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Touching at a distance: the elaboration of communicative functions from the perspective of the interactants

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9 **remote communication.**

10 Abstract

11 Touch is an inherent part of human social interactions and the diversity of its functions has been
12 highlighted in numerous works. Given the varied roles of touch, with technology-mediated
13 communication being a big part of our everyday lives, research has been interested in enabling and
14 enhancing distant social interactions with mediated touch over networks. Due to the complexity of
15 the sense of touch and technological limitations, multimodal devices have been developed and
16 investigated. In this article, we explore the use of mediated visual touch in distant social interaction.
17 Adopting an interactionist and collaborative approach to human communication, we focus on the
18 communicative functions of distant touch behaviours which interactants co-elaborate throughout their
19 mediated interactions. For this purpose, we conducted an exploratory study placing five romantically
20 involved couples in interaction, where each discussed shared biographical events via a video call,
21 using mediated touch devices (producing tactile cues and coloured lights). Their interactions were
22 recorded, and excerpts were presented to participants in interviews using a collective confrontation
23 technique (participants are confronted with a recording of their activity and encouraged to comment
24 on it). This technique allows a better understanding of the participants' points of view on their use of
25 the touch devices in context. Through analysis of the interviews, our results highlight: (1) a variety of
26 visual-touch functions with a redistribution of functions mostly supported by other modalities of
27 communication in face-to-face interactions, such as illustrating aspects of the ongoing conversation;
28 (2) the visual-touch characteristics as well as the verbal, paraverbal and non-verbal indicators of the
29 interactional context considered by the participants to make sense of the stimuli and; (3) the
30 multifactorial and dynamic aspects of the co-elaboration process of the visual-touch functions,
31 reaffirming the role of interactional context, combined with cultural and biographical knowledge, in
32 the meaning making.

33 1 Introduction

34 Social touch – touch behaviours occurring within social interactions, such as handshaking, hugging,
35 kissing on the cheeks, patting the shoulder, etc. – supports a wide range of functions in human social
36 life, and it is through the context of interaction that interactants can determine the meaning of a touch
37 (e.g., van Erp and Toet, 2015; Jones & Yarbrough, 1985).

38 Given the diverse roles of touch in our social interactions, especially with regard to affective
39 communication, interest in its integration into technology-mediated interactions is growing (van Erp
40 & Toet, 2015), not least because of globalisation that leads to more individuals living distant in
41 space, separated from family and friends (Janta, Cohen & Williams, 2015; Ryan, Klekowski Von
42 Koppenfels, & Mulholland, 2015). Most studies focus on the emotional meaning of mediated touch
43 in restricted experimental settings, where subjects are asked to judge the emotions expressed by
44 discrete touching events, reporting greater feelings of connectedness, as well as the communication
45 of several affects with various mediated touch devices (e.g., Bailenson et al., 2007; Rantala et al.,
46 2013; Tsalamlal et al., 2013). In order to enhance mediated communication and overcome the
47 limitations of current technology, multimodal devices have been investigated. For instance,
48 researchers in pseudo-haptics are able to simulate social touch and elicit a feeling of presence by
49 combining visual and auditory cues (Desnoyer-Steward, 2023). Regarding the integration of
50 additional modalities to mediated touch devices, research on visuo-tactile stimuli (combining visual
51 and tactile cues through the means of a technological device, referred to as “visual-touch” in the rest
52 of the article) has shown enhanced emotional communication in laboratory situations (Wilson and
53 Brewster, 2017; Zhang et al., 2019). Exploring mediated touch in more complex interactional
54 settings, a few studies of mediated touch have allowed for the observation of functions of touch in
55 social interaction, such as *turn-taking* – e.g., to help change who has the floor – and co-verbal touch
56 functions such as *emphasis* – the interactants use touch devices to emphasise certain words or
57 utterances (Chang et al., 2002), as well as the construction of idiosyncratic meanings over time (Park
58 et al., 2013). These studies allow for the observation of some mediated touch functions, though their
59 methodological frameworks lack a clear theoretical background to address the understanding of
60 mediated touch in interaction, especially the role played by the verbal interaction in the interactants’
61 co-elaboration of the touch functions.

62 Our research aims to go further, combining the use of a multimodal device and a naturalistic
63 interactional context. We explore visual-touch and how its functions are co-elaborated in interaction.
64 The originality of our exploratory study of visual touch is to adopt a collaborative model of human
65 interaction, according to which meaning emerges from social interaction. This can be distinguished
66 from the classic encoding-decoding model more widely followed in HCI (e.g., Bailenson et al., 2007;
67 Rantala et al., 2013; Wilson & Brewster, 2017) that posits a univocal relation between the form of
68 touch (e.g., a stroke with a certain intensity) and its function (e.g., communicating a specific
69 emotion).

70 Our results highlight: (1) twelve functions of mediated touch falling into three main dimensions of
71 interactions, with a redistribution of functions across the modalities of communication in distant
72 mediated interactions – for instance, we observed an illustration function (interactants using the
73 device to illustrate physical, emotional or conceptual aspects of their stories) mostly supported by co-
74 speech gestures in face-to-face interaction; (2) several indicators drawn from visual-touch
75 characteristics and the context of the interaction to make sense of the stimuli; (3) the co-elaboration
76 process relying on these indicators, reaffirming the role of interactional context, combined with
77 cultural and biographical knowledge, in meaning making.

78 **2 Related Work**

79 **2.1 The functions of social touch in face-to-face interactions**

80 Social touch plays an important role in the communication of emotions in daily life. Jones and
81 Yarbrough (1985) highlighted Positive Affect touches, including the communication of affection and

82 support, which has been studied extensively. For instance, Hertenstein *et al.* (2006; 2009)
83 investigated the communication of affects through touch, using pairs of participants. Their results
84 indicate that it is possible to communicate distinct emotions through touch, including for instance
85 anger, sadness, disgust, love, and sympathy. Besides the mere communication of affects, touch helps
86 to maintain and negotiate social relationships. In social interactions, touch facilitates mutual
87 understanding as interactants can emphasise certain elements of the verbal modality (words,
88 sentences) or modulate the tone or mood of the interaction by introducing a playful dimension (e.g.,
89 Jones & Yarbrough, 1985, Knapp, 1978).

90 In general, social touch shows multiple beneficial effects on health and well-being. Several studies
91 report that physical contact (e.g. holding hands, hugging) with a close relative helps reducing pain,
92 stress and blood pressure (Ditzen *et al.*, 2007; Grewen *et al.*, 2003; Master *et al.*, 2009); touching
93 with non-relatives also has beneficial effects on heart rate, stress levels and inflammation (Henricson
94 *et al.*, 2008; Thomas & Kim, 2021; Whitcher & Fisher, 1979). Therefore, the lack of touch may be
95 detrimental to human health (Floyd, 2014). However, touch behaviours have decreased in recent
96 years, especially with the Covid-19 pandemic (Field *et al.*, 2020), leading to challenges for
97 establishing new touch practices (Zhang *et al.*, 2021). In that regard, mediated social touch can be
98 seen as a way to overcome the lack of actual social touch, raising the questions of how to design
99 social touch devices and for what purpose, as discussed by Jewitt *et al.* (2021).

100 **2.2 Mediated social (visual-)touch communication**

101 Aiming to enhance computer-mediated communication with regards to affective aspects, research has
102 investigated ways to convey touch at a distance. It appears that mediated social touch can also have a
103 positive effect on health and well-being. When confronted with a sad emotion, mediated social touch
104 in the form of warmth and vibration can help to mitigate participants' sadness responses by reducing
105 heart rate (Cabibihan *et al.*, 2012). Furthermore, it has been shown that mediated social touch can
106 also reduce the level of the stress hormone cortisol (Sumioka *et al.*, 2013). As in the case of actual
107 social touch, mediated social touch research also largely focuses on the communication of affect –
108 showing a variety of discrete emotions or variations in valence (i.e., emotional pleasure) and arousal
109 (i.e., physiological arousal associated with emotion) scales (Bailenson *et al.*, 2007; Rantala *et al.*,
110 2013; Tsalamlal *et al.*, 2013; Wilson & Brewster, 2017) – and increased feelings of connectedness
111 (Giannopoulos *et al.*, 2008; Nakanishi *et al.*, 2014; Sallnäs, 2010) allowed by touch in remote
112 situations.

113 The expressiveness of social touch devices is limited due to cost and technology, and mediated touch
114 stimuli can be difficult to discriminate from one another (Zhang *et al.* 2019). In that regard,
115 researchers have explored the use of multimodal signals for enhanced affective communication. In
116 virtual reality research, for example, pseudo-haptic (a technique to simulate tactile sensation in
117 virtual environments through other modalities) notably uses the tactile-visual interaction by
118 combining the sensorimotor actions of the user with visual feedback (Lécuyer, 2009). Recent work
119 suggests that it is possible to use a combination of visual and auditory cues to simulate social touch
120 between interactants in a virtual environment and elicit a feeling of presence (Desnoyer-Steward,
121 2023). Vision appears to have a strong cross-modal interaction with touch (Gallace & Spence, 2010)
122 and several studies highlight increased haptic spatial perception and tactile acuity with co-occurrent
123 visual cues (Eads, Lorimer Moseley, & Hiller, 2015; Newport, Rabb & Jackson, 2002). Both the
124 perception speed and accuracy of touch are improved with additional visual cues, and spatially
125 congruent visual cues can affect tactile perception (Mancini *et al.*, 2010).

126 Researchers such as Wilson and Brewster (2017), as well as Zhang and colleagues (2019), studied
127 the integration of colours into touch devices, since this has been shown to influence affective
128 communication (Valdez & Mehrabian, 1994; Suk & Irtel, 2008; Wilms & Oberfeld, 2018) and touch
129 perception (Simner & Ludwig, 2012). Their results suggest broadened possibilities in affective
130 communication when using multimodal devices combining tactile cues through vibrations, visual
131 cues using colours (Wilson & Brewster, 2017) and congruent visual patterns (Zhang et al., 2019).

132 **2.3 Context matters, social interaction even more**

133 Most mediated touch studies have been conducted under strict experimental conditions, without
134 actual interaction between the person touching and the person being touched, with the objective of
135 correlating specific forms to specific meanings. For instance, Wilson and Brewster (2017) presented
136 their stimuli and asked the participants to adjust cursors on a computer screen for two scales
137 (emotional arousal and valence), without human-human interaction. However, researchers have long
138 pointed out the limits of considering only the tactile features of social touch (Jones & Yarbrough,
139 1985; van Erp & Toet, 2015).

