perspective, cognition is not merely a product of the CNS, but emerges from the dynamic interaction between the CNS, the PNS, and the external world. Studies in this area show that peripheral sensation, behavioural/motor actions, and internal expectations (Clark, 2015), along with factors such as self-confidence (Afifah et al., 2024), environmental familiarity (Batista-Brito et al., 2018; Gheorghiu & Kingdom, 2017), also regarding to the actors of the environment (Askari et al., 2023), can all directly influence high-order cognitive processes. Applied to the domain of touch, this framework suggests that the perception of a caress is not determined solely by skin-receptor activation. But is shaped by previous experiences and the social meaning attributed to the context, nonetheless, supporting research on phenomena like the Social Softness Illusion, where perception is modulated by interpersonal dynamics.

Building on embodied cognition, predictive processing models further emphasise the dynamic interaction between sensory inputs, internal models, and expectations. Studies exploring predictive processing reveal a significant framework in the cognitive science field. According to Hohwy (2020), perceptual and cognitive systems minimise prediction error to make inferences about the environment. The author covers the role of predictive processing in explaining phenomena such as binocular rivalry, multisensory integration, bodily self-awareness, and the global sense of self. This model suggests that the brain does not passively elaborate input data from bottom upwards but actively generates predictions about the world. Sensory inputs from the PNS are then compared to these forecasts. Prediction errors are broadcast through the higher sites to update internal models. This implies a continuous and bidirectional flux of information between “higher” (predictions and expectations) and “lower” (raw sensor data) levels, integrating CNS and PNS in a dynamic cycle.

Predictive processing models provide a compelling lens through which examine sensory functioning, particularly in the context of neurodiversity such as ASD. Within this framework, it has been hypothesised that individuals with ASD may update prior beliefs in atypical ways, placing greater reliance on immediate sensory input and engaging less with contextual or relational inferences compared to TD individuals. According to (Shi et al., 2025), this pattern does not imply an absence of long-term priors, but rather a difference in how new information is integrated over time. These dynamics influence perceptual and adaptive processes across successive trials, shaping how events are parsed and anticipated. Applied to sensory processing in ASD, this approach offers a way to interpret inconsistencies in empirical findings by focussing on the variability in how predictive signals are calibrated across individuals. Therefore, within the theoretical framework of predictive processing, the Social Softness Illusion may arise from a mismatch between the sensory predictions associated with touching oneself versus touching another person, or from differences in how the social meaning of these actions is encoded.

## Conclusion

This chapter has traced the foundational relevance of social touch, particularly affective touch, in shaping human development, communication, and emotional life. Far from being a passive channel of sensory input, touch emerges as a rich, multimodal, and deeply social experience. Through the exploration of the C-tactile afferent system and its integration within broader neurobiological and cognitive frameworks, we have seen how tactile perception is dynamically modulated by context, meaning, and interpersonal variables. Phenomena such as the Social Softness Illusion (SSI) exemplify how these mechanisms translate into perceptual biases that reflect, rather than distort, our embeddedness in social life.

By bridging neurophysiological, developmental, and embodied approaches, the chapter has also highlighted the relevance of studying affective touch in neurodivergent populations, particularly individuals with Autism Spectrum Disorder (ASD), for whom both sensory processing and social interaction may follow atypical developmental paths. Differences in tactile experience, early affective exchanges, and sensory modulation may all contribute to the way touch is perceived and socially interpreted, offering a crucial lens for understanding the variability in the SSI across populations.

Finally, the theoretical frameworks of embodied cognition and predictive processing have offered a broader conceptual landscape within which to interpret the complex interplay between the central and peripheral nervous systems, personal history, and the social environment. These perspectives call for a departure from rigid stimulus-response models, proposing instead a dynamic and integrated understanding of perception, especially in the context of interpersonal touch.

Building on these premises, the following chapter presents the experimental paradigm and methodology used to investigate the SSI, with particular attention to its perceptual and physiological components, and to the comparison between ASD and TD individuals. This empirical approach aims to clarify how the Social Softness Illusion operates at multiple levels and how it may differ as a function of individual and contextual variables.

