Out of touch: Touch deprivation and affective touch perception during the COVID-19 pandemic

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ABSTRACT

Interpersonal touch and affective touch play a crucial role in social interactions and have a positive influence on mental health. The social distancing regulations related to the COVID-19 pandemic have reduced the ability to engage in interpersonal touch. This could cause touch deprivation, and it might alter the way in which affective touch is perceived. To investigate this, we conducted an online survey with 2348 participants, which contained questions regarding the COVID-19 regulations, touch deprivation and the perceived pleasantness of affective and non-affective touch. Results showed that participants reported feelings of touch deprivation. This significantly increased with the duration and severity of the COVID-19 regulations. Participants who experienced more touch deprivation rated videos of affective and non-affective touch as more pleasant. Current results provide insight in the impact of sudden and prolonged COVID-19 regulations and show that increasing the duration and severity of these regulations is associated with a higher desire for touch, which leads to increased perceived pleasantness of touch.

Keywords: Touch deprivation, affective touch, CT-optimal touch, COVID-19, touch perception

1. Introduction

To contain the outbreak of the COVID-19 virus, a variety of public health measures have been implemented globally to limit physical and social interactions. One aspect of social interactions that has been particularly affected by these public health measures is the ability to engage in social touch (Verity et al., 2020). Regulations such as quarantine and social distancing minimize social touch interactions with people outside the own household. Recently, first evidence emerged showing that the restrictions to contain the COVID-19 pandemic are linked to self-reported touch deprivation (Field, Poling, Mines, Bendell, & Veazey, 2020; Von Mohr, Kirsch, & Fotopoulou, 2021). Touch deprivation during the COVID-19 pandemic potentially has a large impact on our well-being and social life, as research shows that touch plays an integral role in social interactions (Morrison, Löken, & Olausson, 2010). It promotes the formation and maintenance of social bonds (Dunbar, 2010), helps to convey emotions (Hertenstein, Verkamp, Kerestes, & Holmes, 2006), facilitates prosocial behavior (Morrison et al., 2010) and reduces feelings of ostracism (von Mohr, Kirsch, & Fotopoulou, 2017). Moreover, research shows that interpersonal touch is important for social support and has a positive impact on mental health. For example, holding hands with a loved one can reduce anxiety and pain (Coan, Schaefer, & Davidson, 2006; López-Solà, Geuter, Koban, Coan, & Wager, 2019) and massages have a positive effect on psychological symptomatology (Field, 2019). In addition, interpersonal touch is associated with a higher quality of life (Floyd, 2014). Indeed, previous, pre-COVID-19, research showed that touch deprivation increases stress, disrupts psychological resilience as well as coping with stressful situations, which can increase the risk of developing anxiety disorders and depression (Banerjee et al., 2021). However, these previous studies have not been performed during global social distancing measures but focused on individuals who experienced touch deprivation even under unrestricted societal circumstances (Field, 2010). As such these previous findings have a limited generalizability, as during the COVID-19 pandemic a vast majority of the adult general population experienced a reduction in touch frequency, regardless of, for example, their mental health status, age or gender. It is therefore crucial to examine touch deprivation in the general population during the COVID-19 pandemic, as this will further our understanding of the impact social distancing has on individuals.

A form of interpersonal touch that is closely linked to its beneficial effects is affective touch (Björnsdotter, Morrison, & Olausson, 2010). Affective touch is a gentle and slow (1-10 cm/s) stroking of the skin that is generally experienced to be very pleasant (McGlone, Vallbo, Olausson, Loken, & Wessberg, 2007; McGlone, Wessberg, & Olausson, 2014). Gentle stroking at 1-10 cm/s (optimally at 3 cm/s) activates specific unmyelinated low-threshold mechanosensory C-fibers namely, C-tactile (CT) afferents, therefore it is also referred to as *CT-optimal touch*. CT-afferents are mostly located in the hairy skin ((Vallbo, Olausson, & Wessberg, 1999) but see (Watkins et al., 2020)). The CT-system contains a distinct neural pathway projecting to cortical areas mostly involved in affective and