140 Aiming for a finer understanding of the construction of the meaning of affects conveyed through
141 mediated touch, some researchers integrated contextual cues in their experimental protocols to
142 investigate how they could alter the meanings of touch behaviours. Results suggest that textual and
143 facial cues can modulate the perceived emotion of mediated touch behaviours (Ipakchian Askari,
144 Haans, Bos, et al., 2020; Teyssier et al., 2020). Price *et al.* (2022) highlighted the crucial role of
145 context for the elaboration of meaning. In two experimental studies, they showed that mediated social
146 touch using pressure and temperature can convey a myriad of emotions between people who have
147 close relationships (e.g., partners, friends), depending on the sensorial characteristics of touch, and on
148 its context of occurrence (e.g., the relationship of the interactants, textual context), which helps to
149 “negotiate the ambiguity”. The importance of the context surrounding both interactants is also
150 reaffirmed by the Remote Social Touch framework proposed by Alsamarei and Bahar Şener (2023).
151 Investigating touch in everyday life between couples, Sailer and colleagues (2024) underline “the
152 complexity of interpersonal touch in everyday life”. Their results indicate that the interaction partner,
153 situational characteristics and needs fulfilment, such as relatedness, are better determinants of the
154 valence of a touch experience, in comparison with its physical characteristics.

155 Most of the studies of mediated touch in interaction consist of a controlled environment where
156 researchers identify the effect of one or more factors on a small number of dependent variables (e.g.,
157 feelings of presence, helping behaviour, task success) (e.g., Haans & IJsselsteijn, 2009; Nakanishi et
158 al., 2014). However, a small number of studies explore mediated touch in social interactions under
159 certain tasks or conditions (e.g., making a list of objects dedicated to survival, communicating
160 exclusively by audio and touch, minimising the use of speech), thus paving the way to identifying
161 potential functions of mediated social touch in interaction.

162 Chang *et al.* (2002), used the ComTouch device (connected smartphones allowing the transmission
163 and reception of vibrations) and audio communication, following an experimental protocol. Their
164 study highlighted four categories of mediated touch functions: *emphasis* (highlighting certain points
165 in the message); *turn taking* (to make the exchange more fluid); *mimicry* (a game of imitation with
166 vibration patterns); and *coding*. The latter is particularly used when speech is limited, where creating
167 a code allows speakers to exchange “yes/no” responses or to count. The work of Park *et al.* (2013)
168 with the POKE system (a phone with an area that swells in response to pressure on the remotely
169 connected phone) through a longitudinal study with three couples in a long-distance relationship,

170 showed the emergence of a shared code (e.g., “I love you” represented by two very weak touches;
171 “it’s annoying” represented by six strong and fast touches) amongst couples.

172 These studies give an insight into functions of mediated touch and their elaboration throughout social
173 interaction. Our aim is to go further, hence our need for a clear theoretical and methodological
174 framework to comprehend how social visual touch functions are co-elaborated in interaction.

175 **2.4 An interactive-collaborative approach to the study of mediated touch in interaction**

176 As suggested by the manifesto of Jewitt *et al.* (2021), in order to design touch we believe that it is
177 necessary to understand mediated social touch throughout the course of an interaction. Therefore, in
178 line with Huisman's (2022) perspective, our position is that the analysis of social interactions is better
179 suited to explaining social touch interactions and “how we understand each other in day to-day
180 interactions” (*ibid.*, p.3). In a verbal interaction, speaker and addressee co-construct the interaction
181 itself; even while listening, interactants actively regulate the interaction through numerous
182 behaviours signalling their degree of attention and (lack of) understanding (Kerbrat-Orecchioni,
183 1996). We see inter-action as a series of interdependent actions, verbal or not, which mutually
184 influence each other, involving two or more interactants (Baker, 2004; Olry-Louis, 2011) or as
185 Goffman stated, interaction “may be roughly defined as the reciprocal influence of individuals upon
186 one another’s actions when in one another’s immediate physical presence [in our case,
187 telepresence].” (Goffman, 1959, p.15).

188 According to a collaborative theory of human communication, the function of touch is contextual in
189 an extended sense, taking into account the dynamic evolution of the interaction context. Whereas this
190 paradigm has been extensively used to understand the communicative functions of various modalities
191 of communication (e.g., verbal, gestural) it has not been mobilised to understand the functions of the
192 tactile modality.

193 The co-elaboration of the functions of touch can be understood in terms of the processes of: (1)
194 interactive alignment (Garrod & Pickering, 2009) – automatic alignment of para-verbal behaviour in
195 the interaction (e.g., alignment of posture or speech rate) – and (2) grounding (Clark & Brennan,
196 1991; Clark & Schaefer, 1989) – the interactive process by which interactants exchange evidence
197 about what they do (not) understand over the course of a conversation, as they accrue common
198 ground by a collaborative effort. In these theoretical frameworks, the co-elaboration of the
199 associations between forms and meanings is observed at the micro level with *ad hoc* constructions,
200 and not only with associations that are stable in time, observed at the macro level. For instance, when
201 two persons are having a conversation about a child and the first interactant utters “He’s still healthy”
202 followed by the second interactant who utters “He’s still walking around”, both forms (healthy and
203 still walking) are locally associated with the same meaning (Brône & Zima, 2014).

204 Vion (1992) proposes to categorise the different functions of verbal interactions through three main
205 dimensions: *interaction management*, *meaning making* and *relationship building*. In the following
206 paragraphs, we briefly review verbal, para-verbal and non-verbal functions according to these
207 dimensions.

208 *Interaction management* – through the verbal modality, interactants can give feedback, structure the
209 interaction or manage turns with dialogue control acts (Bunt, 1994) or turn-taking acts (Traum &
210 Hinkelman, 1992). Non-verbal and paraverbal behaviours also helps, as in the initiation and closing
211 of the interaction (Floyd et al., 2000; Kendon, 1990; Knapp et al., 1973), turn management (Duncan,
212 1972; Knapp, 1978) or speech segmentation (Burgoon et al., 2016; Quek et al., 2002) with gaze, hand
213 gesture, or prosody.

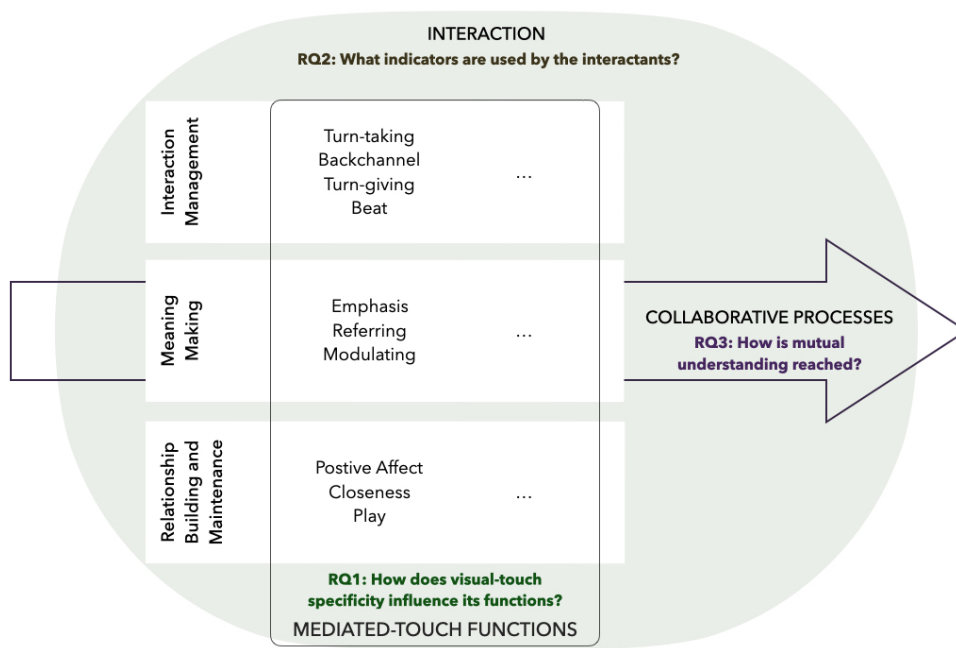
214 *Meaning making* – by their verbal behaviour such as informative acts (e.g., question, inform,
215 correction) (Bunt,1994), grounding (e.g., repairs, continuers, acknowledgments) and core speech acts
216 (e.g., inform, suggest) (Traum & Hinkelman, 1992), interactants co-elaborate the meanings of their
217 interventions. Through prosody, the interactants can make more precise or modulate meanings,
218 notably in the case of humour or irony (Attardo et al., 2003; Bryant & Fox Tree, 2005), and add
219 emphasis to the verbal content (Chieffi & Ricci, 2005; Quek et al., 2002). Iconic gestures – forms
220 related to meanings – can also accompany speech (Hadar & Butterworth, 1997; McNeill, 1992).
221 *Relationship building* – paraverbal and nonverbal behaviours such as emotional communication
222 (Buck et al., 1992) with facial expressions (Ekman et al., 1972), prosodic and paraverbal cues (Banse
223 & Scherer, 1996) or touch (Hertenstein et al., 2006) play an important role in the co-construction of
224 relationships through the course of their interactions.

225 As for verbal interactions, we posit that mediated (visual-)touch functions are co-elaborated in action
226 by the interactants taking context into account (un)consciously. They can be analysed through the
227 three aforementioned dimensions.

228 Our study aims at understanding *how the functions of visual-touch emerge in interaction*. For that
229 purpose, we address three research questions:

- 230 - RQ1: How does the specificity of visual-touches influence the elaboration of their functions?
- 231 - RQ2: What are the indicators used by interactants to elaborate the functions of their visual-
232 touches?
- 233 - RQ3: How do interactants reach mutual understanding of visual-touches in interaction?

234 In brief, the frameworks described above scaffold our work as follows (cf. Figure 1). The dimensions
235 of interaction functions (Vion, 1992) and previously highlighted functions (Héron et al., 2022;
236 presented in section 3.5) will enable us to understand how the characteristics of VisualTouch influence
237 its use (RQ1). The understanding of the interaction as a series of interdependent multimodal actions
238 (Kerbrat-Orecchioni, 1996; Baker, 2004) will guide our identification of the indicators used to
239 elaborate the functions of visual-touch (RQ2). Finally, theories of human communication (Garrod &
240 Pickering, 2009; Clark & Brennan, 1991), positing that meaning is co-elaborated through interactive
241 and collaborative processes, will frame our approach to the mutual understanding of visual-touch
242 functions (RQ3).



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Figure 1 – Frameworks and Research Question integration

note: The figure illustrates the framework we use to address each research question. The large round shape represents a social interaction, within which are presented the dimensions of functions (Vion, 1992) with the associated functions of mediated-touch (highlighted by Héron et al., 2022) as well as empty spaces for possible specific functions of visual-touch (or alternative mediated-touch devices). An arrow runs through the interaction to depict the dynamic and collaborative processes taking place within the interaction. The research questions (RQ) are associated with the different frameworks.

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3 Method

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3.1 A mediated-touch device: VisualTouch

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The device we used in our research is based on multimodality (tactile and colour stimuli) which has been previously acknowledged as being able to communicate emotion combined in mediated touch devices (see section 2.2.) (Huisman & Darriba Frederiks, 2013; Wilson & Brewster, 2017). A first prototype of this device (combining vibration and coloured visual patterns) has previously demonstrated its possibilities for affective communication in a laboratory experiment (Zhang et al., 2019).