# Chapter 2 – Experimental Procedure

## Setting and Design

The experimental subject and the unfamiliar confederate sat in front of each other. A computer monitor placed on the participants’ sides displayed trial-by-trial instructions, while two distinct laptops were placed in front of the Experimental Subject for reporting subjective measures via **Visual Analog Scales** (**VAS**; *Fig 2*). The Target receiving the touch from the subject could be either the unfamiliar confederate, or an object (i.e., a wooden tube covered with fake skin that resembled a human arm; Object). During each trial, the subjects was instructed to promote two distinct contacts (i.e., affective touch), one on their own Skin (Self), and one on the Target’s skin (Other). Each Contact lasted 12 sec, with acoustic and visual cues signalling the start and the end of it. A training phase preceded the experimental procedure, to let the participants familiarise with the task. The experiment was divided into two blocks, each one involving a different Target. Each block consisted of 2 trials. Within each trial, the order of the contact (self vs other) was randomised and balanced within the subjects. During each contact Skin Conductance was recorded a BIOPAC MP160 (Biopac Systems, Inc), acquired at 500 Hz sampling rate, with a 2 µSiemens/Volt gain. Before the beginning of the experimental procedure, two non-polarizable Ag-AgCl electrodes filled with GEL101 isotonic gel were placed to Immagine che contiene testo, schermata che raffigura il setting sperimentale.
participants’ proximal phalanges of the right index and ring fingers.

Figure 2. Experimental setting.

## Trial Progression

At the beginning of each trial, the instructions for the upcoming condition were shown on the computer monitor, to inform the experimental subject about the order of the contacts (e.g., “Promote the touch to yourself first, and then to the Other”). A fixation cross preceded the beginning of the first contact, also, an acoustic cue signalled its beginning. Hence, the experimental subjects were instructed to promote the Contact (12 sec) and to stop when hearing a second sound. After the second contact, performed according to the same procedure, participants were instructed to report subjective measures via 3 distinct VAS using the laptops besides them. Crucially, Experimental Subjects were asked to rate which skin they found softer between their own skin and the other’s skin (i.e., “Which skin did you find softer?”; Softness Ratings), on a scale ranging from –10 (“mine”) to 10 (“other’s”), with 0 indicating no difference between the two skins (“same”). In addition to this, they were asked to rate how pleasant (Pleasantness Ratings) and comfortable (Comfort Ratings) they found the interaction to be on two specific scales.

## Sample

The total sample consisted of 31 participants, with 14 in the TD group and 17 in the ASD group (Mean age 26,48; N Females: 8; N Male: 19). Most of the participants composing the control group 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 ASD participants met criteria for level-1 need of support according to DSM-5 criteria (Diagnostic and Statistical Manual of Mental Disorders; American Psychiatric Association, 2013), based on a specific diagnostic evaluation through the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2000) or the Ritvo Autism Asperger Diagnostic Scale-Revised (RAADS-R; Ritvo et al., 2011). This assessment procedure fits into a framework of a Multistep Network act to help individuals with ASD define their life projects (Keller et al., 2020). All but one participants were native Italian speakers, while an English-adapted version was administered to a Polish control subject.

All the experimental subjects gave written informed consent to participate, which was approved by the local ethics committee and performed following 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.

Behavioural ratings from the whole sample were collected for perceived softness, pleasantness, and comfort. The electrodermal activity (EDA) analyses included **27** participants in total, with **14** in the TD group and **13** in the ASD group. Note that some participants for whom behavioural ratings were available were excluded from the physiological analyses because technical issues during recording rendered their EDA signals unusable for analysis.

## Experimental Design

The study employed a mixed design with one between-subjects factor, Group, and two within-subject factors, Skin and Target. Participants performed four experimental conditions, each repeated twice for a total of eight trials. The design was structured so that in each trial, the participant compared two touches: their own forearm (self) versus either another person’s forearm (other) or a human-skin-like object (obj). This setup systematically manipulated social and perceptive properties of the Target while keeping the self-touch as a constant comparison reference.