emotional processing, i.e. the insula and anterior cingulate cortex (ACC) (Löken, Wessberg, Morrison, McGlone, & Olausson, 2009). These areas have been suggested to account for the affective component of this kind of touch (Banerjee et al., 2021). Besides bottom-up processing of CT-optimal touch, top-down processes, such as contextual and social factors (e.g. the intentions of the toucher, the relationship between the toucher and the individuals being touched) play an important role in the appraisal of CT-optimal touch as well (Banerjee et al., 2021; McGlone et al., 2014). Even more so, several studies show that the top-down processes involved in CT-optimal touch are related to its beneficial effects. Several studies show that when someone is touched by their romantic partner they experience stronger pain reduction compared to being touched by an experimenter (Krahé, Drabek, Paloyelis, & Fotopoulou, 2016; von Mohr, Krahé, Beck, & Fotopoulou, 2018).

In addition to contextual and social factors, other factors such as age (Sehlstedt et al., 2016), presence of psychological disorder (I. Croy, Geide, Paulus, Weidner, & Olausson, 2016) and exposure to touch (Sailer & Ackerley, 2019) play a top-down role in individual differences in CT-optimal touch perception. Sailer and Ackerley (2019) found that adults who reported to experience interpersonal touch infrequently perceived CT-optimal touch to be less pleasant than those who reported to receive interpersonal touch frequently. Sailer and Ackerley (2019) propose that this could be explained by the “use it or lose it” hypothesis, postulating that experiencing infrequent interpersonal touch results into a decrease in CT-optimal touch processing. As such, touch frequency appears to impact the appraisal of CT-optimal touch. This is especially of interest during the COVID-19 pandemic, as social distancing regulations might influence the amount of touch individuals receive. Changes in touch frequency as a result of COVID-19 might be associated with how CT-optimal touch is appraised and the extent to which individuals can benefit from the positive (mental health) effects of CT-optimal touch.

A first aim of the current study was to examine the link between the duration and severity of COVID-19 regulations and self-reported touch deprivation in an adult community sample, while also taking certain socio-demographic factors into account, such as age (Sehlstedt et al., 2016), gender (Croy, Angelo, & Olausson, 2014), and living conditions (e.g. living with a romantic partner or alone). We expected participants’ level of touch deprivation to increase with the duration of social distancing regulations. This is in line with very recent work by Von Mohr et al. (2021) who showed that during the COVID-19 pandemic individuals crave social touch and that this craving increases with the duration of social distancing measures.

A second aim of the current study was to explore the relation between touch deprivation and perceived pleasantness of CT-optimal touch. The perception of CT-optimal touch is typically studied using an in person paradigm in which participants are touched by the experimenter. Due to the COVID-19 pandemic it was not possible to physically interact with participants at the time of testing, we therefore included a CT-optimal touch paradigm in which participants observed and evaluated videos

of CT-optimal touch (adapted from Lee Masson, Van De Plas, Daniels, and Op de Beeck (2018); Willemse, Huisman, Jung, van Erp, and Heylen (2016)). Previous research shows that the mere observation of CT-optimal touch activates similar brain areas, e.g. the insula, as during the actual physical experience of CT-optimal touch (Lee Masson et al., 2018). Furthermore, the perceived pleasantness of observed touch also interacts with the stroking velocity (Willemse et al., 2016). Specifically, and similar to observations from in person studies, participants tend to rate the observation of CT-optimal touch as more pleasant than CT non-optimal touch. Therefore, CT-optimal touch observation seems a reliable way to assess perception of CT-optimal touch in the current study. In addition, several factors that might influence the perception of CT-optimal touch were taken into account, including the presence of mental disorders (Croy et al., 2016; Crucianelli, Cardi, Treasure, Jenkinson, & Fotopoulou, 2016; Crucianelli et al., 2020), age (Sehlstedt et al., 2016), gender (Ilona Croy et al., 2014), and neurological and skin conditions (Liljencrantz & Olausson, 2014). Following Sailer and Ackerley (2019) “use it or lose it principle” we expected that an increase in touch deprivation would be related to a decrease in pleasantness ratings of CT-optimal touch videos.

