Autonomic and hedonic response to affective touch in autism spectrum disorder

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RESEARCH ARTICLE

Autonomic and hedonic response to affective touch in autism spectrum disorder

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Abstract

Interpersonal touch plays a crucial role in shaping relationships and encouraging social connections. Failure in processing tactile input or abnormal tactile sensitivity may hamper social behaviors and have severe consequences in individuals' relational lives. Autism Spectrum Disorder (ASD) is characterized by both sensory disruptions and social impairments, making *affective touch* an ideal meeting point for understanding these features in ASD individuals. By integrating behavioral and physiological measures, we investigated the effects of *affective touch* on adult individuals with ASD from both an implicit and explicit perspective. Specifically, at an implicit level, we investigated whether and how receiving an *affective touch* influenced participants' skin conductance tonic and phasic components. At the explicit level, we delved into the affective and unpleasant features of *affective touch*. Overall, we observed lower skin conductance level in ASD compared to TD subjects. Interestingly, the typically developing (TD) group showed an increased autonomic response for *affective touch* compared to a control touch, while ASD subjects' autonomic response did not differ between the two conditions. Furthermore, ASD participants provided higher ratings for both the affective and unpleasant components of the touch, compared to TD subjects. Our results reveal a noteworthy discrepancy in ASD population between the subjective experience, characterized by amplified hedonic but also unpleasant responses, and the physiological response, marked by a lack of autonomic activation related to *affective touch.* This insightful dissociation seems crucial for a deeper understanding of the distinctive challenges characterizing people with ASD and may have implications for diagnosis and therapeutic approaches.

Lay Summary

In the present study, we investigated the effects of affective touch on adult individuals with ASD from both an implicit and explicit perspective, integrating behavioral and physiological measures. Our results reveal that ASD individuals show a noteworthy discrepancy between explicit and implicit experience, characterized by the co-occurrence of amplified hedonic and unpleasant ratings together with a lack of autonomic activation related to affective touch. This dissociation seems crucial for a deeper understanding of the distinctive challenges characterizing this syndrome and may have implications for diagnosis and therapeutic approaches.

KEYWORDS

affective touch, autism spectrum disorder, autonomic response, hedonic response, implicit processing, explicit processing, skin conductance response

INTRODUCTION

Touch is one of the most powerful forms of communication, developing early in life and facilitating social interactions even before the acquisition of verbal skills (Cascio et al., 2019; Field, 2010). By conveying both emotional and social meanings, touch promotes socially relevant mechanisms such as attachment behaviors, social affiliation, and interpersonal bonding, acting as one of the cornerstones of human relational survival (Ellingsen et al., 2014; Krahé et al., 2018).

The pleasant effects of social touch are primarily associated with a specific caress-like type of touch known as *affective touch* (Hertenstein et al., 2006). This kind of touch relies on a distinct and highly specialized somatosensory system called C-Tactile (CT) afferent system (Löken et al., 2009; Olausson et al., 2002; Vallbo et al., 2016), that is specifically activated by slow and gentle strokes (1–10 cm/s; Löken et al., 2009; McGlone et al., 2012) and human-skin temperature (Ackerley et al., 2014). Crucially, people tend to perceive and rate a touch as more pleasant when its stroke velocity resembles that of a caress (Ali et al., 2023; Long et al., 2021; Pfabigan et al., 2023; van Hooijdonk et al., 2019; von Mohr et al., 2017) and when it is promoted by a human hand rather than an artificial tool (Ellingsen et al., 2014). Indeed, genuine human-to-human interaction triggers a wide array of positive physiological, emotional, and behavioral effects that cannot be replicated by artificial touch (Willemse et al., 2017), highlighting the unique and significant role of human *affective touch* in fostering social and relational bonds.

However, individuals who struggle to modulate tactile inputs or display disrupted tactile sensitivity might also present diverse processing of *affective touch*. As such, *affective touch* might be experienced as a negative or disturbing event, thus losing its positive social meaning as well. This challenge is particularly evident in Autism Spectrum Disorder (ASD), characterized by atypical sensory processing and social challenges (Diagnostic and Statistical Manual of Mental Disorders, 2013). Indeed, individuals with ASD often exhibit sensory perceptual difficulties, namely hypo- or hyper-reactivity to sensory inputs, which profoundly impact the quality of their lives and significantly hinder their social interactions (Baranek et al., 2006; Grandin, 1992; Reynolds et al., 2011; Tomchek et al., 2018). Specifically, in this population social impairment has been proven to be positively correlated with defensiveness to *affective touch* (Cascio et al., 2016), supporting the idea that the tactile communication represents a clinically relevant aspect in mediating ASD symptomatology in the social domain.