The within-subject factors and resulting conditions were:

* Skin (self vs other): comparing self-touch to touch given to another person.
* Target (unfam vs obj): comparing self-touch to touch given to an unfamiliar person versus a matched human-skin-like object.

Participants completed four comparison conditions, each structured as a paired-touch trial in which they consecutively touched their own forearm and a comparison Target, then directly evaluated the difference. The conditions were defined by the specific pairing and order of touches. In the other\_unfam condition, participants first touched an unfamiliar person's forearm and then their own, comparing the two tactile sensations. In self\_unfam, they began by touching their own forearm and then the unfamiliar person's arm. Similarly, the other\_obj condition involved touching a human-skin-like object first, followed by their own forearm, while in self\_obj, participants touched their own forearm first and then the object. Each of these four comparison conditions was repeated twice, resulting in eight trials per participant. After each trial, participants provided subjective ratings of perceived softness, pleasantness, and comfort. Electrodermal activity (EDA) was recorded continuously during the task to capture physiological arousal associated with these tactile comparisons.

## Analyses

Three main analyses were performed to examine behavioural ratings and physiological responses.

First, one-sample t-tests against zero were conducted separately for each group on the behavioural ratings of perceived softness, pleasantness, and comfort. These tests aimed to determine whether participants' subjective evaluations in each condition differed significantly from a neutral baseline, with positive or negative values indicating deviations toward greater perceived softness, pleasantness, or comfort, respectively.

Secondly, a mixed-effects linear model was used to analyse skin conductance data (EDA\_Mean) in a 2×2×2 design. The model included Group (TD vs ASD) as a between-subjects factor, and Skin (self vs other) and Target (unfamiliar person vs object) as within-subject factors. This approach allowed us to evaluate for main effects and interactions while appropriately handling the repeated-measures structure of the data and the non-normal distribution of EDA values.

Finally, to compare EDA\_Mean values between groups within each specific condition, nonparametric Mann–Whitney U tests were performed. This analysis provided pairwise comparisons for each combination of Agent and Target factors, offering a condition-specific assessment of group differences without assuming normality.

## Results

*Behavioural ratings: one-sample t-tests against zero*

One-sample t-tests were conducted separately for each group to assess whether participants’ ratings of softness, pleasantness, and comfort significantly differed from zero (neutral value).

In Group (TD), softness ratings were significantly different from zero in both conditions: Morb\_Unfam (t(55) = 4.673, p < .001) showed positive values indicating higher perceived softness when touching an unfamiliar person, while Morb\_Obj (t(55) = -3.571, p < .001) showed negative values when touching the object. For pleasantness, no significant deviations from zero were found: Piac\_Unfam (t(55) = 0.400, p = .691) and Piac\_Obj (t(55) = -0.387, p = .700) were both non-significant. Comfort ratings showed significant differences for both conditions: Agio\_Unfam (t(55) = -2.792, p = .007) indicated reduced comfort with an unfamiliar person, while Agio\_Obj (t(55) = 2.810, p = .007) indicated increased comfort with the object.

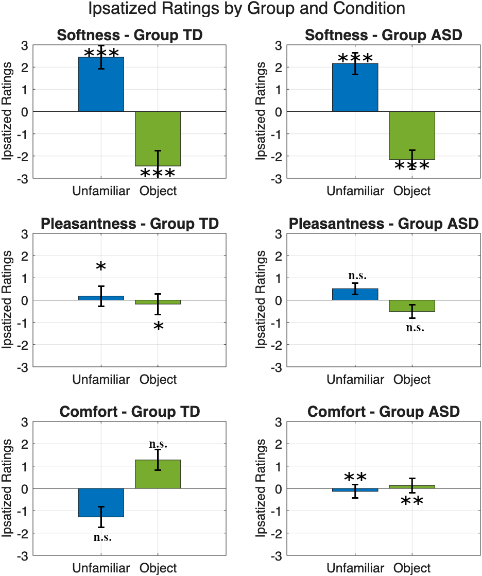
In Group (ASD), softness ratings were likewise significant: Morb\_Unfam (t(67) = 4.441, p < .001) and Morb\_Obj (t(67) = -5.007, p < .001) differed from zero in the expected directions. For pleasantness, Piac\_Unfam was significant (t(67) = 2.005, p = .049), indicating higher pleasantness when touching an unfamiliar person, while Piac\_Obj was not significant (t(67) = -1.679, p = .098). Comfort ratings were not significantly different from zero in either condition (Agio\_Unfam: t(67) = -0.446, p = .657; Agio\_Obj: t(67) = 0.404, p = .688).