2. Methods

2.1. Participants

Between April 5th and October 8th 2020, 2403 participants completed the experiment in Qualtrics. In the analyses we only included participants older than 16 who reported that COVID-19 public health regulations were in effect in their country of residence. In addition, two participants with anomalous data were excluded from analyses. This resulted in a final dataset for analyses consisting of 2348 participants. The majority of these participants were female ($n = 1874$), and aged between 16-87 ($M = 38.17$, $SD = 15.47$). All participants provided written informed consent at the start of the experiment and did not receive any form of compensation. The study was approved by the local faculty ethical review board of Utrecht University (protocol number 20-210).

Most participants lived in the Netherlands (69.2%) or Italy (9.9%) and were experiencing a lockdown at the time of testing (62.9%). This means that the government advised them to stay at home as much as possible and that social gatherings and social interactions were prohibited. Participants estimated that the COVID-19 regulations in their country of residence had been in place for an average of 45.92 days at the time of testing ($SD = 30.21$; 0-250). The majority of participants were not and had not been infected with the COVID-19 virus at the time of the experiment (73.6%), 24.2% was not sure if they had been infected. In addition, most participants were working or studying from home (58.1%)

and were living with housemates with whom they had a good relationship (58.8%). A complete overview of the demographic characteristics of the sample can be found in the Table 1.

Table 1. Demographics of sample population

Variables	N	%
Gender		
Male	453	19.3
Female	1874	79.8
Non-binary	15	0.6
Location		
Europe	2143	91.3
North America	44	1.9
Australia + New Zealand	10	0.4
South America	5	0.2
Asia	4	0.2
Africa	3	0.1
Severity of regulations		
Advice to not shake hands	45	1.9
Advice not to engage in social interactions (social distancing)	510	21.7
Lockdown	1453	61.9
Complete lockdown	337	14.4
COVID-19		
I am currently infected	6	0.3
I was infected in the past	33	1.4
I am/have not been infected	1728	73.6
I am unsure	568	24.2
Living Conditions		
Living alone without housemates/pets	512	21.8
Living without housemates, but with pets	178	7.6
Living with housemates, poor relationship	165	7.0
Living with housemates, good relationship	1380	58.8
Current employment status		
Unemployed	358	15.2
Working or studying from home	1365	58.1
Working or studying at an external location	362	15.4
At home but unable to work/study	253	10.8

2.2. Materials

CT-optimal touch perception

Participants watched two videos that depicted a forearm being stroked with a hand with an CT-optimal (3 cm/s) and CT non-optimal (30 cm/s) velocity. Each video had a duration of 10 seconds and the order of the videos was counterbalanced across participants (see Supplementary Materials for videos). The participants completed a touch perception questionnaire after watching each video. Participants responded to five statements regarding the pleasantness of the touch (e.g. *“How did the videoclip make you feel?”*) on a 10 point scale ranging from 0 (*“Very unpleasant”*) to 10 (*“Very pleasant”*) (See Supplementary Materials for full questionnaire). A mean score was subsequently calculated, with a higher score indicating that the touch observed in the video was perceived as pleasant.

Socio-Demographic questionnaire

Information about sample characteristics (age, gender and the presence of mental/neurological disorders, current work situation) and the current COVID-related regulations (duration and severity) was obtained with a 23-item questionnaire (see Supplementary Materials for full questionnaire). Participants also answered a number of questions about their living conditions, including if they lived with housemates and/or pets and how they would rate the quality of their relationship with potential housemates. The latter was rated on a 10-point scale ranging from 1 (*“Very Poor”*) to 10 (*“Very Good”*). We categorized living conditions into: living without housemates and pets, living with pets, living with housemates with whom relationship quality was poor (Quality relationship < 5), and living with housemates with whom relationship quality was good (Quality relationship > 5).

