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Examining the relationship between touch and visual perception: pareidolia perception in the social brain

Dokunma ve görsel algı arasındaki ilişkinin incelenmesi: sosyal beyinde pareidolia algısı

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Abstract

Purpose: Human perception is a complex system based on the interaction of different modalities. However, it is unclear how adults' perception of social touch influences their social dimension of visual perception. The aim of this study is to investigate the relationship between social touch perception and visual perception in the social brain.

Materials and methods: The survey study recruited 802 healthy participants. Thus, a self-report survey that included the Social Touch Questionnaire consisting of three factors and the pareidolia test were used. Pearson's Correlation and one- way ANOVA was performed for analysis.

Result: We display a statistically significant negative correlation between face reaction time, personal social touch factor, and liking personal social touch factor. An adverse important relationship emerged between pareidolia reaction time, liking of personal social touch, and social touch behavior factors.

Conclusion: According to our results, multimodal perception necessitates the simultaneous activation of multiple heteromodal associations in the social brain. Our findings can be interpreted as an interaction between the Dorsal and Ventral Attention Networks and the Social Brain Network.

Keywords: Social touch perception, visual perception, pareidolia, multimodal perception, social brain.

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Öz

Amaç: İnsan algısı, farklı modalitelerin etkileşimine dayalı karmaşık bir sistemdir. Ancak yetişkinlerin sosyal dokunma algısının görsel algının sosyal boyutunu nasıl etkilediği belirsizdir. Bu çalışmanın amacı, sosyal beyinde sosyal dokunma algısı ile görsel algı arasındaki ilişkiyi incelemektir.

Gereç ve yöntem: Çalışma 802 sağlıklı katılımcı ile gerçekleştirildi. Üç faktörden oluşan Sosyal Dokunma testini ve Pareidolia testini içeren öz bildirim anketi kullanıldı. Pearson Korelasyon ve tek yönlü ANOVA analizi gerçekleştirildi.

Bulgular: Yüzlere verilen tepki süresi ile kişisel beğenilen sosyal dokunma faktörü ve kişisel sosyal dokunma faktörü arasında istatistiksel olarak anlamlı bir negatif ilişki bulundu. Pareidoliaya verilen tepki süresi ile kişisel sosyal dokunma ve sosyal dokunma davranışı faktörleri arasında anlamlı negatif ilişki bulundu.

Sonuç: Sonuçlarımıza göre, multimodel algı, sosyal beyinde çoklu heteromodal ilişkilendirme alanları ile eş zamanlı olarak aktive olmasını gerektirmektedir. Bulgularımız, Dorsal ve Ventral Dikkat Ağları ile Sosyal Beyin Ağı arasındaki etkileşimi yansıtabilir.

Anahtar kelimeler: Sosyal dokunma algısı, görsel algı, pareidolia, multimodel algı, sosyal beyin.

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Introduction

The perception of touch has a prominent role in effective communication with both physical and social aspects of our environment. Due to social touch perception affecting empathy, bonding, communication, and social perception [1] social touch is regarded as a complex social cue. Complex social cues are defined as nonverbal or verbal indicators that are denoted by face and body to guide social interactions with others [2]. The face as another significant complex social cue is naturally perceived by vision modality for adaption to the social environment whereas social touch, another significant social cue, is dominated by tactile modality. In terms of cognitive limitations, humans tend to choose the most suitable social cues and integrate them during perception with sensory modalities working together in interaction [3]. Evidence of this interaction has been released in Dionne et al. [3] fMRI study in which a change in the Bold signal between performed simultaneous visual and tactile stimulus and single trials in the sensory-related motor task was shown. Additionally, Della Longa et al. [4] has found that social touch has a role in face perception in infants regarding complex social cues.

The pareidolia test has been used specifically in face perception studies. Pareidolia is interpreting information in a stimulus or image that does not exist as a familiar pattern [5]. Palmer and Clifford have stated that pareidolia is a phenomenon that shows how our visual system is sensitive to complex social cues and how fast we perceive them [6]. In a study conducted by Akdeniz with electroencephalography (EEG), face, and pareidolia conditions were compared and it was found that the N170 response was earlier and greater in response to faces [7]. In Liu et al. [8], study investigating face-specific neural and behavioral reactions throughout illusory visual processing, researchers compared neural and behavioral reactions of face pareidolia using letter pareidolia with fMRI and they have found specific right fusiform face activation in letter pareidolia conditions. Wardle et al. [9] also used fMRI to analyze how pareidolias are represented in category-selective areas. In addition, Wardle et al. [10] used MEG to evaluate individuals' brain activation patterns in reaction to illusory faces, non-facial items, and face images to comprehend the perception of illusory faces temporally.