To date, only a limited number of studies have explored the hedonic experience of *affective touch* within the ASD population. Although only artificial tools have been exclusively employed to promote *affective touch*, preliminary findings indicate that individuals with ASD provide ratings of pleasantness comparable to those of typically developing (TD) adults. However, it is noteworthy that these ratings exhibit greater variability and more extreme responses than those provided by TD individuals (Cascio et al., 2008; Cascio et al., 2012). Notably, in these studies the hedonic experience of *affective touch* was solely assessed in terms of ratings of pleasantness, overlooking other central aspects of touch experience, such as its affective or unpleasant components, which could be crucial for fully understanding how this kind of touch is perceived in ASD subjects.

Interestingly, functional magnetic resonance imaging (fMRI) studies found that, when receiving an *affective touch* with pleasant or neutral textures, ASD participants exhibited lower activation compared to TD in brain regions associated with affective processing (i.e., insula and somatosensory regions), while such areas were more activated by strokes promoted with unpleasant textures (Cascio et al., 2012). Hence, while studies employing subjective ratings suggest that the hedonic experience of receiving an *affective touch* is similar in ASD and TD individuals, their brain activity diverges significantly. This dissociation suggests a discrepancy between the explicit ratings of pleasantness and the implicit central nervous system's response to affective tactile stimulation within the ASD population.

Recent research has started to examine in TD individuals autonomic nervous system responses—pupil dilation, skin conductance, and heart rate activity—evoked by *affective touch* (Chatel-Goldman et al., 2014; Gusso et al., 2021; Mazza et al., 2023; Triscoli et al., 2017) but to our knowledge only one study has investigated physiological responses to *affective touch* within the ASD population and has reported an overall hypoactivation in children with ASD compared to TD children (Bufo et al., 2022). Nevertheless, the limited research on autonomic responses to *affective touch* in adults with ASD, coupled with the observed dissociation between explicit and implicit outcomes in this population—present in other sensory domains (Mazza et al., 2020) - underscores the necessity for additional investigations.

The objective of the present study is to bridge this gap by examining the impact of *affective touch* on autistic adults, considering both implicit and explicit processing. By combining physiological measures and subjective hedonic responses, our goal was to comprehensively assess the experience of *affective touch* in adult autistic population in an ecologically valid setting. Specifically, we investigated whether and how receiving an *affective touch*, compared to a control touch (i.e., a tapping touch, that is an unnatural form of touch; Etzi et al., 2018), influenced both the participants' autonomic responses and their subjective experience related to the affective and unpleasant components of the tactile stimulation. We hypothesized that, at the implicit level, autistic participants would exhibit lower skin conductance activation compared to TD subjects. Furthermore, in line with the current literature, we expected TD individuals to show a greater autonomic response when receiving an *affective touch* compared to a control touch, while we did not anticipate such differences in ASD subjects. Conversely, at the explicit level, we predicted that ASD group would provide similar or even more extreme subjective ratings in terms of both the affective and unpleasant components of the tactile stimulation, compared to TD subjects.

MATERIALS AND METHODS

Participants

Forty-eight participants (Biological sex: 37 males and 11 females, mean age = 25.083, SD = 5.21) were tested for this study. Twenty-four subjects (17 males and 7 females, mean age = 26.125, SD = 4.32) with a diagnosis of Autism Spectrum Disorder were tested and recruited from the Piedmont Adult Autism Center (Centro Regionale Disturbi Spettro Autistico in Età Adulta, Turin), while twenty-four Typically Developing (TD) subjects (20 males and 4 females, mean age = 24.041, SD = 5.88) were included in the control group. All ASD participants met criteria for level one need of support and were without cognitive impairment. Diagnoses were made by a team of expert clinicians according to DMS-5 (Diagnostic and Statistical Manual of Mental Disorders, 2013) criteria, based on Autism Diagnostic Interview-Revised (ADI-R; Rutter et al., 2003) and a specific diagnostic evaluation with Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2000) or The Ritvo Autism Asperger Diagnostic Scale-Revised (RAADS-R; Ritvo et al., 2011). The evaluation is related to a Multistep Network model aimed to help individuals with ASD to find their individual project of life (Keller et al., 2020). All participants were native Italian speakers and signed the written informed consent before taking part in the experiment. The experimental procedure was approved by the Bioethical Committee of the University of Turin and conducted in accordance with the Declaration of Helsinki (World Medical Association, 2013). At the end of the experiment, all participants were informed about the aims and scopes of the experiment and did not receive any compensation for participation in this research study.