Touch deprivation

A 2-item questionnaire was used to measure touch deprivation (*“Currently I would prefer to be touched by others ...”* and *“Currently I would prefer to touch others ...”*). Participants responded using a scale that ranged from 0 (*“Currently I would prefer to be touched less by others/to touch others less”*) to 10 (*“Currently I would prefer to be touched more by others/to touch others more”*). To calculate an average touch deprivation score, the mean response was taken across these two items. Higher average scores (> 5) indicated that participants felt touch deprived.

2.3. Data analyses

SPSS 24.0 was used to analyze the data. Data were checked for normality with a Shapiro-Wilk test and a Q-Q plot. The plots were used as additional check because of the sensitivity of the Shapiro-Wilk test to large sample sizes (Ghasemi & Zahediasl, 2012). Scores on the touch deprivation questionnaire were not normally distributed, as indicated by both the Shapiro-Wilk test ($p < .05$) and the Q-Q plots.

Multiple linear regression with bootstrapping (1000 iterations) was therefore used. The Shapiro-Wilk test also indicated that the responses to the touch perception questionnaire were not normally distributed ($p < .05$). However, Q-Q plots demonstrated that these scores were approximately normally distributed. Therefore, regular linear regressions were used to analyze these variables. For all tests, the other assumptions were met. Unless stated otherwise $\alpha = .05$ (two-tailed).

3. Results

3.1. Touch deprivation

A score of 5 on the touch deprivation questionnaire would reflect a perfect balance between touch wish and touch frequency. In the current sample 87% of the participants scored higher than 5. The average score on the touch deprivation questionnaire was 7.75 ($SD = 2.31$). A one sample t-test with a test value of 5 showed that participants scored significantly higher than 5, $t(2228) = 56.19$, $p < .001$, implying that participants reported to feel touch deprived.

A multiple linear regression with bootstrapping was used to investigate the influence of the duration and severity of COVID-related regulations and six socio-demographic factors (age, gender, living conditions, current work situation and presence of mental disorder and neurological and/or skin disorders affecting touch perception) on touch deprivation. The overall regression model was significant, $F(15, 2112) = 13.24$, $p < .001$, $R^2 = .09$. The regression coefficients are displayed in Table 2.

Table 2. Regression Coefficients.

Model	B	Std. Error	β	P
(Constant)	6.25 (5.77, 6.57)	.26	-	.001
Duration of regulations	.01 (.01, .02)	.00	.15	.001
Regulation severity	-	-	-	-
ANSH vs. Complete Lockdown	-.30 (-1.20, .48)	.41	-.02	.449
Social distancing vs. Complete lockdown	.34 (-.01, .73)	.19	.06	.072
Lockdown vs. Complete lockdown	.32 (.02, .65)	.16	.07	.045
Age	.00 (-.00, .01)	.00	.03	.299
Gender	-	-	-	-
Non-binary vs. Men	-.23 (-.57, 2.31)	.80	-.21	.374
Women vs. Men	.25 (-.01, .71)	.15	.24	.084
Presence of mental disorders	-.00 (-.01, .00)	.00	-.02	.355
Presence of neurological/skin disorders	.01 (-.01, .03)	.01	.02	.400
Living conditions	-	-	-	-
Alone vs. Housemates (GR)	1.03 (.84, 1.20)	.10	.19	.001
Pets vs. Housemates (GR)	.73 (.38, 1.07)	.18	.09	.001
Housemates (PR) vs. Housemates (GR)	.51 (.15, .83)	.19	.06	.009
Current work situation	-	-	-	-
Unemployed vs. working externally	-.10 (-.37, .36)	.15	-.13	.457

Working at home vs. working externally	-.01 (-.18, .39)	.11	-.01	.953
Home, unable to work vs. working externally	.09 (-.18, .58)	.16	.12	.490

Note: Multiple linear regression model (95% bias-corrected and accelerated CI reported in parentheses). Confidence intervals and standard errors based on bootstrapping samples (1000 iterations). ANSH = Advice to not shake hands. GR = Good Relationship. PR = Poor Relationship.