Although there are many neuroimaging studies on this subject, the digital pareidolia test has not been performed until now. The purpose of this study is to investigate the relationship between touch and visual perception by using the digital pareidolia test. We have developed a new digital face pareidolia test to measure how touch and visual perception affects each other.

Materials and methods

Respondents

Data from 802 respondents have been included in the study. The sample consists of Turkish people currently residing in Türkiye. To find the relationship between visual sense perception and sense of touch perception and to find out how much the decrease in sense of touch several questions were asked to the respondents. Respondents were asked to fill out a self-report survey that took approximately 15 minutes. All surveys were formed and performed on the Qualtrics XLM platform. The survey consists of a social touch questionnaire to measure the effect and attitude to touch-related experiences (Adapted from STQ) [11] and a pareidolia test to measure visual perception. After approval by Ethics Committee of Training and Research Hospital in Türkiye, informed consent forms from the respondent were obtained.

Social Touch Questionnaire (STQ)

To examine the overall effect and attitude toward touch-related experiences, respondents were asked for 19 items rated on 5 points (1/ Not at all to 5/Extremely) from the Social Touch Questionnaire (STQ;20) [11]. The items were selected to examine various reactions to the social touch. The questionnaire contains 3 main factors: dislike of social touch, liking of personal social touch, and social touch behavior [12].

Face Pareidolia Test

To examine face pareidolia, three different types of images were shown to the respondents: face, pareidolia, and scramble. Visuals taken by the image-processing laboratory of Centro

Universitário da FEI, Sao Paolo, Brazil provided from Google Images. The luminosity of all the visuals used in the study was equalized. Every face image that was used in the study had a neutral facial expression. Scramble images were designed in MATLAB, Shine toolbox. (MathWorks, Inc., Natick, MA, USA). Pareidolia, a visual perception test with proven reliability and validity in Turkish [5] was performed. 10 images were used for each stimulus type, and a total of 30 images were shown to the respondents (Figure 1). As soon as the respondents see the images, they were asked whether they see a face in the given images. 3000 milliseconds were given to the respondents to answer this question.

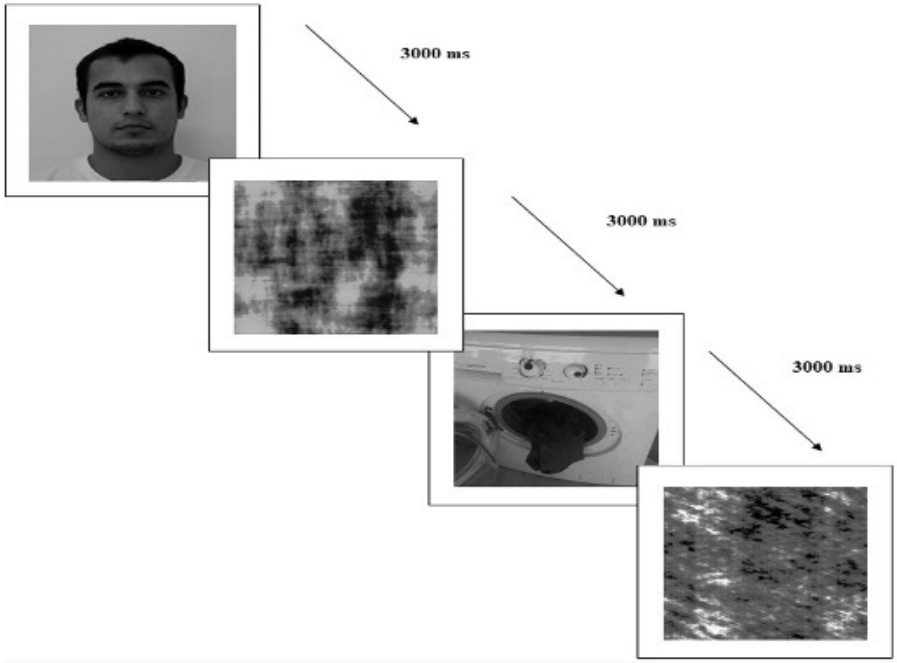

Figure 1. The example of stimuli and experimental design of the pareidolia test

Statistical analysis

Statistical Package for the Social Sciences (SPSS 22.0, SPSS Inc., Chicago, IL) was used to perform all the statistical analysis. Descriptive statistics, mean, and standard deviation were used to summarize the data. Pearson's Correlation was used for correlation analysis. One-way ANOVA analysis was used to compare the means. Eta squared was used to calculate the effect size.