Figure 3. Ipsatised Ratings by Group and Condition.

*Skin conductance: 2×2×2 mixed-effects model.*

A mixed-effects linear model was fitted to EDA\_Mean values with Group (TD vs ASD) as a between-subjects factor and Agent (self vs other) and Target (unfamiliar vs object) as within-subject factors.

Results showed a significant main effect of Group (F(1,424) = 13.049, p < .001), indicating that EDA\_Mean was overall higher in the TD group compared to the ASD group. No other main effects or interactions were significant: Agent (F(1,424) = 1.097, p = .295), Target (F(1,424) = 2.348, p = .126), Group × Agent (F = 0.012, p = .914), Agent × Target (F = 2.326, p = .128), Group × Target (F = 2.056, p = .152), and the three-way interaction (F = 0.006, p = .940) were all non-significant.

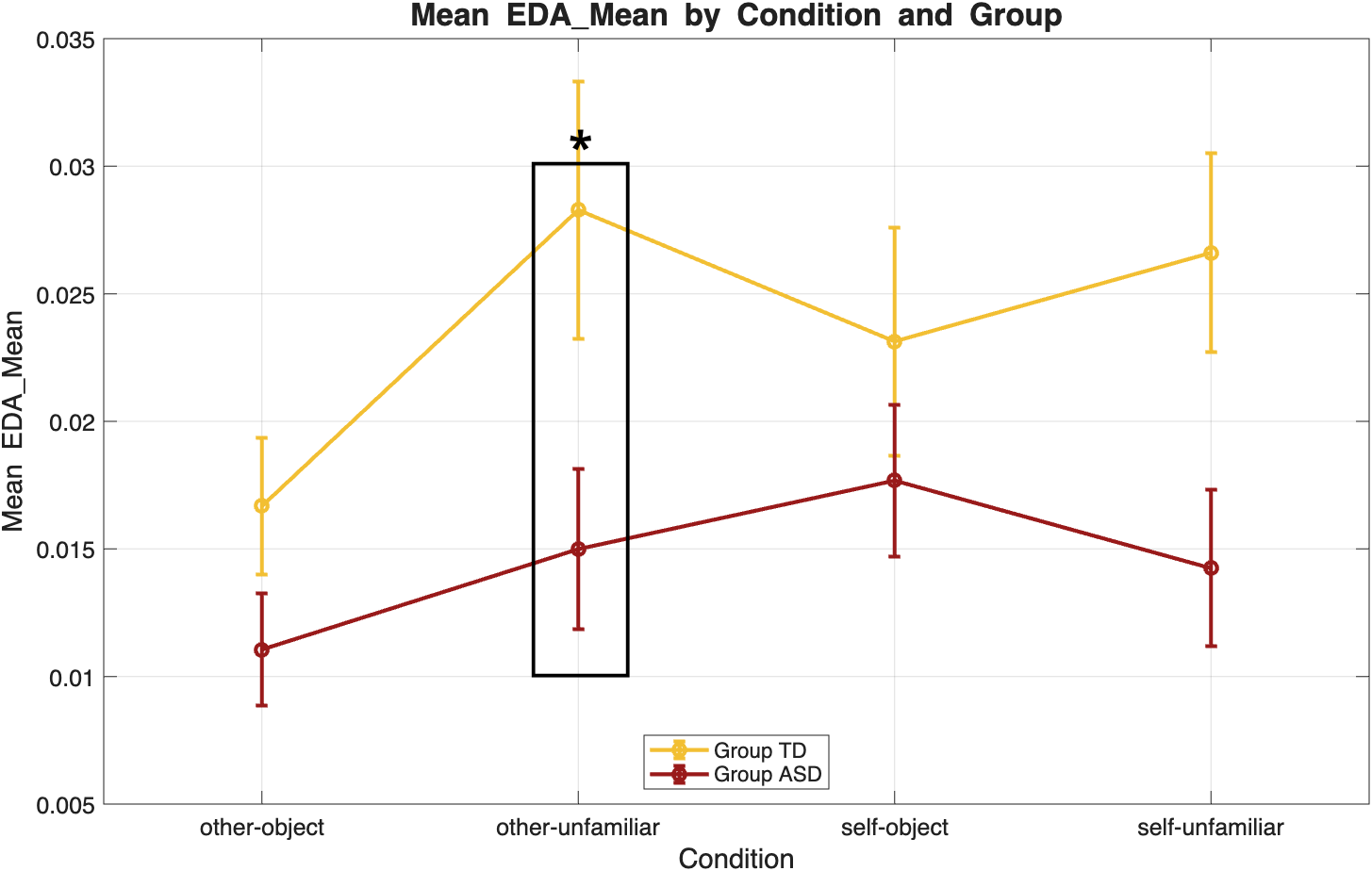


Figure 4. Mean EDA\_Mean by Condition and Group

*Skin conductance: Mann–Whitney U tests by condition*

To assess group differences in EDA within each specific condition, independent-samples Mann–Whitney U tests were conducted. Results indicated significant differences in two conditions. In the self\_unfam condition, TD participants showed higher EDA\_Mean values than ASD participants (U = 996.000, z = -2.828, p = .005). In the other\_obj condition, a significant difference was also found (U = 1085.000, z = -2.281, p = .023), with TD participants again exhibiting higher EDA.

In contrast, no significant differences were observed in the self\_obj condition (U = 1282.000, p = .285) nor in the other\_unfam condition, where a trend toward significance was noted (U = 1140.000, p = .052).

# Chapter 3 – Discussion

This study investigated the perceptual and physiological correlates of the Social Softness Illusion (SSI), with a particular focus on differences between Autism Spectrum Disorder (ASD) adults and Typically Developing (TD) controls. The findings confirm the presence of the SSI across groups, with participants generally perceiving others’ skin as softer than their own during an affective-like touch. This supports the hypothesis that social-affective tactile perception is modulated by interpersonal context and is not a purely stimulus-driven phenomenon.