Touch deprivation was found to increase significantly with the duration of the regulations. Regarding the severity of the regulations, a difference was observed only between lockdown and complete lockdown: participants in lockdown demonstrated a higher level of touch deprivation than those in complete lockdown. The touch deprivation scores of participants in complete lockdown did not differ significantly from those who had only received the advice not to shake hands, and those who were only social distancing. With respect to the socio-demographic factors, touch deprivation was significantly associated with living conditions. Participants who lived alone, with pets, or with housemates with whom they had a poor relationship all reported to be significantly more touch deprived than participants who lived with housemates with whom they had a good relationship (see Table 3). There was no significant association between touch deprivation and gender.

Table 3. Mean touch deprivation scores for living conditions

Living condition	Mean	Std. Deviation
Living alone	8.55	1.70
Living with pets	8.39	2.26
Living with housemates and poor relationship quality	7.83	2.24
Living with housemates and good relationship quality	7.33	2.43

3.2. Perceived pleasantness of touch

Manipulation check

Prior to the main analysis, a manipulation check was conducted to determine whether participants scored higher on the touch perception questionnaire after viewing the CT-optimal touch video compared to the CT non-optimal touch video. A paired t-test showed that the CT-optimal touch video ($M = 7.03$, $SD = 1.99$) was indeed rated as significantly more pleasant than the CT non-optimal touch video ($M = 3.35$, $SD = 1.97$), $t(2301) = -70.61$, $p < .001$.

Main analysis

Two multiple linear regressions were conducted with perception of CT-optimal and CT non-optimal touch as respective outcome measures. The level of touch deprivation, the severity and the duration

of COVID-related regulations were included as between-subjects factors. Gender, age and the presence of mental, neurological and skin disorders were also included as predictors in the model, to control for the potential influence of these variables. The first model was a significant predictor for the perceived pleasantness of the CT-optimal touch video, $F(10, 2196) = 41.78$ $p < .001$, $R^2 = .16$. The regression coefficients can be found in Table 4.

Table 4. Regression Coefficients with CT-optimal touch as outcome measure.

Model	B	Std. Error	β	t	P
(Constant)	4.62 (4.25, 4.99)	.19	-	24.43	< .001
Touch deprivation	.29 (.26, .32)	.02	.34	16.89	< .001
Duration of regulations	.00 (-.00, .00)	.00	.00	.18	.855
Regulation severity	-	-	-	-	-
ANSH vs. Complete Lockdown	-.61 (-1.22, -.00)	.31	-.04	-1.96	.050
Social distancing vs. Complete lockdown	-.48 (-.76, -.20)	.14	-.10	-3.37	.001
Lockdown vs. Complete lockdown	-.63 (-.85, -.41)	.11	-.16	-5.53	< .001
Age	.02 (.02, .03)	.00	.17	8.18	< .001
Gender	-	-	-	-	-
Non-binary vs. Men	.06 (-.12, .25)	.10	.07	.66	.507
Women vs. Men	-.08 (-.26, .10)	.09	-.09	-.86	.388
Presence of mental disorders	-.00 (-.00, .00)	.00	-.01	-.33	.743
Presence of neurological/skin disorders	-.00 (-.01, .01)	.01	-.00	-.21	.837

Note: Multiple linear regression model (95% CI in parentheses). ANSH = Advice to not shake hands.

The perceived pleasantness of the CT-optimal touch video significantly increased as the level of touch deprivation and age increased. Participants in complete lockdown also perceived the CT-optimal touch video to be significantly more pleasant than those who were advised not to shake hands, who were under social distancing measures and those in lockdown. The perceived pleasantness of the CT-optimal touch video was not significantly associated with the duration of regulations, gender, nor presence of a mental/neurological disorder.