Results

A total of 802 Turkish citizens (68.3% female, 31.7% male), 18-56 and above filled out the online survey named "Self-Report Touch and Vision Measurement". The socio-demographic characteristics of the participant was displayed in Table 1 and Table 2 shows the questions of the STQ. Figure 2 shows the frequency distribution of dislike of the social touch factor. 66.3% of respondents feel uncomfortable when they have to contact physically to a stranger on public transportation. Figure 3 includes the frequency distribution of liking personal social touch factor, 43% of respondents like touching animals. As shown in Figure 4, the frequency distribution of the Liking Social Touch Behavior Factor, 37.9% of respondents stated that they never feel comfortable when they are physically contacting a stranger.

The mean reaction time measurements of 802 participants are shown in Figure 5. The mean reaction time given to the face is 1250 milliseconds (1.25 seconds), the pareidolia is 1610 ms (1.61 seconds), and the scrambles is 2080 ms (2.08 seconds).

Table 1. Items of STQ

	ITEMS
I.	I feel uncomfortable if a stranger keeps holding my hand after shaking it.
II.	I feel annoyed if someone unexpectedly touches me.
III.	I feel uncomfortable if a stranger hugs me.
IV.	I feel disturbed if I have to have physical contact with a stranger person in public transportation.
V.	I get anxious if someone I have just met touches on my wrists.
VI.	I feel disturbed if a professor touches my shoulder in front of people.
VII.	I feel uncomfortable if I have to touch strangers to get their attention.
VIII.	I'd rather skip shaking hands with strangers.
IX.	I despise being tickled.
X.	I don't like when people physically contact each other in public. (e.g. hugging, kissing)
XI.	I generally received hugs from family members when I was a kid. (e.g. parents, relatives)
XII.	I kiss the cheeks of my close friends when I want to greet them.
XIII.	I like touching animals.
XIV.	I feel delighted if I give shoulder/neck massages to my friends when they are distressed.
XV.	I would like to get a professional massage if I have an opportunity.
XVI.	I describe myself as someone who loves touching while communicating.
XVII.	I like when people express their love for me physically. (e.g. hugging, kissing)
XVIII.	I generally like contacting people physically. (e.g. hugging, kissing, shaking hands)
XIX.	I am at ease making physical touch with strangers.

Table 2. Demographic table

Variables	Percentage	Respondents
Total		802
Gender		
Woman	(68.3%)	548
Man	(31.7%)	254
Age		
18-30	(63%)	505
31-40	(9.5%)	76
41-55	(22.7%)	182
56 and above	(4.9%)	39
Education status		
High School	(21.8%)	175
Graduate	(62.2%)	499
Postgraduate	(13.5%)	108
PhD	(2.5%)	20
Chronic disease		
Yes	(19%)	152
No	(81%)	650
Smoking status		
Smoker	(27.9%)	224
Nonsmoker	(72.1%)	578
Dominant hand		
Right-handed	(92.4%)	741
Left-handed	(7.6%)	61