Experimental setting, task, and design

Participants were seated in front of a desk with an experimenter on the other side. A wooden panel placed perpendicular to their left shoulder prevented the participants from seeing their left arm during the procedure (Figure 1a). In each trial, participants received a 14 s tactile stimulation on the dorsal side of their left arm; each stimulation consisted in either an *affective touch* (Affective Touch condition) or a *control touch* (Tapping condition) (Figure 1b). A monitor in front of the experimenter displayed experimental slides to set the timing for the beginning of each trial, the onset of the tactile stimulation, and the end of it. Only one experimenter was involved in the procedure and was trained to prepare herself with her right hand in position above the participant's arm (without touching it) to be ready to initiate touch once the instruction slide appeared to prompt the timing of the stimulus onset. During the stimulation, participants were instructed to relax and remain as still as possible. Next, they were asked to answer two questions

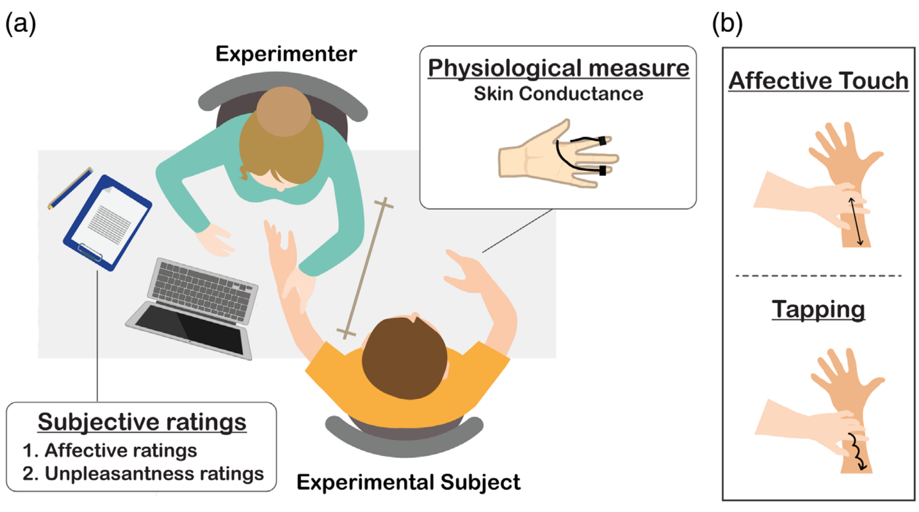

FIGURE 1 Experimental setting and variables. (a) Experimental setting: Participants were invited to sit comfortably and place their left arm on the table with their palm facing down. They were instructed to look in front of them during the task; touch was promoted outside their field of vision beyond a wooden panel. The experimenter, sitting in front of the participants, promoted 14 s tactile stimulations on the dorsal side of their forearm. Throughout the task, skin conductance was recorded; after each trial participants were asked to rate the affectiveness and unpleasantness of the touch received. (b) Experimental variables: Participants received two different types of touch: either an *affective touch* at CT-optimal stroke velocity (i.e., 3 cm/s) (i.e., Affective Touch condition) or a control touch (i.e., Tapping condition).

posed by the experimenter, regarding the perceived level of affectiveness ("On a scale from 0 to 10, how affective did you perceive the touch you just received?"; Affective ratings) and unpleasantness ("On a scale from 0 to 10, how unpleasant did you perceive the touch you just received?"; Unpleasantness ratings) of the touch. Each experimental session lasted about 30 minutes and included a total of 10 trials (balanced across Affective Touch and Tapping conditions and presented in a random order). Despite the whole experimental session including 10 trials, not all subjects managed to complete the entire task (ten ASD participants completed a total of 8 trials; two ASD participants completed a total of 6 trials; five TD participants completed a total of 8 trials). Indeed, we designed a flexible paradigm where the experimenter oversaw the experimental progression by manually advancing one trial at a time. Subjects were encouraged to communicate with the experimenter if they experienced fatigue or felt overwhelmed at any point. In such cases, the experimenter had the discretion to halt the task to prioritize the well-being of participants.

Skin conductance recording and processing

Skin conductance was recorded using a *BIOPAC MP160 EDA100C* module (Biopac Systems, Inc.) and visualized online using *iMotions A/S Software 8.2*. Before the beginning of the experimental session, two non-polarizable Ag-AgCl electrodes filled with GEL101 isotonic gel were placed on the participant's proximal phalanges of the right index and ring fingers. Data were acquired at 500 Hz sampling rate, with a 2 μSiemens/Volt gain, and then processed offline with *MATLAB r2023a*. First, we extracted the epoch of interest: a 14 s window during which a tactile stimulation was delivered to the experimental subject (touch epoch). Then, after extracting the tonic component of the signal, data were filtered with a 0.05 Hz high pass filter to retain the phasic component while excluding tonic activity, and a 20.0 Hz low pass filter to exclude noisy high-frequency fluctuations (Figure 2a). Finally, we extracted three measures of interest: the Mean Tonic from the tonic component of the signal, the Area Under the Curve (AUC), and the Trough-to-Peak (TTP) amplitude of the first peak occurring in each window to quantify skin conductance (Boucsein, 2012) and submitted these measures to subsequent statistical analyses. Peak detection threshold was set to 0.01 μSiemens.