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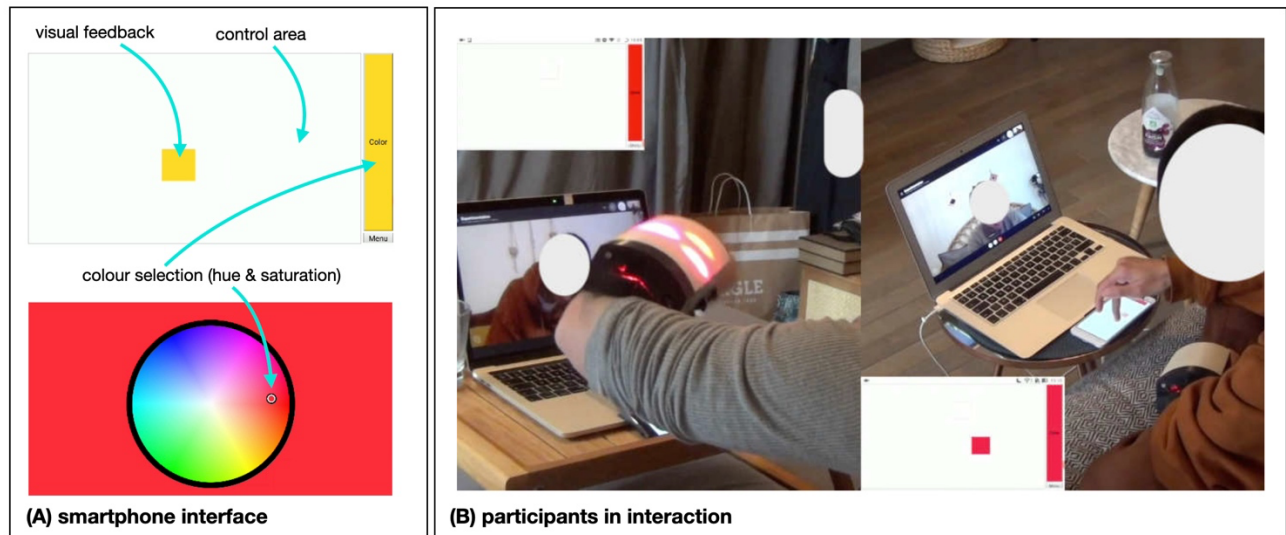
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The current prototypes used in this study were slightly revised in order to work wirelessly in interactional contexts. They comprise two superimposed layers: 60 multicoloured LEDs and 10 servomotors each moving a small rod (1 servomotor for 6 LEDs, instead of the 60 vibration actuators in the original design which were leading to lags over time). The idea behind this two-layered device is for the visual cues to alleviate the ambiguity of the tactile stimuli alone. Thus, every stimulus received combines visual and tactile sensations congruently mapped on the forearm (participants wore the device on the arm of their choice). The competition between neural representations and the recruitment of attentional resources results in a visual dominance effect (Hartcher-O'Brien et al., 2008), so that users generally do not perceive small conflicts between visual and tactile cues (Ramachandran & Rogers-Ramachandran, 1996). The two layers and all the circuitry are integrated into a 3D-printed case, and the LEDs are covered by a translucent screen. Each device has a Wi-Fi antenna and a battery, enabling it to operate completely independently. The devices are automatically connected to a Wi-Fi router, to which the smartphones used to control them are also connected.

271 The devices are controlled by a web application (accessible via smartphone) that allows the users to
272 select the colour and draw visual-touches on a white interface. In order to select a colour, the
273 participant has to first touch the coloured zone on the right of the screen, then choose the colour in a
274 circular colour picker. The hue and saturation can be adjusted in this way. The selection is confirmed
275 with a dot appearing where the selection was registered and the background changing colour before
276 going back to the interaction screen. Visual feedback on the screen confirms to the user which areas
277 have been touched and with what colour. (Figure 2)



278 **Figure 2 - VisualTouch Device; a) interface, b) interaction picture**
279 note: Panel A shows the interface presented on the smartphone through which the participants can create/send visual-
280 touch stimuli. Panel B shows an excerpt of the interaction of a couple. On the left, the visual effect on the forearm of the
281 interactant is produced by the use of the smartphone of the interactant on the right (due to a decay effect on the visual and
282 short transmission delay, three red dots can be seen on the screen while there is only one on the smartphone). For a better
283 understanding, short video excerpts are available online.
284

285 3.2 Participants

286 We recruited cohabiting couples given that people in close relationships use touch more in day-to-
287 day life (Heslin & Boss, 1980; Smith & MacLean, 2007) and are able to co-elaborate a common
288 understanding of mediated touch (Brown et al., 2009, Park et al., 2013; Price et al., 2022). This
289 allowed us to observe many touch behaviours covering a wide range of functions.

290 Participants were recruited through word of mouth, amongst friends and friends of colleagues. The
291 final sample was composed of five cohabiting couples. None of the participants were colourblind.
292 They neither had previously used visual-touch or mediated touch devices, and they had no
293 knowledge of mediated touch technologies. (see Table 1).

294 With a small-sized sample, we were able to deploy a complex protocol in order to frame close-to-
295 natural remote interactions and obtain participants' in-depth perspectives on their use of visual-touch
296 in interaction.

297

298 **Table 1 – Couples of participants**
 299 note: each line reports information related to the couples (C1 to C5) involved in our study, with from
 300 left to right, the couple code, the age, gender and profession of each partner, the total duration of their
 301 interaction, the duration of the interview.

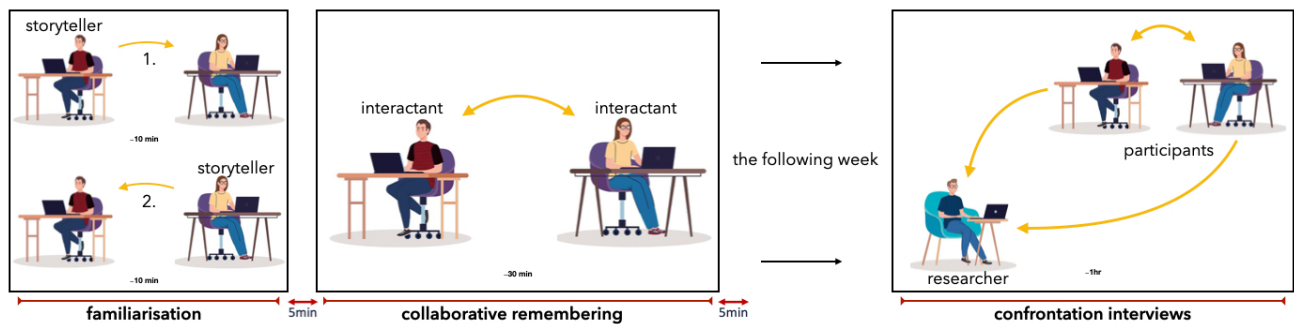
Couple	Participant A			Participant B			Interaction duration	Interviews duration
C1	32 yrs	F	Production assistant	30 yrs	F	Actress	35min	1h21min
C2	28 yrs	F	Designer	30 yrs	M	Engineer	30min	1h12min
C3	28 yrs	F	Unemployed (training in real estate)	28 yrs	M	Business Consultant	21min	1h09min
C4	37 yrs	M	School teacher	30 yrs	M	Dancer	24min	1h04min
C5	29 yrs	F	Speech therapist	30 yrs	M	e-commerce manager	22min	43min

302

303 3.3 An interactionist protocol in participants' homes

304 Drawing from our interactionist theoretical framework, we developed a methodological framework to
 305 analyse touch in coherent and close to naturalistic social interactions.

306 The protocol consisted of three phases: familiarisation, collaborative remembering, and, in the
 307 following week, a collective confrontation interview – a technique for analysing human activity.
 308 Participants are presented with a video-recording of their activity and encouraged to comment on it
 309 (see Figure 3). Between and after the first two phases, participants were given five-minute breaks
 310 during which they were able to discuss their use of the device. The first two phases took place at the
 311 participants' home. The interviews were conducted remotely via video call.



312

313 **Figure 3 - protocol phases¹**

314 note: each panel represents a phase of the protocol. In the familiarisation phase, participants alternately talk
 315 about their story while the non-talking participant can respond through touch. During the collaborative
 316 remembering phase, participants can talk freely as they discuss their memories. There are five-minute breaks
 317 between the phases (after the familiarisation and after the collaborative remembering) for the participants to talk
 318 about their first experience of the device. Participants are interviewed during the following week. Both

¹ The images used in the figure are from Studiogstock and are free of royalties.

319 participants discuss with each other and answer to the researcher's question, the video recording of their
320 interaction being used as a support for remembrance.

321 The participants were both equipped with the VisualTouch device (which they were asked to wear on
322 their forearm), a laptop and a smartphone to control the touch device. Participant A's phone was
323 paired to Participant B's touch device and vice-versa.

324 Before the familiarisation phase, the participants were invited to explore the device on themselves
325 (controlling the device they wore) for around 5 minutes, so they could grasp how their use of the
326 smartphone app affected the perceived stimuli. Then, during their interaction, participants used the
327 device in a variety of way by "drawing" different patterns on the smartphone's screen, playing with
328 rhythm, changing colour, and supporting a variety of functions (cf. video excerpts online; presented
329 in more detail in section 4.)

330 **3.3.1 Familiarisation phase**

331 The participants were asked to take turns telling their life stories, focusing on highlights and
332 positive/negative events. Each participant had a maximum of ten minutes to do so. The listener's
333 microphone was switched off. Listeners were encouraged to react to the speaker's story using the
334 available modalities (webcam and touch device). The purpose of this phase was for the participants to
335 discover the device, to feel more comfortable with being filmed and to explore the use of mediated
336 touch in context.

337 **3.3.2 Collaborative Remembering phase**

338 Collaborative remembering activities occur in everyday life, when people relive shared memories
339 (Maswood et al., 2019), hence our choice of this task. Furthermore, the task encourages the
340 embodiment of memories – with the involvement of co-verbal gestures, glances, etc. – and the
341 expression and regulation of memories. In this phase, the participants are lead to express and regulate
342 their emotions (Alea & Bluck, 2003; Bietti et al., 2016; Bietti & Galiana Castelló, 2013; Kendon,
343 1986), which we believed would also encourage the use of social touch.

344 Prior to the day of the observation, participants were informed that they would talk about events they
345 had experienced together based on related artefacts (e.g., a concert ticket, a museum ticket, a
346 photograph, a book, a coffee cup). On the day of the observation, participants alternately presented
347 their artefacts and related memories, and then continued to talk around and about these shared events.
348 Even though the protocol is structured, the interaction of the participants in this phase was mostly
349 free. Once the proceedings of this phase were clearly understood, participants discussed the different
350 artefacts until they had nothing to add or wished to skip to the next one autonomously (without the
351 researcher asking them to). Furthermore, they often discussed other subjects not related to the
352 artefact, and were not forbidden to do so. The primary objective of this task is to be able to observe
353 conversations that are natural and rooted in the participants' lives, hence at no time does the
354 researcher intervene (even if the participants discuss events not directly related to the artefacts)
355 except when directly questioned. During this phase, participants could communicate through all
356 modalities (i.e., oral, visual, tactile).