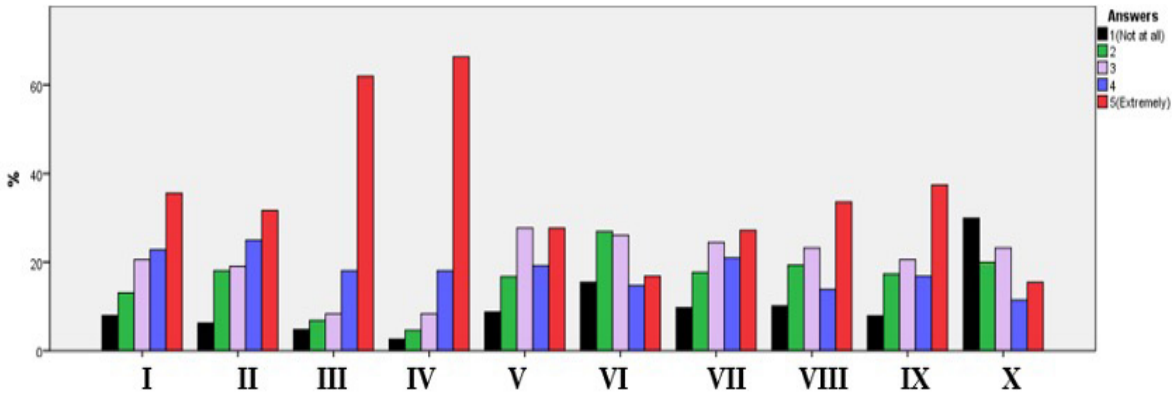

Figure 2. Frequency distribution of responses to Dislike of Social Touch Factor

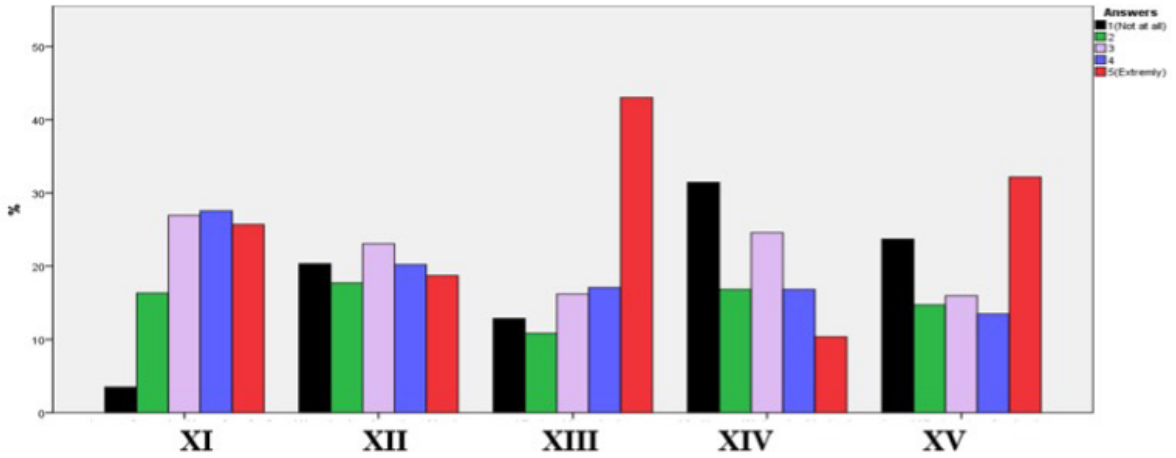

Figure 3. Frequency distribution of responses to liking of personal social touch factor

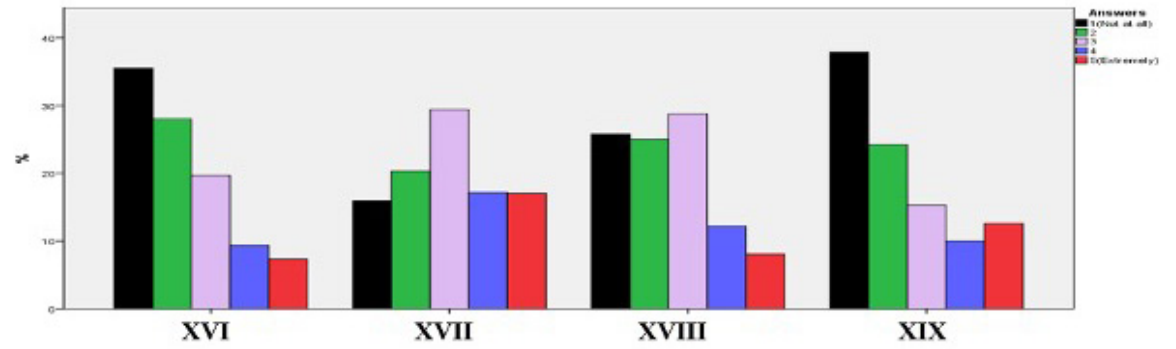

Figure 4. Frequency distribution of responses to liking of social touch behavior factor