STATISTICAL ANALYSES

Skin conductance

Skin conductance data, referring to the 14 s touch epoch, were first cleaned by excluding non-respondent subjects (i.e., those in which no above-threshold peak was detected in any of the conditions). As such, five subjects were removed from the analyses (three from the ASD group and two from the TD one). Next, we extracted the epoch of interest for statistical analyses: a 13 s window starting 1 s after the beginning of the touch epoch, to analyze only evoked responses. Data were additionally cleaned by excluding outlier trials falling above or under 3 standard deviations from the mean AUC and TTP amplitude, within *Group* (ASD, TD) and within *Condition* (Affective Touch, Tapping). As such, four trials were removed from the analyses. All subsequent analyses were run on *SPSS* (Statistical Package for Social Science) only on trials where above threshold peaks were detected ($n_{tot} = 263$). As the distribution of all measures violated the normality assumption ([ASD: all $ps < 0.001$; TD: all $ps < 0.001$] Shapiro–Wilk Test) non-parametric statistics (Mann–Whitney *U*-tests) were implemented to investigate whether AUC values and TTP amplitude within *Condition* changed between *Group*. Multiple comparisons were corrected using false discovery rate (FDR; Benjamini & Hochberg, 1995).

Affectiveness and unpleasantness ratings

To test whether the two types of touch (*Condition*) impacted on the perceived affectiveness and unpleasantness in ASD and TD participants (*Group*), subjective ratings were analyzed between *Group* and within *Condition*. As the distribution of all measures violated the normality assumption ([ASD Affectiveness Ratings: all $ps < 0.001$; ASD Unpleasantness Ratings: all $ps < 0.001$; TD Affectiveness Ratings: all $ps < 0.01$; TD Unpleasantness Ratings: all $ps < 0.001$] Shapiro–Wilk Test) non-parametric statistics (Mann–Whitney *U*-tests) were implemented to compare Affectiveness and Unpleasantness Ratings between *Group*. Wilcoxon Signed-Rank Tests were implemented to investigate whether Affectiveness and Unpleasantness Ratings differed within *Condition*.

Correlations

To investigate the relationship between physiological activity and hedonic responses, Spearman's bivariate correlations between skin conductance measurements (i.e., Mean Tonic, AUC, and TTP) and subjective ratings (i.e., Affectiveness and Unpleasantness Ratings) were run. Significant effects were corrected using false discovery rate (FDR; Benjamini & Hochberg, 1995).

RESULTS

Skin conductance

As a preliminary analysis, the tonic component of the mean skin conductance (Mean Tonic) was extracted in

