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The Power of Social Touch: Pleasantness is a Matter of Regularity

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I. Introduction

Touch is a powerful way of conveying messages and emotions non-verbally [1]. Individuals may reduce each other's stress and show affection through gentle caresses. The positive effects of social touch begin in infancy, as physical contact with a caregiver contributes to social and cognitive development [2] and extend into adulthood, where affective touch becomes a way of expressing intimacy in close relationships [3]. One of the goals of affective touch in romantic relationships is to invoke pleasantness, most frequently with a gentle stroke [4]. Although previous studies have shown general positive effects of a stroke, movement parameters of a pleasant touch remained largely unexplored.

Major insights on movement parameters for pleasant touch stem from the firing behavior of C-tactile afferents (CTs) that encode gentle strokes on hairy human skin [5]. These afferents are activated most strongly with a stroking velocity of 1-10 cm/s [6], suggesting preferred velocities. Another study demonstrated that circular, curvilinear trajectories feel more pleasant than linear ones [7]. However, previous studies typically used arm stroking devices to present simplified and standardized stimulation. Only few studies examined gentle touch in a naturalistic, social (human-to-human) context.

A study that extensively examined motion parameters of gentle strokes in a social context focused on the toucher's behavior [8]. Its results suggest that pleasant touch behavior exhibits irregular patterns in time and space. In the experiment, participants were instructed to touch social and nonsocial targets with three touching goals: to be fast, slow, or pleasant. When individuals touched a social target to invoke pleasantness, their movement patterns shifted as compared to non-social targets: Strokes ran along two axes rather than one and showed greater spatial variation [8]. One possible explanation could be that a lower predictability of social touch increases its pleasantness by reducing habituation and sensory suppression for predicted events [9].

In this study, we directly tested the pleasantness of touch in a social context: We studied how predictability of a gentle touch from a romantic partner affects pleasantness, focusing on the touchee's feelings rather than the toucher's behavior. We hypothesized that less predictable and more spatially varied touch will feel more pleasant. Further, based on [7] we compared sine-wave to triangle-wave trajectories, expecting that the former feel more pleasant than the latter because movements are more curvilinear and smoother/less abrupt.

II. Methods

12 couples (15 females, 9 males; age range-19-29 years; *M*=23.3; *SD*=2.9) with an average relationship duration of 27 months (*SD*=26.4) participated in the experiment. They gave informed consent before the experiment.

Partners sat on opposite sides of a desk, separated by a curtain. The touchee sat sideways, forming a 90-degree angle with the table and presented the left forearm in the same direction to the toucher behind the curtain. The toucher stroked the touchee's forearm (left-right movement) with the index finger-following a moving dot that was projected on the forearm (Philips Beamer PicoPix Max One). We tracked the position of the finger (Zebris ultrasound system, 50 Hz, in 3D space). The moving dot defined the toucher's trajectory in each trial (with a constant speed of 2.6 cm/s, triangle- or sine-wave pattern). The predictability of each pattern varied in three levels by varying the amplitudes. After each stroke, participants rated the pleasantness of the touch giving a number between 0-100. Overall, there were 36 trials per touchee (2 [shape] X 3 [predictability] X 6 repetition) and each of the two partners was once toucher and once touchee.

In detail, each trajectory contained six periods (2 cm) of the triangle- or sine-wave pattern (see Fig. 1). Predictability was varied by amplitudes between periods: In the high predictability condition, all periods had the same amplitude (A_2); for moderate predictability, two distinct amplitudes (A_1,A_3) and for low predictability, three different amplitudes were used (A_1,A_2,A_3). Amplitudes were chosen as $A_1 = \sim 0.4$, $A_2 = \sim 1$ and $A_3 = \sim 1.4$ cm, to realize considerable amplitude differences and at the same time minimize length differences of the different trajectories within each shape type (around 30 cm for sine-wave and 18 cm for triangle-wave patterns). For moderate and low predictability we used 3 different spatial orders of the different amplitudes.