The second model significantly predicted the perceived pleasantness of the CT non-optimal touch video, $F(10, 2187) = 6.62$, $p < .001$, $R^2 = .03$. The regression coefficients can be found in Table 5.

Table 5. Regression Coefficients with CT non-optimal touch as outcome measure.

Model	B	Std. Error	β	t	P
(Constant)	3.55 (3.15, 3.96)	.21	-	17.24	< .001
Touch deprivation	.08 (.04, .12)	.02	.09	4.29	< .001
Duration of regulations	.00 (-.00, .00)	.00	.00	.12	.909
Regulation severity	-	-	-	-	-

ANSH vs. Complete Lockdown	-.64 (-1.32, .04)	.35	-.04	-1.85	.065
Social distancing vs. Complete lockdown	-.83 (-1.13, -.53)	.16	-.18	-5.36	<.001
Lockdown vs. Complete lockdown	-.59 (-.83, -.35)	.12	-.15	-4.75	<.001
Age	.00 (-.00, .00)	.00	.00	.02	.986
Gender	-	-	-	-	-
Non-binary vs. Men	.32 (.12, .52)	.10	.35	3.12	.002
Women vs. Men	-.30 (-.50, -.11)	.10	-.33	-3.02	.003
Presence of mental disorders	-.00 (-.01, .00)	.00	-.03	-1.44	.149
Presence of neurological/skin disorders	-.02 (-.03, -.00)	.00	-.05	-2.30	.022

Note: Multiple linear regression model (95% CI in parentheses). ANSH = Advice to not shake hands.

Pleasantness scores for the CT non-optimal touch video were significantly and positively associated with levels of touch deprivation. In addition, participants in complete lockdown perceived the CT non-optimal touch video to be significantly more pleasant than those who were socially distancing and those in lockdown. Women and non-binary individuals perceived the CT non-optimal touch video to be less pleasant than men. Furthermore, there was a significant association with the presence of neurological/skin disorders. There was no significant association with the duration of the regulations, age, or the presence of mental disorders.

4. Discussion

Interpersonal touch has been found to play an important role in social bonding and has a positive influence on mental health (Coan et al., 2006; Morrison et al., 2010). Due to the COVID-19 pandemic, several regulations have been in effect to prevent the virus from spreading. Restrictions such as quarantine, lockdown, and social distancing have decreased the frequency of touch interactions outside the own household, which could result in feelings of touch deprivation (Von Mohr et al., 2021). Previous work on touch deprivation shows a link between touch deprivation and altered perceived pleasantness of CT-optimal touch (Field, 2010; Sailer & Ackerley, 2019). However, these studies have not been conducted in a large community sample experiencing restrictions with respect to social interactions. The aim of the current study was therefore to investigate if individuals report feelings of touch deprivation under COVID-19 regulations, which factors contribute to touch deprivation and if the level of touch deprivation is associated with pleasantness perception of CT-optimal touch.

To assess if participants felt touch deprived, they indicated on a ten-point scale whether they would like to receive less touch/touch others less (0) or receive more touch/touch others more (10). On average participants scored 7.75, implying that participants felt touch deprived at the time of testing, as only a score of 5 would reflect a perfect balance between touch wish and touch frequency. Our findings are in accordance with the recent findings by Von Mohr et al. (2021), who also report