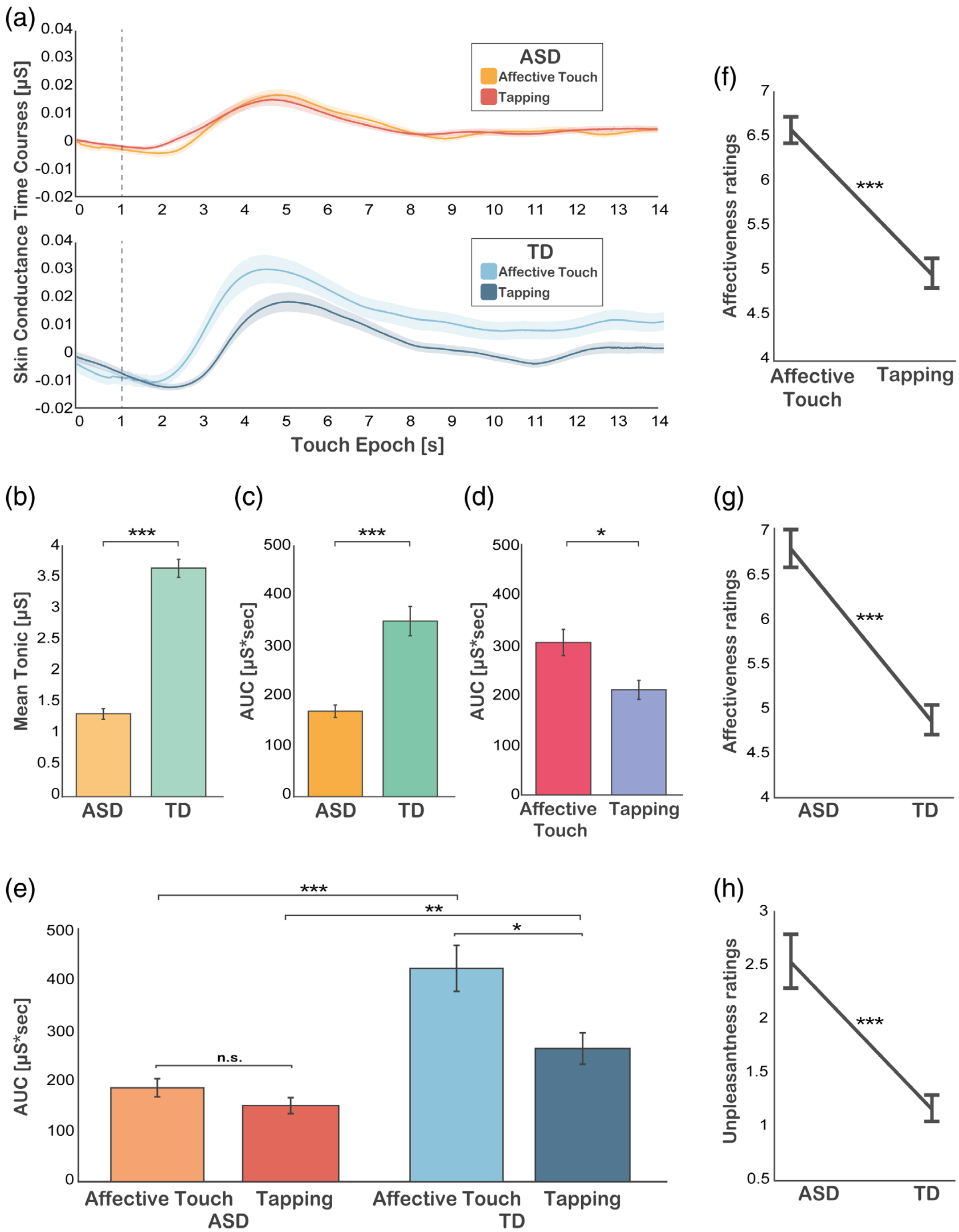

FIGURE 2 Implicit and explicit responses. (a) Panels show skin conductance time course aligned to the time of the two types of tactile stimulation. The first panel (top) highlights the absence of differences over time between *Condition* (Affective Touch in yellow and Tapping in red) in the ASD group. The second panel (bottom) shows the time course of Affective Touch in light blue and Tapping in dark blue in TD group. The shaded traces indicate ±0.5 s.e.m. The dotted lines indicate the beginning of 13 s window used for data analysis. (b) Mean skin conductance level for ASD and TD participants ($n_{TOT} = 443$ ($n_{ASD} = 213$, $n_{TD} = 230$)). (c) Mean AUC values for ASD and TD participants ($n_{TOT} = 263$ ($n_{ASD} = 128$, $n_{TD} = 135$)). (d) Mean AUC values for Affective Touch and Tapping ($n_{TOT} = 263$ ($n_{AaffectiveTouch} = 147$, $n_{Tapping} = 116$). (e) Mean AUC values for ASD and TD participants separately for Affective Touch and Tapping. (f) Mean Affective ratings reported by participants for Affective Touch and Tapping. (g) Mean Affective ratings for ASD and TD participants ($n_{TOT} = 442$; $n_{ASD} = 212$, $n_{TD} = 230$). (h) Mean Unpleasantness ratings for ASD and TD participants ($n_{TOT} = 442$; $n_{ASD} = 212$, $n_{TD} = 230$). Data refer to the mean ± 1 s.e.m. Significant results are indicated by asterisk * = $p < 0.05$; ** = $p < 0.01$; *** = $p < 0.001$; n.s. = not significant.

order to better examine possible differences between ASD and TD autonomic nervous system functioning. The Mann–Whitney *U*-test on Mean Tonic showed that ASD participants ($M = 1.332$, $SE = 0.121$) displayed lower levels compared to the TD group ($M = 3.675$, $SE = 0.117$) [$U = 7826.000$, $p < 0.001$; Figure 2b] suggesting an overall lower skin conductance level in ASD compared to TD subjects.

After testing the tonic component of the autonomic response in ASD subjects, we investigated the phasic component of our physiological data to better understand event-related responses. To test whether ASD and TD subjects differed in their physiological activity, independently of the experimental condition, we analyzed the AUC and TTP Amplitude as a function of *Group* independently of the *Condition*. The Mann–Whitney *U*-test on AUC showed that ASD participants ($M = 167.957$, $SE = 22.968$) displayed smaller values than TD group ($M = 342.534$, $SE = 22.246$) [$U = 5455.000$, $p < 0.001$; Figure 2c]. Similar results were obtained for the TTP Amplitude with ASD participants ($M = 0.052$, $SE = 0.007$) displaying smaller values than TD group ($M = 0.096$, $SE = 0.007$) [$U = 6347.000$, $p < 0.001$].