III. Data Analysis

We analyzed finger movement data with MATLAB2022a to check our predictability manipulation. For each trajectory we assessed the actual amplitude per period from the differences between consecutive maxima and minima in the movement along the y-axis. We computed the log10 values of each amplitude and used bottom-up hierarchical clustering with average group linkage analysis to determine the number of clusters with similar amplitudes in each trial (threshold:

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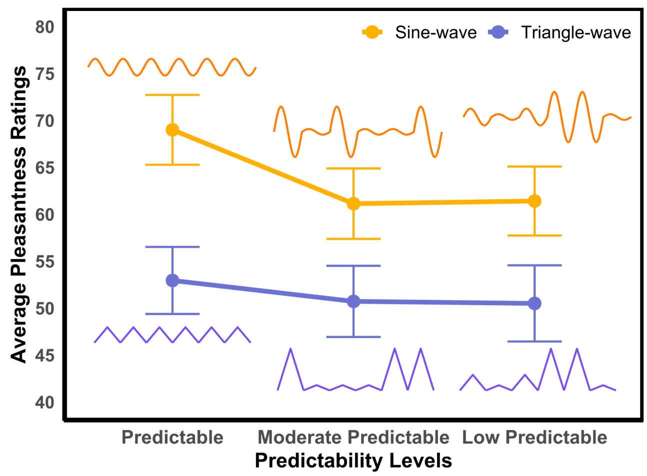

Fig. 1. Average pleasantness ratings for sine- or triangle-wave shapes as a function of predictability level. The error bars show the standard error of the mean. Representative trajectories are depicted next to the data points.

log10[1.5]). The numbers of amplitude clusters (1), (2) and (3) or higher reflect the predictability: high, moderate and low, respectively, of the actually executed trajectories.

We calculated individual mean pleasantness for each of these actual predictability levels and shape, and submitted these values to further analyses. One participant's data was excluded, because in one condition no data was available.

IV. Results

A two-way repeated-measures ANOVA showed a significant main effect of predictability $F(1,22) = 4.935$, $p = .012$, $\eta_p^2 = .183$ and shape $F(1,22) = 14.828$, $p < .001$, $\eta_p^2 = .403$, but no significant interaction effect ($p > .086$). A further investigation revealed a significant linear trend for predictability $F(1,22) = 5.740$, $p = .026$, $\eta_p^2 = .207$. These results indicate that pleasantness ratings decrease when the touch is not highly predictable, and they were higher for sine-wave patterns compared to triangular-wave (see Fig. 1).

V. Discussion

We investigated how predictability and shape of a gentle touch affect pleasantness from the touchee's perspective. Our results show that pleasantness is lower for the touchee when the spatial pattern of gentle touch is not highly predictable. This contradicts our original hypothesis derived from the toucher's behavior in [8]. As predicted, sine-wave patterned touch felt more pleasant than triangle-waves. Overall, we demonstrate that stroke patterns play a core role for pleasant touch in a social context.

Whereas touchers had moved in a spatially more variable manner when they aimed for pleasant social touch in [8], touchees here preferred predictable patterns. This seeming contradiction can be resolved when considering that in [8] touchers' higher spatial variability came along with extending movement from one to two axes. We suggest that spatial extension rather than variability explains the previous results. In the present study, all touch trajectories encompassed two axes. So, our findings show that predictability is an additional factor increasing pleasantness. In line with this, in audition, temporal uncertainty of tone sequences elicits feelings of dislike [10]. Noticeably, both low and moderate predictability were less pleasant than predictable touch. This suggests that uncertainty reduces pleasantness similarly regardless of its extent.

In addition, sine-wave patterns felt more pleasant than triangle-wave patterns. Previous studies had shown that linear stroking trajectories are perceived as less gentle, preferable and comfortable while circular trajectories feel more pleasant [7] [11]. Our results corroborate these findings within a social, more naturalistic context. We had predicted that smoother, more curvilinear patterns feel more pleasant, which is in line with present and previous results. However, in the present experiment, the length of the trajectories may have also influenced pleasantness: sine-wave patterns were slightly longer than triangle-waves. Future experiments may specify the contributions of the different factors.

Taken together, our results suggest that smoother, curvilinear, and predictable trajectories feel more pleasant in a social context, specifically within romantic dynamics. These are initial key insights into understanding relevant movement parameters in the perception of pleasant touch, which can also be directly applied when generating pleasant distanced human-to-human touch that is mediated by a robot.

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