357 **3.3.3 Confrontation interviews: the functions of touch and their co-elaboration**

358 In the following week, participants were interviewed on the basis of the video recordings of their
359 interactions. The time gap between the interaction and the interview was the result of the time needed
360 to prepare the video and of the availability of the participants. The principle of self-confrontation
361 interviews is to question the participants with respect to traces of their actions (video and audio

362 conversation excerpts) in order to access their points of view on what they are doing and assess
363 underlying cognitive processes (Mollo & Falzon, 2004; Theureau, 2010). This type of interview has
364 been largely used in the fields of psychology and cognitive ergonomics and in various settings
365 (Cahour et al., 2016). In dynamic and multimodal settings, such as social interactions in our case, the
366 video recording helps mediate remembering as a memory primer (Cahour, Licoppe, & Créno, 2018).
367 In order to better grasp the way visual-touch functions are co-elaborated by the participants, we
368 conducted collective confrontation interviews allowing for exchanges within the couples about what
369 was understood and how. Fostering discussion between participants on their interaction, we were
370 able to focus the interviews on the indicators enabling the participants to elaborate these functions in
371 interaction.

372 Each couple was first asked to recall moments they found particularly salient with regard to their use
373 of the VisualTouch device (moments where they thought they mutually understood their use of the
374 device particularly well or on the contrary when they thought it did not work), then we displayed the
375 excerpts mentioned by the participants. For each excerpt, we invited the participants to take time to
376 relive their interaction and describe what was happening. We then used prompts to obtain more
377 details about each of the touches, and the communicative functions they associated with them at the
378 time, and why. Participants were free to rewatch any moments at any time during the interview.

379 **3.4 Data recording**

380 The participants' computers were connected via a videocall software. The researcher (first author)
381 was also connected to the call, in order to record the audio channel. During the interaction, the
382 participants were filmed by two cameras (one for each participant). The cameras captured both the
383 computer screen, the touch device, and the smartphone. The smartphones screens were also recorded.
384 The views of the two cameras, the audio of the video call and the screens of the two smartphones
385 were then merged into a single audio-video file, for each couple, to be analysed and presented in
386 interviews.

387 **3.5 Pre-testing the protocol**

388 We conducted a pilot-study with three couples to test our methodological framework in which we
389 demonstrated that it enables the observation of a variety of mediated touch behaviours (Héron et al.,
390 2022). We highlighted 12 functions supported by mediated touch.

391 Drawing on the dimensions of social interactions proposed by Vion (1992): *interaction management*,
392 *meaning making* and *relationship building* (see section 2.4), our categorisation and functions
393 descriptions are presented in Table 2. The function previously called “doodle” is considered outside
394 of our categorisation in the research described here, as a particular form of touch related to self-touch
395 that we call adaptors (Lefebvre, 2008).

396

397 **Table 2 – Mediated Social Touch functions in distant communication**
 398 note: the table presents the categories of interactions functions proposed by Vion (1992) with which
 399 the functions of mediated touch observed by Heron et al. (2022) have been matched. The last column
 400 described each function. Adaptors is a term proposed by Lefebvre (2008), corresponds to Doodle-like
 401 touches and seats outside the presented dimensions.

Dimensions of functions (Vion, 1992)	Functions of mediated touch (Heron, 2022)	Descriptions of the functions
Interaction management	Turn-taking	The addressee touches to take the turn.
	Backchannel (Continuer)	The addressee gives indications to the speaker of their attention
	Turn-giving	The speaker indicates that their turn is over with a touch. The speaker produces rhythmic tactile behaviours related to the prosodic structure of the speech, which do not convey any semantic information.
	Beat	
Meaning Making	Emphasis	Speakers tend to emphasise certain words or phrases (mostly strong emotional content) with co-occurring touch behaviours. Speakers touch when determining the object of their interaction sequence. These touches co-occur with deictic word (e.g., “that”, “the one on the right”) and gestures (e.g., pointing, turning the head), or with implicit content (e.g., participants omitting the end of a story, alluding) and its mutual understanding (e.g., “okay!”, “ah!”).
	Referring (Understanding)	
	Modulating (Playful interaction & Treading Carefully)	The speaker touches to modulate their speech so that their partner understands it to be playful, ironic or apologetic for instance.
Relationship maintenance	Positive Affect	Interactants communicate positive affects such as love, tenderness, support.
	Closeness	Interactants use the device to maintain a sense of closeness between them. Touching is often explained as mimed caressing.
	Play (Mimicry)	The interactants play with the device. This can be a question-and-answer game with the device, or to repeat the partner’s touch.
Adaptors (Doodle)		The interactant uses the device as they would manipulate a pen or a rubber band or scratch themselves for example, mainly while listening to their partners, but also while speaking.

402

403 The results bring to light the collaborative processes of elaborating the meaning of touch, since we
 404 observed specific ways in which the device was used, depending on the couples concerned, and no
 405 clear relations between visual-touch forms and associated functions.

406 Our present study aims at highlighting these underlying processes of co-elaboration in interaction, as
 407 well as the specificity of visual-touch functions. Starting from the functions observed in our pilot-
 408 study, we focus on the context indicators produced and noticed by the participants during their
 409 interaction to make sense of mediated touch, as well as their degree of mutual understanding.

410 **3.6 Analysis of the confrontation interviews**

411 The interviews were transcribed in their entirety and were first analysed into three levels of
 412 discussion. Reading through the transcripts several times, the first author highlighted sections where
 413 participants were discussing their use of the device with different degrees of precision: (1) general
 414 description of their use of the device or understanding for the entirety of the interaction; (2) broad
 415 description of use and understanding within an excerpt; (3) singular visual-touch description, its
 416 functions, and understanding.

417 We then screened the videos of the interactions to find excerpts for each visual-touch described by
 418 the participants (level 2 and 3). For that purpose, the video recordings were annotated with Elan
 419 software (ELAN, 2022). The recordings were segmented with the protocol phases, then each
 420 identified excerpt was annotated (with the timing, duration and colour of the stimuli) and given a
 421 name to facilitate future watching and support our understanding of the participants' descriptions.
 422 This annotation also helped identify relevant examples for illustration purposes.
 423 In total we were able to clearly identify 71 instances of visual-touch behaviours within the video-
 424 recorded interactions, based on the participants descriptions in interviews: 37 specific behaviours
 425 (level 3) and 34 broad descriptions (level 2), for a total of 71 visual-touch behaviours and associated
 426 functions and indicators. (see Table 3). Information about their general use of the device (level 1)
 427 helped us understand the way each couple used the device overall and verbatims are presented in the
 428 results in order to illustrate them.

429 **Table 3 – Visual-touch events reported in the interviews**

430 note: the table presents the number of visual-touch event reported during the interviews for each
 431 couple (C1 to C5) and matched with the phases of the interaction.

Excerpts	C1	C2	C3	C4	C5	Total
Familiarisation	0	0	0	3	0	3
Memory n°1 A	0	0	0	0	0	0
Memory n°1 B	2	2	3	3	0	9
Memory n°2 A	3	1	4	3	2	13
Memory n°2 B	7	2	4	0	2	16
Memory n°3 A	3	7	2	2	1	14
Memory n°3 B	2	6	2	2	3	16
Total	17	18	15	13	8	71

432

433 The analysis of the interviews was conducted mainly on the basis of the highlighted interview
 434 transcripts. The coding scheme was elaborated in an interactive way by the four authors of the paper.
 435 This iterative process in refining the categories over time aimed for a better reliability of the results.
 436 When stabilized, the first author coded the whole corpus on the basis of the elaborated codebook.
 437 The first step was to annotate the 71 visual-touch behaviours highlighted. While reading the
 438 verbatims multiple times, we were attentive to the expressed functions, the description of the visual-
 439 touch characteristics, the touch initiator, the elements supporting the understanding of the functions
 440 as expressed by the participants such as reference to the verbal, paraverbal and nonverbal elements,
 441 or any other descriptions of the context given by the participants.
 442 In order determine the functions of the visual-touch (RQ1), we merged the categories proposed by
 443 Héron et al. (2022) and Vion (1992) (as presented in section 3.5). We were thereby able to categorise
 444 visual-touch functions on the basis of the participants descriptions in interview.
 445 The analysis of the indicators used by the participants to co-elaborate the functions (RQ2), followed
 446 an inductive approach starting from the four types of indicators: visual-touch cues (characteristics of
 447 the sent stimuli), verbal (communication through spoken words), paraverbal (paralinguistic elements
 448 of speech such as pitch, volume, lengthening) and nonverbal (elements of communication such as
 449 gestures or facial expressions) context.

450 Both these analyses were iterative and involved four of the authors of the paper. To keep track of the
451 annotations and categorisation overtime, we used an Excel file.

452 The final codebooks of the functions and the indicators can be found in the supplementary material
453 (cf. supplementary table 1 & 2).

454 Concurrently, for each visual-touch behaviour, we determined, when possible, the degree to which
455 the elaboration of the function was indeed collaborative in order to answer RQ3. For that purpose,
456 drawing from the interviews, as well as the interaction extracts, we noted whether: (1) participants
457 discussed the mutual understanding of the functions, (2) the reported behaviour was perceived by
458 both interactants, as well as (3) the degree of mutual understanding.

459 **4 Results**

460 We first present the functions of the visual-touch behaviours reported by the participants, then the
461 different categories of indicators used by the interactants with contextualised examples. Finally, we
462 look at the relation between the shared understanding by the partners and, the reported functions or
463 indicators.

464 In the following subsections, we illustrate with verbatims the functions highlighted and excerpts of
465 the interactions. In the transcripts of the interactions, ‘.’ indicates a pause, ‘-’ a lengthening, ‘[]’ an
466 overlap, and ‘()’ gives further paraverbal information. Touch behaviours are represented by **—** to
467 present their occurrence and duration, information regarding their form is added underneath in *italics*
468 when necessary.

469 **4.1 Functions of visual-touch (RQ1)**

470 The functions highlighted in Héron et al. (2022) gave us a framework of analysis for categorising
471 those mentioned by the participants in the present study. Two additional functions are identified.
472 First, we notice the use of the device to communicate negative affect. Second, and more interestingly,
473 we highlighted illustrative visual-touches.

474 The reported functions are highly dependent on the couple, hinting at specific co-elaboration
475 processes. Two couples (C1 and C4) reported mainly positive affect communication functions. Two
476 other pairs (C2 and C3) reported mainly illustration functions. For couple C5, one of the participants
477 used the device very little (7 times over the whole interaction) for the functions of closeness and
478 backchannel, while his partner used the VisualTouch device mainly for its adaptor function and the
479 communication of positive affect (cf. figure 4).