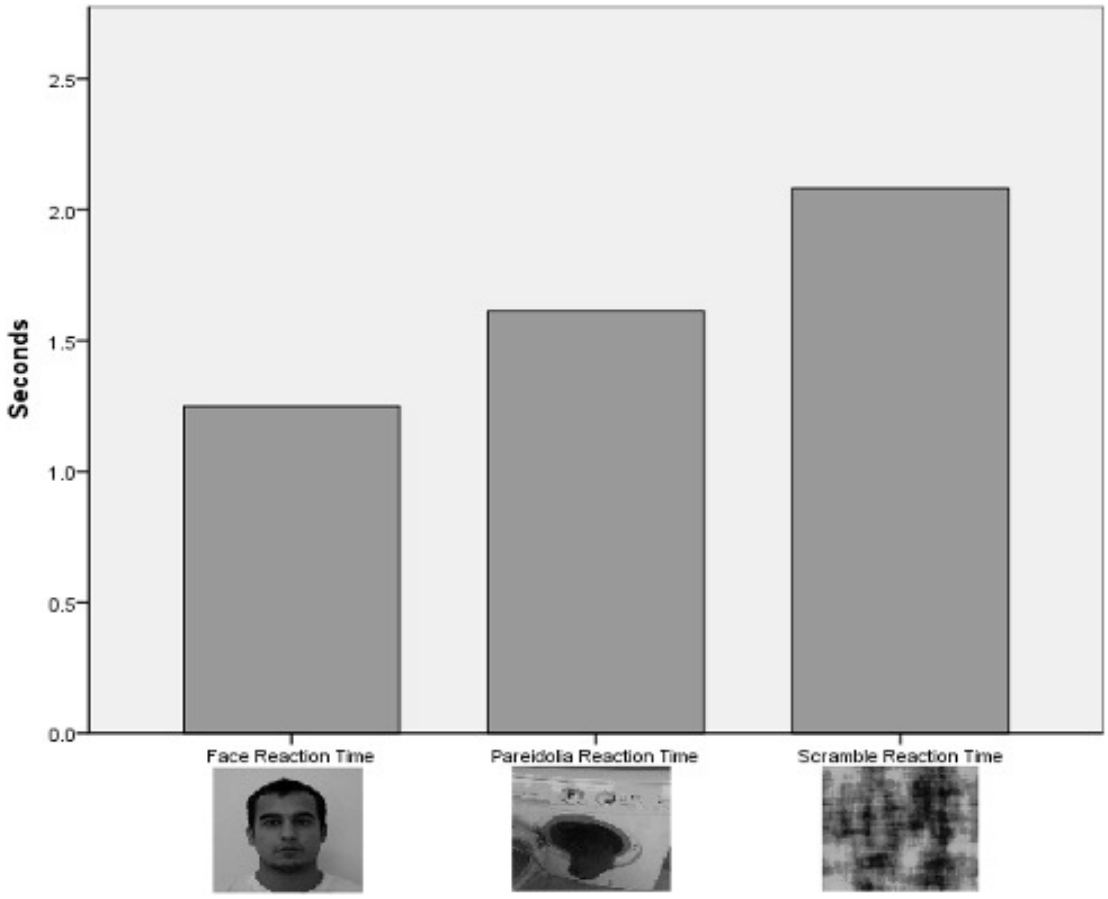

Figure 5. The mean of reaction time given to visual types in the pareidolia test

Table 3 shows Pearson Correlations related to reaction time and STQ factors. The output has revealed a positive correlation between face reaction time and dislike of touch factor. Also, there was a strong negative statistically significant correlation between face reaction time, liking of personal social touch factor, and social touch behavior. We have found a negative significant correlation between pareidolia reaction time, liking of personal social touch factor, and social touch behavior factor. There was no correlation between pareidolia reaction time and dislike of touch factor. We found a positive correlation between scramble reaction time and dislike of touch factor. Also, we have found a strong negative correlation between scramble reaction time, liking of personal social touch, and social touch behavior factors.