Next, to test whether participants' activation changed as a function of *Condition* independently of the *Group*, we analyzed AUC and TTP within the two conditions. The Mann–Whitney *U*-test on AUC showed that Affective Touch ($M = 303.653$, $SE = 21.220$) was associated with larger values than Tapping ($M = 206.838$, $SE = 23.920$) [$U = 7094.000$, $p = 0.019$; Figure 2d]. Similar results were obtained for the TTP Amplitude with Affective Touch ($M = 0.086$, $SE = 0.006$) associated with larger TTP values than Tapping ($M = 0.061$, $SE = 0.007$) [$U = 7254.000$, $p = 0.038$].

Finally, we investigated whether AUC and TTP changed as a function of *Group* and *Condition*. First, we found that ASD ($M = 185.612$, $SE = 30.112$) displayed smaller AUC values than TD ($M = 421.694$, $SE = 29.908$) for Affective Touch [$U = 1542.000$, $p < 0.001$]. Similar results were obtained for the TTP Amplitude with ASD group ($M = 0.055$, $SE = 0.010$) showing smaller values than TD ($M = 0.116$, $SE = 0.010$) for Affective Touch [$U = 1856.000$, $p = 0.003$]. Similarly, for the Tapping condition, AUC values in the ASD group ($M = 150.302$, $SE = 34.691$) were smaller than in the TD group ($M = 263.374$, $SE = 32.941$) [$U = 1162.000$, $p = 0.009$], although not significant, and TTP values in the ASD group ($M = 0.048$, $SE = 0.008$) were smaller than in the TD group ($M = 0.073$, $SE = 0.007$) for Tapping as well [$U = 1306.000$, $p = 0.059$]. Additionally, we found that Affective Touch ($M = 421.694$, $SE = 29.908$) was associated with significantly larger AUC values than Tapping ($M = 263.374$, $SE = 32.941$) only in the TD group [$U = 1700.000$, $p = 0.018$], while in the ASD group Affective Touch ($M = 185.612$, $SE = 30.112$) did not differ from Tapping condition ($M = 150.302$, $SE = 34.691$) [$U = 1730.000$, $p = 0.182$; Figure 2e]. Similar results were found for the TTP Amplitude, where Affective Touch ($M = 0.116$, $SE = 0.011$) was associated with nearly significantly larger values than Tapping ($M = 0.073$, $SE = 0.012$) only in the TD group [$U = 1802.000$, $p = 0.059$], while in the ASD group Affective Touch ($M = 0.055$, $SE = 0.005$) did not differ from Tapping condition ($M = 0.048$, $SE = 0.005$) [$U = 1768.000$, $p = 0.249$].

Affectiveness and unpleasantness ratings

First, we investigated whether Affectiveness Ratings changed as a function of *Condition* and *Group*. The Wilcoxon *W*-test showed that Affective Touch ($M = 6.600$, $SE = 0.128$) was associated with higher ratings than Tapping ($M = 5.027$, $SE = 0.147$) [$Z = -9.340$, $p < 0.001$; Figure 2f]. Additionally, the Mann–Whitney *U*-test showed that ASD ($M = 6.771$, $SE = 0.172$) rated the Affectiveness of the touch higher than TD ($M = 4.857$, $SE = 0.165$) [$U = 9539.500$, $p < 0.001$; Figure 2g].

Next, we investigated whether Unpleasantness Ratings changed as a function of *Condition* and *Group*. The Wilcoxon *W*-Test on Unpleasantness Ratings did not show a significant effect of *Condition* [$Z = -1.200$, $p = 0.230$]. Nonetheless, the Mann–Whitney *U*-Test showed that ASD ($M = 2.531$, $SE = 0.180$) rated the Unpleasantness of the touch higher than TD ($M = 1.170$, $SE = 0.173$) [$U = 8120.000$, $p < 0.001$; Figure 2h].