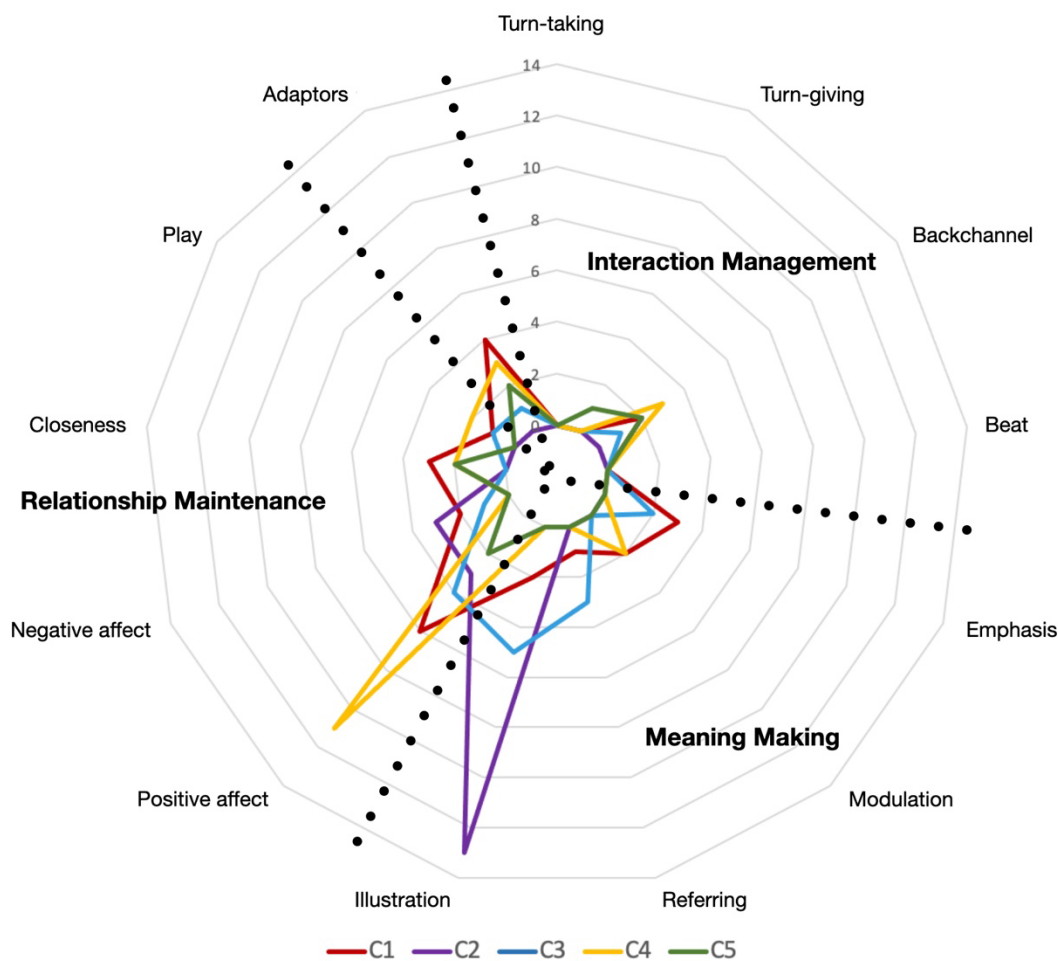


Figure 4 – Visual-touch functions

note: this graph presents the distribution of the functions across couples (C1 to C5). Each coloured line represents a couple, and each concentric line represents the number of reported functions from 0 (the most central line) to 14 (the outer line). The three dimensions of functions are superimposed onto the graph.

480
481
482
483
484

485 The *interaction management* category of functions is the least mentioned in the interviews. This is
486 not surprising, since these behaviours are mostly performed unconsciously, similarly to what we
487 observed in Héron et al. (2022). The participants do, however, report two of the functions highlighted
488 previously: Backchannel and Turn-giving.

489 In terms of *meaning making*, the participants reported functions of Emphasis, Modulation, Referring,
490 and the newly highlighted function of Illustration – the visual-touches illustrate concepts, scenes or
491 emotions related to the stories.

492 As regards the functions of *relationship maintenance*, the same functions as in the pilot-study were
493 identified. However, in this study, participants reported the communication of negative affect
494 directed towards the partner or to the events discussed.

495 *Adaptors* are clearly identified by the participants, who associate them with doodling while listening
496 on the phone for example, as well as a way to mitigate stress relative to the experimental setting or
497 their relived memories. These self-oriented behaviours were numerous, and the context helped the
498 interactants to understand the orientation of the visual-touch, as we will see in the following section.

Interview excerpt

B - I think that **when I draw a line** like that [draws a horizontal line with his finger] **it was to express compassion**. Otherwise, when I poke like that [pokes in the air] it was, in my head, it was just to say “it’s okay, I’m here” more like encouraging.

516 In these two examples, the indicators reported by each participant regarding the form or direction of
517 the visual-touches were not discussed within the couples in interviews. Only one of the interactants
518 explained how they conceived the tactile aspect of their visual-touches. We assume that this is
519 because patterns are not perceived easily. We did not notice any evidence of mutual understanding or
520 misunderstanding.

521 *Cadence*

522 As three couples (C1, C2, C4) mentioned, what was mostly perceived was the rhythm, the cadence of
523 the touches. For the participants, it was a question of discriminating between the haste and frequency
524 of the touches. They distinguish slow, continuous touches and repeated taps of varying speed for
525 instance, rather than their direction or form.

C1 | A - Because you were more in something soft [draw slow curves in the air) and **I was more like [draw something hectic in the air]**
| B - **It was not the same intensity**, the same intent.

C2 | B – When we talked about being lost. We were more in **something continuous with our fingers rather than dots**.

C4 | B – For me it was **more the cadence**, between the lines and fast repetition or a small dot.

526 **4.2.2 Visual indicators**

527 *The colours*

528 Couples elaborated thoroughly about their choices of colour in the interaction (for 30 behaviours out
529 of 71).
530 In couple C1 and C2, each partner carefully considered the colour choice when using the device for
531 most cases. In couple C3 and C4, only one of them considered the colour with a colour code in mind.
532 In addition to the illustrative nature of colours in describing physical aspects of the story (e.g., yellow
533 for the sun, green for the trees) which we will present further down, participants report familiar
534 emotional associations. For instance, red represents love and passion, but also excitement, tension,
535 negation, and danger; blue represents calm, well-being, appeasement and even sadness; green is
536 associated with hope; yellow is associated with gentleness and happiness.

537

C3

A1 (laugh) blue rubbing blue line
B1 I could have chosen any plant (laugh) But ar: I thought It was a funny symbol because ar:
[colour: green]

A2

B2 So I'm sending you lots of green stuff.
green

Interview excerpt

A- You thought of a plant.

B - Yes, that's what it was, plus we'd talked about that before about the choice of colours and the symbolism. And the connotations behind them, and **green means hope**. And also because I like this colour (laughs). And the main reason is what you say A, **it's because it's a green plant**.

538 The interview excerpt of above illustrates how the participants try to associate colours to culturally
539 accepted meanings (the participants looked at the significations of colours during the first break).
540 Relying on culturally shared signification is however not always pertinent as colours often carries
541 multiple significations. In the current matter, A only think about the relation to the plant and not to
542 hope as B suggests.

543 The other partners of C3 and C4, explain being more spontaneous and driven by their liking of the
544 colour. Their choices were guided by broad principles: bright, dark or pastel colours depending on
545 the situation; without settling on a particular colour.

C4

A₁

blue blue [colour: red] red

B₁ I was on fire that night pink pink and I was pink about to leave and I pink said to myself... well I said to my friend

A₂

red red [colour: green] green

B₂ “No we can’t leave I have kissed anyone yet” and I chose you randomly, I thought “he is tall:, it’ll do.” pink pink pink pi-

A₃

(laugh) green green green fate is crazy

B₃

-nk Each time I think about it I am li:ke pink

Interview excerpt

A – The device was to show 'ah I'm frustrated' because this moment is something we've shared and now we can't be together to experience it, to talk about it [...] I didn't want pastel colours, **I wanted real colours, bright colours that showed joy**.

B – I mean, the more I told the story, **the more there was this slightly frenetic and exciting thing** about the story, and the more I used the device. I see **I'm back in pink**.

546 Colour is only accessible through the visual modality. However, three couples (C1, C3, C4) reported
547 looking at the device very little and therefore not paying attention to the colour they received (even
548 though, they were deliberate with their use of colour). This might explain why the colour choices
549 when used outside of illustrative touches are rarely discussed.

C1 | B - What I've noticed is that we don't look at the device very much. At the same time, you don't usually look at your arm.
A - We do look at the screen more.

C3 | B - Well, generally speaking, I wasn't really looking at the device.

C4 | B - It's true that I didn't look at the colours very much. And in any case, it wasn't strong enough to dazzle me. I mean, could I see that it was changing colour without looking at it?

550 *Illustrative aspects of visual-touches*

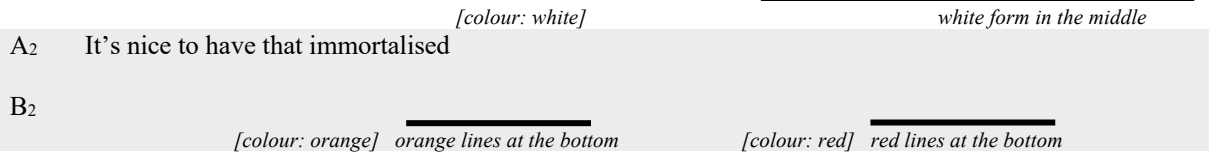
551 Some participants produced more complex drawings. These illustrative aspects can directly
552 participate in the construction of the meaning. Couples C1, C2 and C3 sought to reproduce the

553 physical or conceptual characteristics of their story, as we saw above. Participants also mentioned
 554 drawing hearts to convey affection.

C3

A₁ I like to watch the video because we can see us Thinking that at this time we weren't together yet

B₁



Interview excerpt

B – I remember what I wanted to do. There was a space rocket [in the concert] so I was drawing it with the flames.

A – I thought he was having fun. That he was drawing zigzags.

555 Most of the time the use of drawings is understood by the participants and contributes to the
 556 understanding of the visual-touch behaviours. In this case, however, the participant thinks her partner
 557 is only playing with the device.

558 **4.2.3 The verbal indicators**

559 As the uses of visual-touch take place in a verbal interaction, it seems obvious that the verbal content
 560 will play a role in the elaboration of functions.

561 *Explication*

562 The simplest way for couples to understand their use of the device is to verbalise their action. It
 563 enables partners to pay closer attention to the stimuli, or specify the function they wish to associate
 564 with it. In some cases, this helps establish a code that can be reused later on.

C5



Interview excerpt

B – By the end I stroke her arms and I say it “I stroke your arm”

565 In the example, A looks at the device trying to understand what is happening. B then clarifies his
 566 action. The elaboration is completed with the smile of participant A, acknowledging her
 567 understanding.

568 Explications have been reported by all the couples to some extent (explication of the form, the
 569 function or both.)

C2 | A – Yes, we talked about it at the beginning during the familiarisation phase. And I told him “did you noticed when I did that to comfort you? Something soft as a caress on the arm?” So to reuse it I thought he would understand.

C3 | B – At some point I say “I send you loads of green”.

C4 | B – I said “I will choose red because we are talking about love”.