Results confirmed the presence of the SSI in both groups: participants systematically rated the other’s skin as softer than their own. This supports the view that basic perceptual mechanisms underlying the illusion are preserved in ASD, indicating intact low-level sensory discrimination for softness perception. However, this shared phenomenological experience was accompanied by markedly different physiological profiles.

Subjective ratings revealed nuanced patterns. While both TD and ASD participants reported differences in softness perception consistent with the illusion, only the ASD group showed significantly higher pleasantness when touching an unfamiliar person. The TD group, however, did not show significant deviations from zero for pleasantness ratings in either condition (unfamiliar person or object). For comfort, the TD group indicated reduced comfort with an unfamiliar person and increased comfort with the object, while the ASD group showed no significant differences for comfort in either condition. Physiologically, the ASD group displayed significantly lower overall EDA levels compared to the TD group, suggesting attenuated autonomic responsiveness to affective tactile stimulation. This result aligns with previous literature pointing to altered interoceptive and autonomic processing in ASD individuals (Bufo et al., 2022; Capiotto et al., 2024).

The dissociation observed between explicit (subjective ratings) and implicit (EDA) measures in the ASD group highlights the complexity of affective touch processing in neurodiversity. Although ASD participants did not differ markedly from controls in terms of conscious perception of softness or pleasantness, their reduced physiological reactivity may reflect differences in embodied emotional engagement or sensory integration. A recent review (Sato et al., 2023) outlines how large-scale brain network (including the medial prefrontal cortex, anterior cingulate cortex, insular cortex, and neuromodulatory systems like oxytocin and serotonin) participate in regulating social behaviour. In ASD models, alterations in these circuits are consistently linked to social impairments. These neural atypicalities may underlie the dissociation between subjective reports and physiological responses observed in ASD population.