Correlations

As we were interested in exploring the relationships among physiological activity and ratings of Affectiveness and Unpleasantness we correlated both the tonic and phasic components of the electrodermal activity with hedonic ratings. In ASD group, we found a significant positive correlation between Affectiveness Ratings and Mean Tonic ($r = 0.241$, $r^2 = 0.058$, $p < 0.001$) and a significant negative correlation between Unpleasantness Ratings and Mean Tonic ($r = -0.227$, $r^2 = 0.051$, $p < 0.001$), showing that a greater physiological activation was associated with more positive hedonic experiences, while lower electrodermal activity was associated with more negative hedonic experiences. In the TD group, we did not find any significant correlations between Affectiveness Ratings and Mean Tonic ($r = -0.053$, $r^2 = 0.003$, $p = 0.218$) nor between Unpleasantness Ratings and Mean Tonic ($r = 0.119$, $r^2 = 0.014$, $p = 0.058$). However, we did not detect any significant relationship between the other two electrodermal activity measurements (i.e., AUC, TTP) and the Affectiveness and Unpleasantness Ratings, neither for the ASD nor the TD group (all *ps* >0.05). Since we only observed a significant correlation between hedonic ratings and the tonic component of electrodermal activity, we ran additional control analyses to ensure that such significant relationship could be specifically ascribable to our experimental manipulation, rather than to confounding variables. Thus, we investigated the relationship between hedonic ratings and the tonic component of skin conductance during an ITI (i.e., an inter-trial interval during which touch was not promoted). Since such additional analysis replicated the results found with the Mean Tonic and the hedonic ratings (ASD group: Affectiveness Ratings: $r = 0.237$, $r^2 = 0.056$, $p < 0.001$; Unpleasantness Ratings: $r = -0.231$, $r^2 = 0.053$, $p < 0.001$; TD group: all $ps > 0.05$), we concluded that the significant correlations between the tonic component of electrodermal activity and hedonic ratings were not ascribable to our experimental manipulation and therefore we did not take them into account for further consideration.

DISCUSSION

In the present study, we investigated the effects of *affective touch* on adult individuals with ASD from both an implicit and explicit perspective. By combining physiological measures and hedonics responses, our goal was to comprehensively assess the experience of *affective touch* in an ecologically valid setting. Specifically, we manipulated the nature of the tactile stimulation by delivering to the experimental subject either an *affective touch* (i.e., a touch resembling a caress, which activates CT-fibers system) or a control touch, namely, a tapping. Overall, we observed lower autonomic activation in the ASD compared to the TD group, with regard to both the tonic and phasic components of skin conductance. Specifically, the analysis of tonic skin conductance levels showed an overall lower physiological activity in ASD compared to TD subjects, bringing further evidence of the existence of a divergent functioning of ASD and TD autonomic system (Anderson et al., 2013; Anderson & Colombo, 2009; Arora et al., 2021; Kushki et al., 2013; Lory et al., 2020). Interestingly, phasic responses highlighted that while the TD group showed an increased response for *affective touch* compared to the control touch, ASD participants' autonomic response did not differ between the two touch conditions. This result goes along with existing literature on typically developing population (Bertheaux et al., 2020; Etzi et al., 2018; Pawling et al., 2017; Ree et al., 2019) and, concurrently, fills the existing gap concerning the physiological responses to *affective touch* in autistic adults. Furthermore, higher ratings were collected from ASD compared to TD participants, for both the affective and unpleasant components of the two types of touch, coherently with previous studies on extreme ratings in ASD individuals (Cascio et al., 2008, 2012; Kaiser et al., 2016).

While recent studies have delved into understanding the physiological responses associated with *affective touch* in neurotypical individuals (Chatel-Goldman et al., 2014; Mazza et al., 2023; Triscoli et al., 2017), the only study that has focused on autonomic responses to *affective touch* in children with ASD has reported an overall hypoactivation in ASD children compared to TD peers (Bufo et al., 2022). Bufo et al. (2022) have proposed that the diminished autonomic activation observed in ASD children when receiving *affective touch* could be attributed to a reduced engagement reaction commonly found in the ASD population. This reaction is likely influenced by both a lack of social motivation (Chevallier et al., 2012), and a deficiency in rewarding experiences associated with touch in general (Gordon et al., 2016) typical of the ASD subjects. However, in their pioneering work Bufo et al. (2022) did not contrast the physiological response to *affective touch* with any other type of control touch. In contrast, our experiment uncovered this critical point by showing that while autonomic responses to *affective touch* were greater than those to control touch in TD individuals, participants with ASD exhibited comparable levels of activation between the two types of touch. This lack of a differentiated autonomic response to *affective touch* and control touch within the ASD group is consistent with prior findings indicating altered implicit discrimination of emotional stimuli in this population (Cascio et al., 2012; Dawson et al., 2004), thus supporting the previously suggested notion of a deficiency in motivational and rewarding aspects related to the social component of touch in individuals with ASD. Considering the significant role of *affective touch* in enhancing social connections and nurturing relationships (Ellingsen et al., 2014; Hertenstein et al., 2006; Krahé et al., 2018), the diminished or potentially absent autonomic response to the emotional aspect of touch observed in individuals with ASD may reflect an autonomic counterpart to their difficulties in the social and emotional domains (Diagnostic and Statistical Manual of Mental Disorders, 2013).