Reaction time for every condition (face, pareidolia, and scramble) were measured and compared with factors of social touch by means. Multiple comparisons between reaction times and STQ factors are displayed one-way ANOVA comparison in Table 4. One-way ANOVA revealed a significant difference in the main effect between pareidolia reaction time and dislike of social touch factor ($f(38.763)=1.502$, $p<0.05$). Furthermore, there is an important difference in the main effect between face reaction time and liking personal social touch factor ($f(20.781)=3.754$, $p<0.01$). Also, as a result of one-way ANOVA performed between scramble reaction time and dislike of social touch factor, a significant difference emerged between them($f(38,763)=1.726$, $p<0.05$). A significant difference emerged in the main effect between pareidolia reaction time and liking of personal social touch factor ($f(20.781)=1.513$, $p<0.01$). Also, there was a significant difference in the main effect between face reaction time and liking of social touch behavior factor ($f(16.785)=2.184$, $p<0.01$).

Table 3. Correlations related to reaction time and STQ

	M	SD	1	2	3	4	5	6
Dislike of Social Touch (1)	3.52	.802	1					
Personal Social Touch (2)	3.19	.829	**-.274****	1				
Social Touch Behavior (3)	2.53	.911	**-.394****	**.513****	1			
Face RT (4)	2.14	.547	**.070***	**-.160****	**-.093****	1		
Pareidolia RT (5)	1.62	.732	.049	**-.137****	**-.151***	-.**689****	1	
Scramble RT (6)	2.08	1.154	**.077***	**-.241****	**-.80****	**.659****	**.620**	1

M: mean, SD: standart deviation, RT: reaction time, *p<0.05, **p<0.01

Table 4. Multiple comparisons between reaction times and STQ factors

	SS	df	MS	f	*p*	η^2
Comparison of Reaction Time Means and Dislike of Social Touch Mean						
Face RT	15.449	38	.407	1.382	.065	.70
Pareidolia RT	29.881	38	.768	1.502	.028	.064
Scramble RT	84.518	38	2.224	.079	.005	.079
Comparison of Reaction Time Means and Liking of Personal Social Touch Mean						
Face RT	37.661	20	1.883	3.754	.000	.088
Pareidolia RT	12.638	20	.632	2.172	.002	.053
Scramble RT	40.262	20	2.013	1.513	.064	.038
Comparison of Reaction Time Means and Liking of Social Touch Behavior Mean						
Face RT	18.296	16	1.143	2.184	.005	.043
Pareidolia RT	7.068	16	.442	1.489	.097	.029
Scramble RT	25.504	16	1.594	1.201	.261	.024

RT: reaction time, SS: sum of the square, MS: mean of square, *p<0.05

Discussion

This study is the first to research a self-report test for measuring touch and vision perception and the relationship between visual perception and the touch experience of participants. The study demonstrates a negative correlation between face reaction time, liking of personal social touch factor, and social touch behavior. The more people dislike social touch, the longer they react to faces. To the best of our knowledge, the present study is the first study on the neuropsychological evaluation of touch and vision perception in the brain performed on a digital platform by now in Türkiye.

In the current study, we used STQ to examine attitudes towards the social touch. According to the dislike of social touch factor in STQ, the highest 'extremely' response given by participants was 'I feel disturbed if I have to have physical contact with a stranger person in public transportation' with 66%. In this context, Ceccato, Näsman, and Langefors conducted a study to assess patterns of sexual victimization in public transportations of a total

of 1122 college students in Sweden. The results revealed that 22.2% of participants experienced physical sexual harassment while using public transportation [13]. This kind of physical violation may be one of the reasons why our participants do not want to have physical contact with a stranger on public transportation. In addition, 61.6% of women stated that they have been exposed to this kind of violation at least once in the previous three years, while the ratings for men have affected aspects faces by only 26.6%. As a result, women, the majority of participants in the study, were found to be at higher risk with regard to the violation. Based on these findings, the reason why our participants avoid physical contact in public transportation can be explained in terms of gender differences [13]. Furthermore, strangers in public places like transportation can be a risk factor in terms of health. Harvey et al. [14] conducted a longitudinal study where 1815 people were observed in 12 different public areas, including a metro station, and RNA samples were taken from 348 surfaces to detect whether the COVID-19 virus was on those surfaces. 52% of these samples tested positive for COVID-19 at least once. These surfaces were touched 781 times with bare hands during observation. The study showed that touching surfaces with bare hands might be the secondary route for COVID-19 transmission. This may be a second reason for participants feeling uncomfortable being touched in public places like transportation during the COVID-19 pandemic. Moreover, 62% of our participants stated that they feel uncomfortable if a stranger hug them. Consistently, Suviletho et al. [15] conducted a cross-cultural study with a total of 1368 participants, in which 13 body regions were asked to be colored in order to determine which area can be touched by family, friends, acquaintances, and strangers. The touchability index was calculated based on the coloring measurement. Results have shown that emotional closeness explained the width of the touchable areas by 92%. Based on this finding, strangers were permitted to touch limited areas due to a lack of emotional closeness, which explains a reason why participants may be uncomfortable with the touch of strangers. Additionally, 33% of our participants stated that they avoid shaking hands with strangers. According to a cross-cultural study conducted on 2736 people in Türkiye, Iran, and Afghanistan in 2021, 80.1% of Turkish participants (1080) has stated that there was a tendency to avoid shaking hands during COVID-19 [16]. Health protection/ disease prevention might be an explanation for the lower percentage of handshaking avoidance in our study.