570 Looking at the "pauses" between protocol phases, we are able to highlight further aspects of explicit
571 grounding. This could relate to the way they used the devices in general,

- C1 | B – I was writing little words
A – But because you couldn't look at the device. Because I was sending you things.
B – No I wasn't looking
A - **Look [draws a heart]**
B – You drew a heart! No I didn't look at this. I looked at you.

572 question their partner's perception about the visual-touch stimuli,

- C4 | A - **Did it bore you when I was touching you like this all the time?** [...]
B - No, I got bored when you stopped (laughs).
A - I realised that sometimes you called me to order.

573 test the limits and possibilities of the system,

- C2 | A - And **how hard does it hit?**
B - No, **it's not like a piano where there's sensitivity.** The phone screen would have to be able to pick up the force. And the frequency? I mean, here [touch] do you feel a lot?

574 or, as we have just seen, explain a specific code.

- C3 | B - You see, **blue is more about calm, red is more about tenderness,** I think I wanted to use yellow for youth and green also for hope.

575

576 *Theme and memory*

577 Beyond mere explications, the verbal content linked to memory enables the couple to understand the
578 functions (C1, C2, C3, C4). The importance of the theme of discussion is the most reported indicators
579 (42 out of 71 behaviours). Touch can then act as an alert, allowing them to pay attention to the
580 context at emotionally charged moments or to other para-verbal elements of the interaction that we
581 present later. In this regard, as they are recalling shared events, prior knowledge of these events
582 makes it easier for the couples to co-elaborate the functions.

C1

A₁

B₁ You touched my forehead to remove something. So I felt your hands. Oh my! Your hands were warm!

— brief touches — rubbing
rubbing

Interview excerpt

A – **It was when I think we had felt something strong.** The both of us, we would send some little spikes to notify.

B – **It was always the strong moments.**

[...]

A – it was to express excitement, adrenaline.

B – Excitement, adrenaline and tension. **The tension between us.**

583 In this interview excerpt, participants are discussing the way visual-touch was used when they were
584 talking about emotionally-charged events.

585 As most participant recall, the understanding of the visual-touch is tied to the context of the
586 interaction. It helps place emphasis on what already lies in the context.

C4 | B – Each time it was like in my brain. **Each time it vibrated I thought “ah look at his emotion because it’s that one he tries to communicate”**. It was more like a notification.

587 4.2.4 Paraverbal indicators

588 Aside from what participants are discussing, several paraverbal indicators help the participants
589 understand visual-touch.

590 *Alignment and prosody*

591 One of the participants in C2 wilfully aligned the rhythm of the visual-touch and the rhythm of his
592 speech, so that his partner was attentive to the form and function.

C2

A₁

B₁ It’s also associated with a good memory it’s a little bad thing
magenta stroke *[colour: white] white square* *[colour: red] red small dot* *red square*

A₂

B₂ in a en - sem - ble . . . of good
[colour: white] white circle

Interview excerpt

B - The little thing in an ensemble.

A - Yes I'd been paying attention, you see it was a little red dot and the white thing and **then it really follows the rhythm of your voice**.

B - Yes, that's what I was going to say, it's just that when I said it **I slowed down, but I wanted to synchronise it more or less with what I was saying**, so that it would be understandable because it was important to me that you understood that moving in wasn't a negative memory, even if I'd said that I didn't want it to create any misunderstanding.

593 In this example, the participants specifically discuss the role played by the alignment between the
594 prosody and the touch patterns of B in the understanding of the illustration. The other couples were
595 not explicit about alignment and their prosody. Though, we are able to identify similar alignments
596 within the reported visual-touch, especially with C1.

C1

A₁ There was one here: one here: (laughs) There was one here on here
small circle on the left *small circle on the right* *similar small circles (left and right)*

B₁ What ?

A₂ And the tension was there
rubbing in the middle of the screen

B₂ In the middle yes there
rubbing

597 Here, we see how A synchronises her touch in space and time with the words “here”. With regards to
598 the elaboration of meaning we also notice the repetition of this sequence, following B’s interrogation,

599 as part of a grounding process. Theses alignments between the deictic words “here” and the small
600 circles drawn by A, while not mentioned in interview, help for the understanding of the illustration
601 functions.

602 Otherwise, the most common alignments are observed when the participants are laughing and using
603 the device simultaneously, in a way serving emotional emphasis purposes.

604 *Interaction: role and time*

605 Participants evoke how they used the device differently whether they were speakers or listeners (C1,
606 C3, C4, C5). This is often related to functions such as backchannels and adaptors.

- C1 | A - Sometimes you use it, but to play. Like a child [...] I was saying something, **she listens** and
B - But I listen, **but I listen**
A - For example, I was cleaning my laptop and **you were using the screen in front of you to do it**. I
don't think that was in response to anything I was saying.
B - No, it wasn't in response, it's as if **I've got a rubber band in my hand, well it turns in my hand,**
a little stress thing. I don't know if it's stress because I wasn't stressed.

607 Another aspect of the interaction is the timing of the touch. In that regard, participants only evoke
608 how touch was used as closure (C3 and C5).

- C3 | A - Well, I think I was trying to convey the reactions you'd normally have in a conversation, but
through touch, and I was trying to respond to him as I would normally respond to him, but through
touch. [...] **we made a lot of hearts at the end, as if you were on the phone** and you were saying kiss
or something. Sorry, I can't find the right words.
B - [...] **At the end of the text message, it was almost the last word**, the last piece of information we
sent. The heart. Because on the phone that can be the case too.

609 4.2.5 Nonverbal indicators

610 To conclude, participants evoke the role played by nonverbal indicators, such as gaze direction and
611 facial expression in the understanding of meaning.

612 *Gaze & facial expression*

613 The participants (C1, C4, C5) are particularly interested in the orientation of their partner's gaze in
614 order to determine the orientation of the touch (e.g., communication or adaptor). They also make the
615 link between their partner's facial expressions and the perceived touches.

- C1 | B - I don't know, I think it's a bit of both, because when I say things like that **I often cross my eyes**
and look a bit shy. So this gesture may be a bit about shyness. I'm not sure I want to caress her, it's
more for me.
A - Yeah, I think so. And I remember at the time I didn't really know why she was using the device and
I didn't respond, I just listened. It was a good memory and all.
- C4 | B - No, because I can see that the **times when I want to communicate something are the times when**
I'm looking at him.
- C5 | B - Tenderness, yes, especially at the end, but it's also helped by the camera, because **she's looking at**
me a bit like that [with tenderness] and **she's also using the device at the same time**. And that's when
I respond to her. It's the whole thing, not just the device.

616 In these examples, we see how gaze and facial expression help, in association with other indicators
617 such as the theme, to understand the functions.

618 *Unconscious Visual-Touch Mimicry*

619 Finally, participants (C1, C2, C3, C4) noted, often without being aware of it during the interaction,
620 that they aligned their choice of colour, the rhythm, and the pattern of the touches. Not surprisingly
621 mimicry was not limited to the tactile aspects of the visual-touches but also to their visual
622 characteristics. In fact, we observe several cases where they used very similar colours without
623 realising it before our interviews, or where the interactants produced the same type of movement,
624 sometimes to the point of being identical.

C1 | A – **I chose blue and you used a light blue** at that moment too
B – Yes, but I don't know if I saw that you changed the colour.

C3 | A – We noticed that **we do exactly the same patterns again**, and at the end it was very close in terms
of colours. But we couldn't say why.

625 We assume that these alignments also helped to facilitate the sharing of representations between the
626 interactants, as expressed by one of the participants in pair C2 regarding the similar use of illustrative
627 elements they had at the beginning of the extract.

C2 | B – Yes me too. It was a little like I found a congruence between what I was doing and what I received,
so it confirmed that there was something in common.

628 Here, the perception of congruent visual-touches played a role in the grounding processes.

629 **4.3 Degree of mutual understanding (RQ3)**

630 As mentioned in our analysis and noticed in the examples presented above, the interactants did not
631 always understand each other. Even while discussing their exchange in interviews, they did not agree
632 on every function of the produced and perceived visual-touches.

633 For each reported visual-touch behaviour, we identified to what extent there was mutual
634 understanding, on the basis of the interaction and of the interview. Figure 5 presents the different
635 degree of mutual understanding: (1) no evidence², (2) the receiver did not perceive the visual-touch,
636 (3) the receiver perceived the visual-touch but did not understand it, (4) the receiver perceived the
637 visual-touch but understood it differently to the sender's intent, and (5) the two interactants share the
638 same understanding of the touch.

² In 18 cases, there is no clear evidence of mutual understanding or misunderstanding, neither in the interaction itself or in the interview.

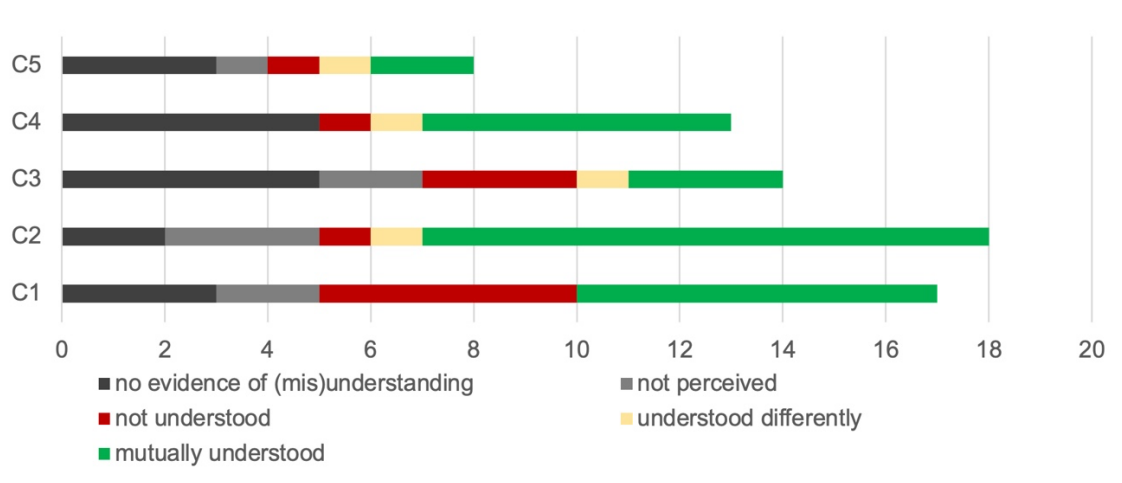


Figure 5 - Mutual understanding of the visual-touches

note: This graph illustrates the mutual understanding levels. Each couple (C1 to C5) is represented on a line and from left to right is presented the number of visual-touch behaviours which are: discussed but no evidence of understanding or misunderstanding is accessible, not perceived by the receiver, not understood by the receiver, understood differently from the sender intention, or mutually understood.

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645 First, plotting the mutual understanding degrees on the timeline of the interactions, we hoped to
646 observe higher degree of shared understanding by the end of the interaction, with regards to the
647 construction of common ground and routinisation processes as suggested by our theoretical
648 framework. However as presented in Figure 6, we see no such progression, which might be explained
649 by the relatively short duration of the collaborative remembering phase.