touch deprivation in their sample, especially with respect to professional and friendly touch, and to a lesser extent with respect to intimate touch. As we do not have touch deprivation scores of our sample before the COVID-19 pandemic, we cannot draw any conclusions with respect to how the COVID-19 pandemic has impacted touch deprivation scores. In other words, at this point we do not know whether the touch deprivation score of 7.75 that we report here reflects a (significant) increase in feelings of touch deprivation. However, a pre COVID-19 study of Beßler, Bendas, Sailer, and Croy (2020) showed that over 70% of the healthy individuals in their sample reported that they experienced a longing for touch. So, it appears that even in a society in which there are no restrictions with respect to social interactions, individuals experience a discrepancy between the amount of touch they would want to receive and the amount of touch they actually receive. Interestingly, in our sample 87% of the participants reported that they felt touch deprived. Although a direct statistical comparison between our post COVID-19 touch deprivation scores and the pre COVID-19 touch deprivation scores reported by Beßler et al. (2020) is not possible, we cautiously suggest that the restrictions following from the COVID-19 pandemic have had a negative impact on the level of touch deprivation reported in the community.

In addition, we investigated which sociodemographic variables were associated with variability in touch deprivation scores. The results showed that higher levels of touch deprivation were linked to a longer duration of COVID-19 regulations. This is in line with the recent work of Von Mohr et al. (2021) who also found that touch deprivation is associated with the duration of COVID-19 and social distancing regulations. We further extend the findings by Von Mohr et al. (2021) by showing that not only the duration of the COVID-19 regulations is associated with higher levels of touch deprivation but also to the severity of these measures. Our results show that individuals in lockdown report higher levels of touch deprivation compared to individuals in complete lockdown. Remarkably, the complete lockdown group did not report higher levels of touch deprivation than the groups that were advised not to shake hands and the group that was socially distancing. It is possible that the lockdown group, who appeared to suffer from the highest levels of touch deprivation, had also the longest duration of regulations. On visual inspection, it seems this only accounts for the difference between lockdown (M=40.94) and complete lockdown (M=28.07). The mean duration for the group whom had the advice not to shake hands (M=86.68) and the social distancing group (M=68.33) are much longer than the lockdown group and can therefore not explain this unexpected result. Furthermore, we found that participants who lived alone, who lived with pets, or who lived with housemates with whom they have a poor relationship reported higher levels of touch deprivation than participants who lived with housemates with whom they had a good relationship. These findings are in accordance with recent work by Field et al. (2020), who also showed that living situation correlated with touch deprivation.

Interestingly, although participants living with housemates with whom they had a good relationship quality might have had more opportunities to engage in touch interaction compared to participants living alone, they reported to feel touch deprived at time of testing as the mean touch deprivation score was still 7.33. This might be explained by findings of Von Mohr et al. (2021) who, reported that under COVID-19 regulations individuals seem to especially crave friendly and professional touch. This highlights the importance of touch interactions with a variety of touch partners, e.g. significant others, but also friends or colleagues, for maintaining a satisfying balance between the need for touch and touch frequency.

A second aim of our study was to investigate the perceived pleasantness of CT-optimal touch during COVID-19. Participants watched short touch videoclips and rated the pleasantness of these videoclips. We specifically investigated which factors were associated with the appraisal of touch observation. We found a positive association between touch deprivation and pleasantness ratings for both CT-optimal and CT non-optimal touch videoclips, indicating that participants who felt more touch deprived reported higher levels of pleasantness when observing touch. This might be explained by top-down mechanisms such as social and contextual factors that have been found to be involved in the perception of CT-optimal touch (Banerjee et al., 2021; McGlone et al., 2014). It could be that the restrictions in social interaction increased our desire to be touched which led to a higher appraisal of touch itself. In addition, appraisal of CT-optimal touch is also linked to activation of brain areas involved in the reward system (Morrison, 2016), it could be that in our study increased pleasantness ratings of touch reflect an increased activation of the reward system. A parallel can be drawn here with work focusing on the positive link between food deprivation and the subjective appraisal of high-calorie foods (Goldstone et al., 2009). Similarly, craving touch might make the observation of touch more appealing. This explanation fits with our finding that not only CT-optimal touch videoclips were rated as more pleasant when touch deprivation increased, but that the same pattern was observed for videoclips depicting non-affective touch as well. An interesting hypothesis following from this line of reasoning is that even other forms of touch which do not necessarily activate the CT-afferents may become more desirable when there are fewer opportunities to receive touch. To further explore this, future studies could focus on investigating how the perception of specific types of physical interactions (i.e. a handshake or an accidental brush) changes as touch deprivation increases.