The experimental manipulation involving a human-skin-like object served to disentangle the social from the purely tactile component of the illusion. The object condition elicited lower ratings of comfort and pleasantness in the TD group, and while not statistically significant for pleasantness in the ASD group, the softness ratings for the object were significantly negative for both groups, indicating it was perceived as less soft than their own skin. This further supports the idea that SSI is not merely the result of physical stimulus characteristics but rather depends on the social and emotional context in which touch occurs.

In conclusion, this research provides empirical support for the Social Softness Illusion as a perceptual phenomenon grounded in interpersonal dynamics and modulated by both sensory and cognitive-affective mechanisms. It demonstrates that while the illusion is preserved at the subjective level in ASD individuals, it is accompanied by altered physiological responsiveness, suggesting a divergence in the embodied processing of social touch within neurodivergent population. These findings not only underscore the multifaceted nature of tactile perception in social contexts but also offer a foundation for future investigations into the intricate intersection between tactile perception, predictive models of self and other, and neurodevelopmental variability.

# Glossary

* **Affective Touch**: A category of tactile stimulation involving gentle, slow stroking, typically perceived as pleasant. Affective touch activates C-tactile afferents and is linked to emotional regulation, attachment, and social bonding (McGlone, 2014; Morrison, 2016).
* **Allocentric vs Egocentric Perspective**: Refers to whether spatial judgments are made from one’s own body position (egocentric) or from an external point of reference (allocentric). Studies suggest that allocentric perspective increases perceived softness and ownership of touched skin, especially in affective contexts (Gentsch et al., 2016).
* **Allogrooming**: A form of social touch found in primates and other mammals, involving mutual grooming behaviours to provide comfort and reinforce social bonds (Dunbar, 2010).
* **Attachment (Theories of)**: Psychological theories (e.g., Bowlby, Ainsworth) emphasizing the need for secure infant-caregiver bonds. Affective touch contributes to these bonds by supporting neurobiological systems involved in stress regulation and affiliative behaviour (Cascio et al., 2019).
* **Autism Spectrum Disorder (ASD)**: A neurodevelopmental condition marked by atypical social interaction and restrictive, repetitive behaviours(American Psychiatric Association, 2013). Individuals with ASD often exhibit differences in sensory processing, including tactile hypersensitivity or hyposensitivity (Tomchek & Dunn, 2007).
* **Autonomic Nervous System (ANS)**: Regulates involuntary physiological functions. ANS responses (e.g., heart rate, skin conductance) to social touch are altered in ASD, showing either reduced or atypical activation patterns (Porges, 2011).
* **C-Tactile Afferents (CT fibres)**: Specialized unmyelinated mechanoreceptors in hairy skin that respond optimally to slow, caressing touch (~1–10 cm/s). They are believed to convey the emotional quality of touch and project to brain areas related to affective processing (Löken et al., 2009).
* **Central Nervous System (CNS)**: Comprises the brain and spinal cord. It integrates sensory input and coordinates behavioural responses, including the affective appraisal of touch.
* **Confederates** (in experimental design): Individuals who are part of the experimental setup but are unknown to the subject, also referred to as unfamiliar. In SSI research, confederates receive touch from participants to simulate real-world interpersonal interaction.
* **Discriminative Touch**: Processes physical properties of touch (e.g., pressure, texture), mediated by myelinated A-beta and A-delta fibres. It is complimentary to affective touch, which conveys emotional quality (McGlone et al., 2014).
* **Embodied Cognition**: A theoretical framework positing that cognition is shaped by bodily interactions with the environment. This is relevant in social touch research, where sensory and motor systems co-construct emotional meaning (Gallese & Sinigaglia, 2011).
* **Endogenous Opioids**: Neurochemicals that mediate pleasure and social bonding. Touch-induced activation of the opioid system may reinforce affiliative behaviours (Nummenmaa et al., 2016).