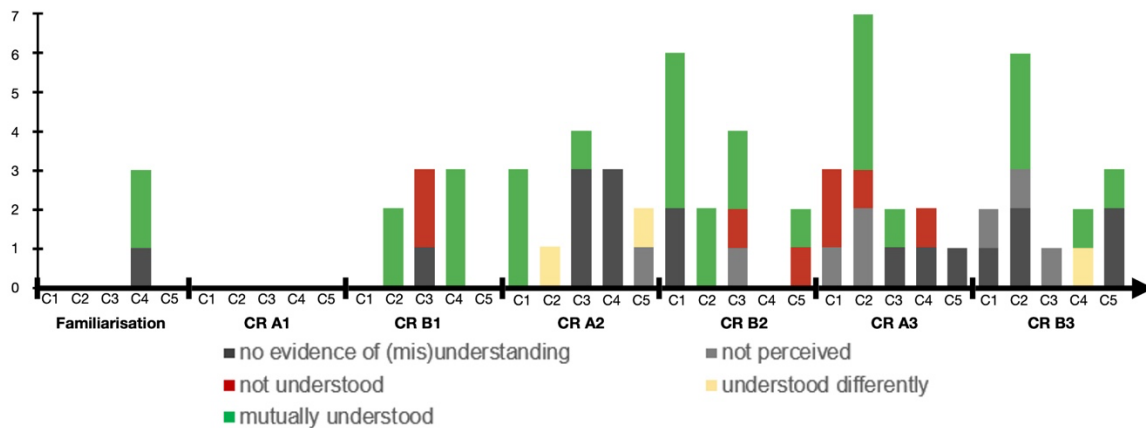


Figure 6- Mutual understanding evolution over the course of the interactions

note: the figure presents the mutual understanding of the visual-touch behaviours distributed across the interaction phases for each the couple (C1 to C5), from the familiarisation to the last memory of participants B (CR B3: Third memory of participants B in the Collaborative Remembering phase).

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655 Trying to correlate the degree of mutual understanding to the functions or the indicators reported by
656 the participants, we first notice that the most understood visual-touch behaviours are those used to
657 illustrate the related stories ('illustration') as well as those communicating 'positive affects'. Both
658 these functions are also the most reported, hence we can assume that participants tend to mention
659 moments when they think they understood each other better.

660 In a similar manner, some indicators are more often associated with mutual understanding. *Theme*
661 and *Colours* show the higher number of reported indicators associated with mutually understood

662 behaviours, however those are also the two most reported indicators. *Explication* and *Illustrative*
663 *aspects* on the other hand, not reported as much, are highly associated to mutual understanding.

664 As the co-elaboration process is multifactorial, the indicators are used as a body of cues helping in
665 the elaboration of the functions. Hence, we assume that the more indicators considered, the better the
666 mutual understanding. For instance, the three couples who understood each other best (C1, C2 and
667 C4) were also those who reported using the greatest number of elements (cf. Table 4 & Figure 5).

668 **5 Discussion**

669 Following an interactionist approach to study how visual-touch is used in distant verbal interactions,
670 we are able to answer two of our research questions related to the specificity of visual-touch in the
671 elaboration of the functions (RQ1) and to the indicators considered by interactants to attribute
672 functions to visual-touch (RQ2). We are also partially able to answer our question related to the
673 extent of mutual understanding (RQ3).

674 The three following subsections (5.1, 5.2 and 5.3) discuss our results related to these questions.

675 **5.1 The specificity of visual-touch functions (RQ1)**

676 Our results highlight 13 functions of visual-touch, 11 of which were previously identified by Héron
677 et al. (2022). Here we go a step further by classifying these uses of the VisualTouch device with
678 regards to dimensions of functions of verbal interaction (Vion, 1992): *interaction management*,
679 *meaning making* and *relationship building*; and by investigating the visual aspects of this specific
680 case of mediated social touch.

681 A specificity of mediated touch and more specifically of visual-touch is that we observe a
682 redistribution of the functions over interaction modalities compared to actual touch. In the following
683 subsections, we discuss each dimension of functions and the observed redistributions.

684 *Interaction management*

685 Only a few instances of *backchannel* and *turn-giving* are reported in our results. These behaviours –
686 which can be explained as the low-level automatic processes mentioned in the interactive alignment
687 model (Garrod & Pickering, 2009) – allow for fluid dialogues and are very often subconsciously
688 accomplished. Hence, it is not surprising that our participants did not mention many functions of this
689 category, as previously observed by Héron et al. (2022).

690 In face to face interaction, these functions are mostly supported by other para- and nonverbal
691 behaviours such as glances and co-verbal gestures (Jokinen et al., 2010; Wagner et al., 2014) or
692 pointing gestures (Mondada, 2004).

693 *Relationship building and maintenance*

694 In our study, we identify functions that have already been reported (for both mediated and actual
695 touch) such as the communication of *positive* and *negative affects* (Hertenstein et al., 2006, 2009;
696 Huisman, 2017; Jones & Yarbrough, 1985; van Erp & Toet, 2015). In addition, while we did not
697 evaluate the feeling of presence, we observed a *play* function (where participants are having fun with
698 the device) sometimes called *mimicry* (e.g., Chang et al., 2002) which we believe helps the feeling of
699 connectedness. In our work, mimicry was reported and observed with the visual-touch rhythm,
700 patterns, as well as in the choice of colours. Research indicates that mimicry is closely related to
701 social influence (Bailenson & Yee, 2005) and group membership (Bourgeois & Hess, 2008).

702 *Meaning-making*

703 Our results indicate that visual-touches support many functions associated with the interpretation of
704 meaning previously highlighted in the literature. *Emphasis*, which allows participants to highlight
705 certain parts of their utterances, was also observed by Chang *et al.* (2002) for mediated touch. The
706 functions of *modulation* – to alter the tone of utterances – *referring* – for the interactants to clarify the
707 objects of the exchange – have already been partially highlighted in face-to-face interaction by Jones
708 and Yarbrough (1985) with “playful touch” and “reference to appearance”, respectively. Our results
709 highlight a new function of mediated-touch, *illustration*, which occurs through iconic gestures in
710 face-to-face interactions (McNeill, 1992). This transfer of functions is not limited to *illustration*. For
711 instance, in co-presence, *emphasis* is mostly supported by co-verbal gestures (Bull & Connelly, 1985;
712 Jokinen *et al.*, 2010; Wagner *et al.*, 2014) and intonations (Arons, 1994; Ladd & Morton, 1997),
713 while *referring* is mostly achieved through deictic gestures (Lefebvre, 2008), and *modulation* with
714 prosodic elements (e.g., ironic tone).

715 *A redistribution of the functions over modalities*

716 The several transfers of functions to visual-touch that we observe in mediated communication could
717 have at least three explanations. First, the limitations of video calls which do not necessarily
718 guarantee a good understanding of who is speaking (e.g., overlap) and what is being referred to,
719 create difficulty in identifying the orientation of gazes and co-verbal gestures (Bitti & Garotti, 2011;
720 Olson & Olson, 2000). In mediated contexts, gestures are reduced (Lefebvre, 2008). Indeed, in our
721 study participants did not mention co-verbal gestures. Looking at the video, participants did not
722 produce many gestures and when they did, they were mostly not visible through the webcam. In
723 addition, potential discomfort associated with wearing the device could explain the limited gestures
724 (two participants talked about the weight of the device and one indicated that the device was
725 sometimes limiting in terms of movements). Second, the differences of properties between actual and
726 visual-touch could explain these transfers of functions, as the specificity of visual-touch is the visual
727 dimension enabling people to illustrate physical features, emotions, or other concepts, related to their
728 current narrative. Third, the mere participation in the experiment could also contribute to increased
729 use of VisualTouch. While we aimed at naturalistic interactions, knowing the aim of the study
730 (explore the use of a mediated touch device), as well as the novelty effect, could explain participants’
731 dedication to use the device thoroughly.

732 **5.2 The visual-touch characteristics in the determination of functions (RQ1 & RQ2)**

733 While the visual modality was originally thought to increase the perceived accuracy of the tactile
734 stimuli, our results indicate some form of autonomy. Participants talk about the colour they send, as
735 if the tactile aspects were not present: “I send you some green”. They also report using a colour code
736 and drawing (not just for illustration) precise forms. Research suggests that the frequent occurrence
737 of complex iconic gestures and numerous pointing gestures are associated with the introduction of
738 novel components of the discourse (Levy & McNeill, 1992; Parrill, 2010), hence we can assume that
739 they are closely related to the construction of common ground. Indeed, there are accounts of the
740 cross-modal relationship between the semantic and gestural modalities in speech coordination
741 (Rasenberg *et al.*, 2022) and the priming effect (Yap *et al.*, 2011) for instance. We can say that the
742 illustrative aspects of the visual-touch behaviours actively participate in the elaboration of the
743 understanding of the functions. However, from the receiver perspective, participants did not seem to
744 always pay much attention to visual aspects and were more concerned about the cadence, the rhythm
745 of the touch.

746 Besides illustrative aspects of visual touch, the choice of colour was largely commented on by our
747 participants, with results diverging from what laboratory studies report. In the literature, blue is often
748 associated with positive affects and red with negative affects (Suk & Irtel, 2008; Valdez &
749 Mehrabian, 1994; Wilms & Oberfeld, 2018; Zhang et al., 2019). Our results show that red can also be
750 positive when associated with love and passion, while blue can be linked to sadness. Similarly, the
751 relation between touch forms and their valence will vary depending on situations. Results from a
752 limited context setting should be taken with caution, as recent research on actual touch suggests that
753 the physical characteristics play little role in the determination of positive touch experience (Sailer et
754 al., 2024).

755 As hypothesised in our framework, we consider that the context is responsible for meaning shifts.
756 Our study is concerned with the functions of mediated touch in social interaction, so it is not
757 surprising that a meaning associated with a stimulus with no context is re-evaluated during the
758 interaction in relation to the context. In short, apart from the illustration function, the visual aspects
759 do not matter much, as also suggested by our results.
760 These observations could lead to rethinking the design of the VisualTouch device. Previous research
761 indicates that congruent visual-touch patterns (i.e., identical for visual and tactile cues) lead to a
762 wider emotional communication in comparison to tactile cues alone (Zhang et al., 2019). However,
763 here we note that in interaction, participants do not often take into account the visual pattern as they
764 are looking at their partner, and that the perception of the cadence and broad patterns of the touch and
765 colours are sufficient in combination with the interactional context and the knowledge of shared
766 memories.

767 **5.3 The role of the interactional context (RQ2)**

768 Several studies point out the critical role of the context for social touch functions, in co-present
769 (Jones & Yarbrough, 1985) or distant/mediated interactions (Price et al., 2022). Our results help to
770 understand how participants attribute meanings to the visual-touch they produce and receive by
771 considering the interactional context. Not surprisingly, the indicators reported by the participants
772 comprise verbal, para-verbal and non-verbal behaviours, as the context is key to determining the
773 relation between forms and meanings (Rasenberg, Özyürek & Dingemanse, 2020). Our results
774 reaffirm the ability of *grounding* and *interactive alignment* theories to highlight the explicit and
775 implicit negotiation processes deployed by interactants to co-construct mediated-touch functions in
776 interaction.