Furthermore, 35% of participants feel uncomfortable when a stranger keeps holding their hands after shaking them. This result is also consistent with Nagy et al. [17], cross-cultural study that examined 188 handshakes and found that a normal handshake lasted 3 seconds. According to Wundt, about 2.5 seconds is a duration that is needed for grouping complex stimuli. However, complex stimuli lasting longer than 2.5 seconds were perceived separately [18]. This duration is important for all modalities to perceive a group of stimuli. In visual perception, 3 seconds is duration to change the point of view when perceiving ambiguous visuals [19]. The participants have stated that they were uncomfortable because the longer-than-expected handshake violates temporal communication.

According to findings of the Liking Personal Social Touch Factor in STQ, the highest ‘extremely’ response given by participants was ‘I like touching animals’ with an average of 46%. Odendaal et al. [20] conducted a study to measure changes in blood levels before and after petting dogs and significant changes in dopamine, prolactin, oxytocin, and plasma b-endorphin were revealed [20]. This might be a reason that our participants liked petting animals. Another finding shows that 43% of our participants stated that they would like to get a professional massage if they had an opportunity. This finding is consistently supported by an fMRI study conducted by Lindgren et al. [21] which emphasized that the pregenual anterior cingulate cortex (pgACC) is activated after a massage. pgACC is the brain region including high amounts of opioid receptors serving as targets of opioids which are the substances used for pain relief with risk of addiction [22]. Our participants may have stated that they would like to get a professional massage for this reason. Surprisingly, the highest ‘not at all’ response given by participants was ‘I feel delighted if I give shoulder/neck massages to my friends when they are distressed’ with 31.4% in this factor.

According to findings of the Liking Social Touch Behavior Factor in STQ, the highest 'not at all' response was 'I am at ease making physical touch with strangers.' with an average of 37.9%. A study by Heslin et al. [23] investigated the meaning of touch from strangers or close friends of the opposite or same-sex in which 208 participants evaluated the touch of different body parts from strangers or close friends as pleasing or unpleasant. A touch from strangers of the same sex was found to be unpleasant for all participants. On the other hand, while women found touching strangers of the opposite sex uncomfortable, men found it pleasant. In our study, the majority of the participants were women (68.3%). However, a detailed investigation of this gender difference will contribute to the literature in future studies. The second highest 'not at all' response given by participants was 'I describe myself as someone who loves touching while communicating' with an average of 35.5%. In 2015, the Comfort with Interpersonal Touch scale was developed to measure individual differences that affect tactile communication. During the reliability and validity study of this scale, it was found that age, gender, and personality had an effect on touching while communicating. As a result, women were more comfortable touching while communicating compared to men, and older participants were more comfortable touching while communicating compared to young participants [24]. Additionally, culture plays a significant role in terms of attitudes towards touch. Sidney Jourard conducted an observational pilot study to reveal how culture influences the frequency of touching. In the study, couples were observed in coffee shops in four different locations in London (England), Paris (France), San Juan (Puerto Rico), and Gainesville (USA). Results showed that couples in London touched each other 0 times, couples in Gainesville touched each other 2 times, couples in Paris touched each other 120, and those in San Juan touched each other 180 times in an hour [25]. For the repetition of this study, the difference between rural and urban areas in the USA was examined where 52 people were observed to measure the frequency of touching during communication. The frequency of touching in the countryside was 43 while it was 19 in the city. Hence, touching while communicating may even vary according to the place of residency [26]. It is beyond the scope of this study to analyze demographic variables such as age, gender, personality traits, and culture.