* **Experimental Subject (in SSI context)**: The individual who administers touch in the experiment and provides subjective ratings, central to evaluating the presence and strength of the Social Softness Illusion.
* **Glabrous Skin vs Hairy Skin**: Glabrous skin (e.g., palms) lacks hair and is rich in mechanoreceptors for discriminative touch. Hairy skin contains CT afferents sensitive to affective touch. The SSI may differ between these skin types (Ackerley et al., 2014).
* **Grasp Reflex**: A primitive neonatal reflex triggered by palm stimulation, evoking finger closure. It has implications for early social bonding and sensorimotor integration (Futagi et al., 2012).
* **Hedonic Valence**: Refers to the subjective pleasantness of a stimulus. In affective touch studies, this is often assessed using rating scales and reflects CT afferent activity (Pawling et al., 2017).
* **Hypoesthesia**: Reduced tactile sensitivity. Often studied in clinical populations or sensory deprivation contexts, where it is linked to negative outcomes in social and emotional functioning (Magerl & Treede, 2004).
* **Interoception**: The internal sensing of physiological states (e.g., hunger, heartbeat). Altered interoceptive awareness is documented in ASD and may affect perception of affective touch (Quattrocki & Friston, 2014).
* **Interpersonal Touch**: Socially meaningful touch exchanged between individuals, crucial for attachment, communication, and trust formation (Morrison, 2016).
* **Meso-cortico-limbic System (Reward System)**: A neural network involved in motivation, reward, and social behaviour, including the anterior cingulate cortex and amygdala. Activated during affective touch (Gordon et al., 2013).
* **Multimodal Perception**: The brain’s integration of input across sensory modalities. Social touch is often embedded in multimodal contexts (e.g., touch + gaze), enhancing its communicative power (Thye et al., 2018).
* **Oxytocin**: A hormone and neuromodulator linked to social bonding and affiliative behaviours, released in response to affective touch (Li et al., 2022).
* **Peripheral Nervous System (PNS)**: Comprises nerves outside the CNS, including afferent and efferent pathways that support somatic and autonomic functions. Vital for processing tactile stimuli.
* **Predictive Processing**: A theory suggesting that perception results from the brain’s predictions about sensory input and the minimization of prediction errors. Relevant for explaining sensory atypicalities in ASD (Shi et al., 2025).
* **Self-Other Differentiation**: The ability to distinguish between oneself and others. Touch, particularly affective touch, contributes to the bodily sense of self and boundaries (Fotopoulou & Tsakiris, 2017).
* **Self-Reported Scales**: Subjective rating tools used to assess participants’ experiences of touch (e.g., pleasantness, intensity), often through Likert or VAS formats.
* **Sense of ownership**: the pre-reflective experience that a body part, sensation, or action belongs to oneself. Is considered a key component of bodily self-consciousness and one’s identity (Blanke, 2012).
* **Sensory Integration**: The process by which the brain organizes sensory input into coherent perceptions. Sensory integration dysfunction is common in ASD and affects social behaviour (Schauder & Bennetto, 2016).
* **Skin Conductance (EDA / Electrodermal Activity)**: A psychophysiological index of arousal mediated by the sympathetic nervous system. Lower EDA responses to touch are observed in ASD (Capiotto et al., 2024).
* **Social Softness Illusion (SSI)**: A perceptual illusion where one’s own skin is perceived as less soft than another’s when delivering affective touch. Linked to interoception and body ownership (Gentsch et al., 2015).
* **Social Touch**: Nonverbal tactile interaction that communicates emotion and intention. Essential for human development and relational dynamics (Gliga et al., 2019).
* **Stroking Velocity**: The speed of touch delivery. CT afferents are optimally activated by strokes between 1–10 cm/s, associated with pleasant affective responses (Löken et al., 2009).
* **Tactile Pleasantness**: The perceived pleasantness of a touch stimulus, correlating with CT afferent activity and subjective reports (Pawling et al., 2017).
* **Visual Analog Scales (VAS)**: A psychometric response scale often used to measure subjective states such as pain or pleasantness. Useful in evaluating responses to affective touch.

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1. Terms in **bold** are defined in the [glossary](#_Glossary) at the end of the thesis. [↑](#footnote-ref-2)