777 **5.3.1 The verbal material**

778 The theme of the sequences and the participants' shared knowledge of memories contribute to the
779 construction of functions by drawing on their common ground. Price *et al.* (2022) notably highlight
780 that close friends, family and partners developed idiosyncratic meanings on associations with the
781 touch characteristics and their shared touch histories. The common knowledge of their relationship is
782 key for both the sender and receiver. The interactants also make explicit their use of the device. They
783 announce the sending of certain colours and lines or specify the function they attribute to them. This
784 directly echoes the principle of least collaborative effort set out in *grounding* theory: from a
785 collaborative point of view, it is easier to provide clarification when a statement seems unclear rather
786 than waiting for the interactant to ask for clarification (Clark & Brennan, 1991; Clark & Wilkes-
787 Gibbs, 1986). Sometimes this is done before or after the repeated use of a form of touch. We also
788 note the use of pauses to discuss the use of the device, understand their physical possibilities and
789 determine codes.

790 **5.3.2 The para-and non-verbal material**

791 Automatic or conscious intermodal alignments further support the link between the verbal modality
792 and the occurrence of visual-touch. Interestingly, we observed a mostly unconscious process being
793 used deliberately by a participant to emphasise verbal content. From an interactive alignment
794 perspective, these oftentimes unconscious alignments play a role in the forthcoming mutual
795 understanding. The literature also reports alignments both within and across modalities (e.g., speech
796 or gestures) and amongst interactants (Kimbara, 2008; Louwerse et al., 2012; Tabensky, 2001; Holler
797 & Wilkin, 2011) in line with the interactive alignment model suggesting the interrelation between
798 modalities (Pickering & Garrod, 2004). More importantly behavioural alignments are associated with
799 successful communications (Fay et al., 2018) and gestural co-construction (Oben & Brône, 2016).

800 Non-verbal behaviours such as facial expressions also play a part in the construction of functions, as
801 do the glances that allow us to understand the orientation of the touches (i.e., communicative or
802 adaptive functions). Participants also report alignments in colour choices and in certain touch shape
803 characteristics, although they are not always aware of them. It is likely that these alignments promote
804 the understanding of touches and therefore participate in the co-elaboration of meaning.

805 **5.4 The co-elaboration process and mutual understanding (RQ3)**

806 Park *et al.* (2013) showed that over a long period of time participants stabilised the form-function
807 relation for a few meanings as would be the case for idiomatic expressions.
808 In our studies, participants came up with various functions for the device. The visual-touch forms and
809 their associated functions were context-specific and each couple relied upon different characteristics
810 of the stimuli (colour, pattern, duration, rhythm, etc.) to co-elaborate meaning. For instance,
811 participant A of C2 explicitly associated the context (something sad or difficult) and the touch-form
812 (a slow white stroke) with a function of comforting, which she re-used in the interaction. This can be
813 explained from the point of view of common ground (Clark & Schaefer, 1989), as well as the concept
814 of routinisation proposed by the interactive alignment model (Pickering & Garrod, 2004). Over the
815 course of the interaction, co-activations of different forms and functions of touch, and processes of
816 explicit negotiation, can eventually lead to the formation of more durable form-function associations,
817 i.e., the construction of a specific common frame of reference for each couple.

818 The consideration given to the different indicators and the dynamics of the interaction inevitably
819 leads to different degrees of mutual understanding. Our results in that regard are not completely
820 conclusive. On the one hand, certain indicators, such as Theme, Colours, Illustrative aspects, and
821 Explication, are associated with a higher degree of mutual understanding. On the other hand, it seems
822 that participants who mentioned more indicators of visual-touch characteristics, the verbal, para- and
823 non-verbal context, better understand each other. Throughout the presentation of our results, we
824 specified, when possible, how mutual understanding was achieved. What stands out is the dynamic
825 and factorial aspect of the co-elaboration process regarding the indicators reported. They are
826 combined to participate in the construction of meaning.

827 Our results report several cases of misunderstanding or incomplete understanding. In those cases, we
828 could consider that the interactants reached a common ground sufficient for the continuation of the
829 interaction but did not fully reach mutual understanding. As Cherubini and colleagues (2005) pointed
830 out, grounding at the utterance level is not equivalent to mutual understanding. Drawing from the
831 cognitive environment concept (Wilson & Sperber, 1995), they stress that it is not because common
832 ground is achieved that people share understanding, only that they are able to do so.

833 In the interviews, we noted cases where participants tried to rely on what they believed to be
834 culturally shared meanings (be it for colours or patterns). These are instances of perspective taking –
835 participants “considering how a given utterance would be likely to be interpreted by the receiver”
836 (Micklos & Woensdregt, 2023). Though relying on cultural aspects was not always successful
837 because of the nonunivocal relation between form and function, and interactants associated different
838 meanings to the visual-touches. From the receiver perspective, the assumed intention of the toucher
839 or the purpose of the touch received plays an important role in how it is interpreted (Sailer & Leknes,
840 2022; Sailer, 2024). Relying on the already developed common ground appears to be one of the most
841 important factors for the successful achievement of the co-elaboration of meaning, as suggested by
842 our results, participants frequently mentioning the importance of theme and shared knowledge about
843 the memory. Oben and Brône (2016), for instance, emphasise the importance of the historical
844 perspective of grounding as their results suggest that lexical and gestural alignments cannot solely be
845 explained by interactive alignment. The relationship of our participants might have played a crucial
846 role in mutual understanding. We indeed observe higher degree of mutual understanding for
847 participants reporting more consideration of the Theme indicator – which is associated with the
848 theme of the story and its shared knowledge.

849 **6 Limitations**

850 Even though our work aimed to highlight the functions of the visual-touches and the indicators used
851 by the interactants to co-elaborate these functions was mostly achieved, some limitations are worth
852 noting, on the basis of which we can propose perspectives for future research.

853 One limitation is the participant selection. We developed a complex protocol for in-depth analysis
854 and selected a limited number of participants, making generalisation difficult. Additionally, we
855 focused exclusively on cohabiting couples to observe a wide range of visual-touch behaviours, which
856 restricted diversity of our population. Whereas previous research indicates the importance of
857 relationship quality on the perception of social touch (Jakubiak, 2022; Sailer et al., 2024), we only
858 recorded the duration (3 to 6 years) of relationships, without assessing their quality. While our aim
859 was to explore the interactional context factors influencing the functions of visual-touch, evaluating
860 the quality of relationships could have provided valuable insights. Future research should consider a
861 more diverse participant pool in terms of relationship types, age, professional backgrounds, living
862 environments (as all participants were upper-middle-class residents near Paris), and digital literacy
863 (which we did not assess in this study).

864 Another limitation is the study’s time frame. Our interactionist approach emphasises that meaning is
865 collaboratively constructed over time, yet the brief nature of the interactions in our study did not
866 allow us to evaluate long-term negotiation processes. We plan to conduct a longitudinal study with a
867 broader participant base to better understand visual-touch in technology-mediated interactions.

868 To conclude, we noted limitations related to the devices used for visual-touch. Social touch is a
869 complex phenomenon that consists of “more than tactile stimulation alone, and is accompanied by a
870 rich set of multimodal cues” (p.15, Ipakchian Askari *et al.*, 2022). Thus, the design of the device may
871 influence interactant behaviours, as evidenced by the frequent use of illustrations and colours in our
872 study. Moreover, we observed minor delays in touch stimuli transmission and video calls, though
873 participants did not report any noticeable delays. Future research should explore the impact of these
874 delays on meaning co-elaboration, particularly as participants navigate the interactional context for
875 mutual understanding.

876 7 Conclusion

877 In our study, five couples each interacted during a 1-hour session at their homes. The interactions
878 were realised though video call with the addition of a visual-touch device enabling participants to
879 enrich their communication. We conducted confrontation interviews with each couple using the video
880 recordings of their interactions. We investigated the functions associated to the visual-touches and
881 the processes by which these meanings were created and understood. Our aim was to understand *how*
882 *the functions of visual-touch emerge in social interaction.*

883 With our results we are able to answer our first research question regarding the specificity of visual-
884 touch in interaction (RQ1) as we show that (1) visual-touch enables a variety of functions with some
885 specific to the visual aspect of the device and (2) that these functions are redistributed from the
886 modalities of communication onto the visual touch channel. We also described (3) the verbal,
887 paraverbal and non-verbal context indicators considered by the interactants to elaborate the functions
888 of visual-touches, thus answering our second research question (RQ2). We partially answer our third
889 research question (RQ3) by highlighting the (4) multifactorial and dynamic aspects of the co-
890 elaboration process, meaning that the presence of indicators and grounding do not always lead to
891 mutual understanding. Nevertheless, we lack a complete understanding of this dynamic process,
892 which we wish to explore further in a future study through the fine-grained analysis of the
893 interactions. Contrary to what was expected with our theoretical framework, we did not observe
894 increasingly higher degree of mutual understanding over time. However, with common ground
895 building and routinization in relation with interactive alignments we should observe more
896 convergence in the relation between forms and meanings (Galantucci, 2012; Oben & Brône, 2016;
897 Fay et al., 2018) and therefore a higher degree of mutual understanding. This could be explained by
898 the short duration of the collaborative remembering phase (one hour) and its varied thematic context,
899 which did not give the opportunity to the participants to converge on routinised form and function
900 relationships consistently. In the future, we wish to explore the use of visual-touch in naturalistic
901 settings over longer periods of time.

902 Our study offers a twofold original contribution. Firstly, we highlighted an Illustration function in
903 mediated touch, akin to what is seen in co-speech gestures during face-to-face interactions, which has
904 not been previously associated with touch. Secondly, we demonstrated the interconnectedness of
905 cultural and idiosyncratic contextual meanings in the context of mediated touch, reinforcing the
906 importance of considering context when conducting research on touch, whether mediated or direct.

907 8 Conflict of Interest

908 *The authors declare that the research was conducted in the absence of any commercial or financial*
909 *relationships that could be construed as a potential conflict of interest.*

910 9 Author Contributions

911 RH: Writing – original draft, review & editing, Conceptualization, Methodology, Investigation, Data
912 curation; SS: Writing – review & editing, Conceptualization, Methodology, Supervision; MB:
913 Writing – review & editing, Conceptualization, Methodology, Supervision; ZZ: Writing – review &
914 editing, Software; EL: Writing – review & editing, Project administration, Funding acquisition; FD:
915 Writing – review & editing, Conceptualization, Methodology, Supervision, Project administration,
916 Funding acquisition.

917 10 Funding

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922 in June 2019. The committee approved our study (dossier n°113), subject to minor modifications
923 regarding the explanation of the participant's risks in the consent form and the initial contact email, as
924 well as the way we anonymised the data.

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929 VisualTouch prototype.

930 **12 Data Availability Statement**

931 The anonymised transcriptions of the data supporting the conclusions of this article are available by
932 emailing the corresponding author and at
933 https://osf.io/syfzr/?view_only=0518c98ce0644b768005b04afcc0cdea.

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