Furthermore, coherently with previous research on the hedonic aspect of touch (Perini et al., 2021), both TD and ASD individuals provided higher affective ratings to the *affective touch* when compared to a control touch. These findings suggest that, at an explicit level, both groups appropriately attribute to *affective touch* the hedonic and affective components of touch as a typical form of intimate and comforting interaction. However, we also observed that ASD reported overall higher ratings, compared to TD, when also describing the unpleasant components of the tactile experience, and independently of the type of touch. These apparently incongruent findings regarding ASD population may find an explanation within ASD reports about their personal experiences (Grandin, 1992). Indeed, while the high ratings of affectiveness may be explained by the preserved need of positive tactile contact (Edelson et al., 1999), the unpredictability of human interaction and the often-documented abnormality of ASD tactile sensitivity (Mikkelsen et al., 2018) may have promoted unpleasant sensorial overstimulation, thus explaining the concurring high ratings of unpleasantness.

Taken together our findings indicate a discrepancy between the explicit (i.e., subjective hedonic ratings) and implicit (i.e., autonomic responses) dimensions related to the ASD experience of receiving *affective touch*. While high affective ratings align with strong autonomic activation in TD individuals (Bertheaux et al., 2020; Etzi et al., 2018), physiological responses in individuals with ASD did not correspond to their explicit ratings. Specifically, our results revealed that individuals with ASD can properly differentiate between *affective touch* and control touch at an explicit level, but their physiological response does not match such discrimination at the implicit level, with autonomic activity being comparable between the two touch conditions. In line with previous speculations, we propose that the coexistence of higher subjective ratings and diminished autonomic response to touch may be rooted in behaviors of camouflaging typical of the ASD population (Attwood, 2007; Willey, 2014). Emphasizing the positive aspects of a socially meaningful touch (i.e., *affective touch*) at an explicit level may reflect the learning of social norms through repeated exposure to social interactions (Cascio et al., 2012), rather than representing an internalized form of discrimination between the two types of touch. One possible explanation could be that individuals with ASD may have overemphasized socially-pleasing behaviors to meet social expectations, consistent with ASD tendencies of "putting on their best normal" (Attwood, 2007; Hull et al., 2017; Willey, 2014). It has been observed that individuals with ASD frequently employ cognitive and behavioral strategies aimed at enhancing their social competences and overcoming social reticence, to better fit into a naturally social environment (Cook et al., 2021; Hull et al., 2017; Lai et al., 2019; Lawson, 2020; Willey, 2014). Collectively, these results portray the experience of *affective touch* in adults with ASD as a multidimensional phenomenon. Analyzing the complexity of this experience using both subjective and physiological measures not only revealed potential divergences from the neurotypical population but also, more significantly, highlighted discrepancies between the explicit experience of the participants and their implicit autonomic responses.

It is crucial to acknowledge potential limitations in our study and explore avenues for future research. Firstly, our study focused exclusively on ASD adults meeting criteria for level one need of support. Given the considerable heterogeneity within the spectrum, future studies may benefit from including individuals with lower levels of functioning. Secondly, in light of our results, further investigation should address the well-known controversy surrounding the coexistence of both hypo- and hyper-autonomic sensory activation in the ASD population (Li et al., 2022), recognizing the observed dissociation between implicit and explicit levels of ASD experience. Thirdly, as in our study we obtained a sample composed of young ASD participants only, it would be important for future research to investigate the behavioral and autonomic activities related to *affective touch* in elderly subjects. Moreover, another significant constraint in this study was an unbalanced distribution of male and female subjects within the ASD group. Building on our findings, future research should strive for gender balance and specifically explore the crucial topic of gender disparities in ASD populations. Lastly, future study should investigate the relationship between physiological as well as hedonic measurements and clinical scores. In this way researchers can contribute to advancing our understanding of the link between the severity of ASD symptoms and psycho-physiological measurements.

In summary, the present study comprehensively examined the experience of individuals with ASD in relation to *affective touch* compared to neurotypical individuals. Our findings reveal a dissociation between explicit and implicit measures in individuals with ASD. While the subjective experience reported by individuals with ASD is marked by affective and hedonic aspects, the physiological response following *affective touch* suggests a significant lack of autonomic activation in response to this specific type of touch. These results paint a multidimensional picture of the subjective experience of individuals with ASD, highlighting both psychological and physiological aspects. Such insights are crucial for a deeper understanding of the distinctive challenges associated with this syndrome and may have implications for diagnosis and therapeutic approaches.

AUTHOR CONTRIBUTIONS

F.C., A.M. and O.D.M. designed the study, G.C., C.L., and R.K. recruited ASD patients, F.C., G.R.C., and I.M. performed the experiments, F.C., G.R.C., and A.-M. analyzed the data, and F.C., G.R.C., I.M., A.M., and O.D.M. wrote the paper. All authors reviewed the manuscript.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ETHICS STATEMENT

The experimental procedure was approved by the Bioethical Committee of the University of Turin and conducted in accordance with the Declaration of Helsinki.

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