Our findings are in contrast with previous work that indicated that touch deprived participants experienced CT-optimal touch as less pleasant than participants who were not touch deprived (Sailer & Ackerley, 2019). A 'use it or lose it' mechanism has been proposed, suggesting that infrequent CT-optimal touch experiences shape the interpretation and hedonic evaluation of those experiences. The contrasting findings between our study and that of Sailer and Ackerley (2019) might be explained by the different social circumstances under which the studies were conducted. The study by Sailer and

Ackerley (2019) was conducted in a society with no restrictions on social interactions. As such their participants were potentially touch deprived as a result of, for example, a limited social network or limited amount of touch partners. Indeed Sailer and Ackerley (2019) report that the majority of their touch deprived group did not have a partner and/or child(ren), while the majority of their control group did. In contrast, in our study participants' social network did not necessarily change, but the opportunity to engage in touch interactions with their social network did change. Moreover, another crucial difference between our study and that of Sailer and Ackerley (2019) is methodological. While they asked participants to rate the pleasantness of actual touch to their forearm, our participants observed a videoclip of a hand stroking an arm. Although research shows that observing CT-optimal touch activates the same brain regions as actually receiving CT-optimal touch (Lee Masson et al., 2018), top-down mechanisms also play an important role in the perceived pleasantness of CT-optimal touch. As such, it could be that in the study of Sailer and Ackerley (2019) different social and contextual factors, such as the setting in which the study took place influenced the appraisal of CT-optimal touch.

We furthermore found a link between age and pleasantness perception of CT-optimal touch observation. This is in line with previous observations showing that pleasantness ratings for CT-optimal touch increase with age (Sehlstedt et al., 2016). We also found that participants in a complete lockdown perceived both CT-optimal and CT non-optimal touch to be more pleasant than those only were advised not to shake hands, than those who were socially distancing and then those who were in lockdown. Although this effect is not necessarily unexpected, it might not be entirely driven by the level of restrictions, but also in part reflect cultural differences. The majority of the participants in a complete lockdown lived in Italy. This is considered to be a high-contact culture in which, as recent research suggests, CT-optimal touch is more prevalent (Sorokowska et al., 2021). We therefore speculate that perhaps a combination of more severe COVID-19 regulation and living in a high contact culture both have resulted in higher levels of observed touch pleasantness.

This study is not without limitations, we did not take different types of social touch and interaction partners into account, which could have provided us with more information regarding the way in which individuals feel touch deprived. Von Mohr et al. (2021) did distinguish between professional, friendly, and intimate touch and showed that the difference in touch frequency pre- and post COVID-19 was largest for friendly touch. However, the participants also reported that they craved intimate touch most and that this increased with duration of the COVID-19 regulations. These findings highlight the complexity of our need for touch and how this may affect feelings of touch deprivation.

To conclude, we show here that with an increasing duration of the COVID-19 regulations individuals in the community report to feel more touch deprived. It seems that individuals who live alone, who live with pets or who have a poor relationship with their housemates suffer from the highest levels of touch deprivation. In addition, touch deprivation appears to be related to touch

perception. We found that higher levels of touch deprivation were linked to a more pleasant perception of videoclips showing both CT-optimal and CT non-optimal touch. Thus, individuals who long for touch more find it more pleasant to watch videoclips showing interpersonal touch. We suggest that fewer opportunities to engage in touch may potentially increase the hedonic value ascribed to touch stimuli, similar to an increased liking of high calorie foods when food deprived. Our study contributes to the understanding of the factors that are associated with touch deprivation and how this links to touch perception in (healthy) adults. By doing so, this study also provides new insights into the wider consequences of COVID-19-related public health measures.

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