To examine visual perception, we used the pareidolia test. According to reaction times given to stimuli, we found that the fastest response was given to the face among other stimuli. Consistent with these findings, Akdeniz has found that the face stimulus elicited an earlier N170 response than face pareidolias in EEG [7]. Our findings show that the participants gave a reaction to pareidolia stimulus on average of 1610 ms. However, Guillon et al. [27] found that the average reaction time given to upright pareidolia stimuli in typically developing children was 1303 ms. This delay may be due to the digital presentation of the stimuli in our study. Our results revealed that as the liking of social touch increased, the reaction time to face and pareidolia decreased. In a study by Della Longa et al. [4], two experimental conditions were applied to 40 infants. In both experimental conditions, infants were shown videos of two different unfamiliar female faces. The first video was given with tactile stimulation whereas the second one was given without tactile stimulation, and cardiac responses of the infants were measured during these experimental conditions. The two experimental conditions were separated according to the type of touch given in the first video. The tactile stimulus in the first experimental condition involved social touch by gently stroking the infants' heads by the researcher, while the tactile stimulus in the second experimental condition involved tapping the infants' heads with a brush. Afterward, infants were shown women's faces that were used in experimental conditions to assess their visual choice. As a result, infants looked longer at the faces shown with social touch and they elicit lower cardiac responses. Thus, it has been shown how social touch perception can affect visual perception in infants [4]. The present study used a different paradigm to investigate how adults' perceptions of social touch affect visual perception, and it demonstrates comparable findings. Similarly, Nava et al. [28], conducted a study that includes both adults and infants and investigates whether the social aspect of visual and tactile cues modulates the physiological response. A video clip of an unfamiliar woman as a social cue and a house that resembles a human face (pareidolia) as a non-social cue was shown to all participants. Tactile stimuli

were presented as social and non-social touch by researchers during the presentation of visual stimuli. Electrodermological responses of participants were also measured via using electrodes to measure responses given to tactile stimuli. The results revealed that electrodermal responses of infants decreased in terms of a socially meaningful visual stimulus combined with a social touch that can generate calming responses. On the other hand, adults showed a greater electrodermal response to social touch for every visual stimulus compared to the non-social touch condition. These results indicate a difference between infants and adults in terms of the effect of social touch on visual perception. Moreover, infants' behavioral responses were always strongly directed towards the face, regardless of the type of touch received. This study suggests that visual and social touch perception affects each other on a physiological level, not on a behavioral level. However, the reaction time measured in our study shows that this effect is also reflected in the behavior of adults. We have established that the more people dislike social touch, the longer they react to faces in the social brain.

We draw the conclusion that our new neuropsychological paradigm is a beneficial test to enlighten the relationship between social touch and visual perception. We hypothesize that our findings obtained from participants rely on the relation between the brain networks, which are activated with Social Brain Network and Dorsal (DAN) and Ventral Attention Networks (VAN) [29]. Social Brain Network includes temporoparietal junction, superior temporal sulcus, medial prefrontal cortex (mPFC), and anterior cingulate cortex (ACC). While the VAN includes temporoparietal junction (TPJ) and the ventral frontal cortex, the DAN has intraparietal sulcus (IPS) and the frontal eye fields (FEF) [30, 31]. It is possible that these brain networks can be integrated with the interaction of social touch and visual perception.

Here we have developed a self-report test for measuring touch and vision perception and the relationship between visual perception and the touch experience of participants was evaluated with this newly developed test. Specifically, our results are consistent with a causal role of touch perception in the emergence of visual perception and suggest that the amelioration of touch perception will result in the relief of fundamentally misunderstanding visual perception. Because there remains a lack of evidence for the use of medical imaging modalities, such studies are still needed. Further research on multiple perceptions will almost certainly improve our understanding of complex social cues and perceptions.

Conflict of interest: No conflict of interest was declared by the authors.

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Authors' contributions to the article

G.A constructed the main idea and hypothesis of the study. O.D.D and A.C.F developed the theory and arranged/edited the material and method section. G.Y has done the evaluation of the data in the results section. Discussion section of the article was written by T.K.Y.

P.O reviewed, corrected and approved. In addition, all authors discussed the entire study and approved the final version.