

Harnessing Tactile Waves to Measure Skin-to-Skin Interactions

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Abstract

Skin-to-skin touch is an essential form of tactile interaction, yet, there is no known method to quantify how we touch our own skin or someone else's skin. Skin-to-skin touch is particularly challenging to measure objectively since interposing an instrumented sheet, no matter how thin and flexible, between the interacting skins is not an option. To fill this gap, we explored a technique that takes advantage of the propagation of vibrations from the locus of touch to pick up a signal remotely that contains information about skin-to-skin tactile interactions. These "tactile waves" were measured by an accelerometer sensor placed on the touching finger. Tactile tonicity and speed had a direct influence on measured signal power when the target of touch was the self or another person. The measurements were insensitive to changes in the location of the sensor relative to the target. Our study suggests that this method has potential for probing behaviour during skin-to-skin tactile interactions and could be a valuable technique to study social touch, self-touch, and motor-control. The method is non-invasive, easy to commission, inexpensive, and robust.

Keywords: Tactile interaction · Skin-to-skin touch · Self touch · Social touch

Introduction

Skin-to-skin touch has broad implications for the sense of self ([Merleau-Ponty, 1962](#); [Crucianelli et al., 2013](#)), body representation ([Schütz-Bosbach and Haggard, 2009](#); [van Stralen et al., 2014](#)), affective touch ([McGlone et al., 2014](#); [Cascio et al., 2019](#)) and motor control ([Blakemore et al., 2000](#); [Bays, 2008](#)). It is thus connected to intriguing problems across the domains of philosophy, psychology, and neuroscience. However, to date, no empirical method is capable of measuring how we touch the skin of a living person. Even a seemingly straightforward parameter such as the tonicity of skin-to-skin touch is outside the reach of objective measurement.

When touching surfaces other than the skin, the tonicity of the motor action can be directly measured by instrumenting the touched surfaces with load sensors interposed between the surface and a mechanical reference. For example, in grasping studies, hand-held objects are typically instrumented with load cells connecting grip surfaces to the object (e.g. ([Johansson and Westling, 1984](#))). Such arrangements project the total interaction of the finger onto the tangential and normal directions of the touched surface. Motor behaviour can be inferred from this decomposition. Extensions of this technique using broadband sensors revealed the complexity of the fingers mechanical interactions with surfaces ([Wiertlewski et al., 2011](#); [Klöcker et al., 2013](#); [Gueorguiev et al., 2016](#)).

When the touched surface is the skin, it is not possible to measure the interaction by interposing an instrumented membrane between the skins since the properties of the skin con-

35 tribute to the interaction (Löken and Olausson, 2010; Adams et al., 2013). As far as motor
36 behaviour is concerned, electromyography (EMG), or acoustic myography (AMG) are inval-
37 able techniques to investigate muscle activation (Goldenberg et al., 1991; Hodges, 2019). These
38 techniques, however, cannot provide a precise measure of the activity of an individual at the
39 level of the fingers, even in highly constrained conditions and with sophisticated analysis tech-
40 niques (Waris et al., 2018).

41 Here, a novel technique is introduced which is sensitive to the effects of skin-to-skin touch
42 and which provides a signal containing information about the behaviour of the ‘toucher’ and
43 the nature of the interaction. It is adapted from previous work highlighting the propagation
44 of mechanical energy in soft tissues far from a region of contact. The effect of digital tactile
45 interactions can be measured in the whole hand (Tanaka et al., 2012; Manfredi et al., 2012; Shao
46 et al., 2016, 2020), at least as far as in the forearm (Delhaye et al., 2012). These long-range effects
47 are likely to result from the propagation of elastic S-waves (Vexler et al., 1999) and surface
48 Rayleigh waves (Kirkpatrick et al., 2004) in soft tissues, with a relatively low rate of attenuation
49 over distance.

50 It is known that almost all mechanical sliding contacts undergo fluctuations for any speed (Akay,
51 2002). The fingers are no exception. When they slide on almost any surface, including skin, con-
52 tact fluctuations arise from phenomena that take place at multiple length and time scales. These
53 phenomena vary in relative importance in accordance with the material properties of the solids
54 in contact and the relative topographies (roughness, corrugation, conformability) at molecular,
55 mesoscopic, and macroscopic scales (Baumberger and Caroli, 2006). The friction associated
56 with skin-to-skin touch is the result of the skin’s complex material properties and intricate to-
57 pography at all length scales. In fact, the sounds produced by the sliding of glabrous skin
58 against glabrous skin (the ridged skin corresponding to the prehensile regions of the hand) are
59 sufficiently strong to be heard and to modify perceptual behaviour (Jousmäki and Hari, 1998).
60 These fluctuations are usually called frictional noise. For the present purpose they represent
61 frictional signal.

62 The intensity and spectral properties of the frictional fluctuations of skin sliding against skin
63 depend upon numerous factors, including the gross shape of the regions in contact, the type
64 of skin, the relative states of hydration, the presence of lubricants, and of solid contaminants.
65 Our study aimed to investigate how these fluctuations were linked to how we touch skin,
66 including tonicity and speed. To do so, a consumer-grade accelerometer chip was attached
67 to a single location of the touching finger to measure cutaneous vibrations remotely from the
68 region of contact, see Fig. 1. The captured signal was compared across conditions that varied
69 the participants’ instructed movements.

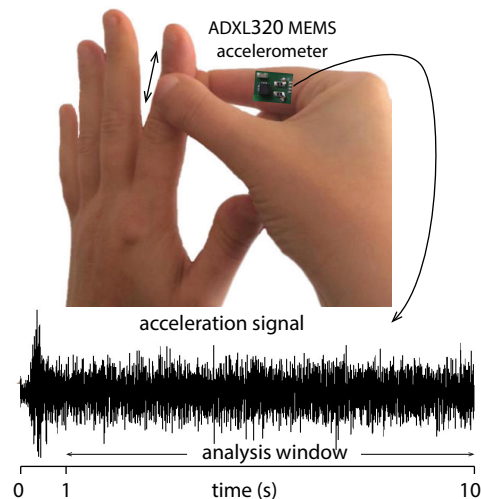


Fig. 1 Capture of tactile waves. Signals propagated from the fingertip during tactile interaction were picked-up by consumer-grade accelerometer placed on the proximal phalange of the right index finger. The signal was acquired using a computer audio channel after 20 dB amplification.

70 In Experiments 1 and 2, participants were instructed to vary the tonicity of their touch
71 (gentle or firm), or their sliding speed (fast, medium, or slow), respectively. If the signal was
72 sensitive to these behavioural features of skin-to-skin touch, then differences in signal should
73 be observed between these conditions (e.g. higher signal power for firm and fast compared to
74 gentle and slow touch, respectively). In Experiment 3, the target orientation was varied such
75 that the dorsal or ventral surface of the touched finger (i.e. the target) was facing the participant
76 inverting the relationship of the touching fingers with the dorsal or ventral surfaces of the
77 target. If sensor placement was critical, then the signal should depend on target orientation.

78 Skin-to-skin touch can be broadly divided into actions that serve to touch one's own skin
79 or another person's skin, with key differences between these two types of touch (Verrillo et al.,
80 2003; Ackerley et al., 2012). It is possible that the signal obtained during skin-to-skin touch
81 depended on the target of the touch (e.g., (Schütz-Bosbach and Haggard, 2009). In all three
82 experiments, the target was varied to be either the participant's own skin, or another person's
83 skin in order to ascertain that the method could be applied to both types of touch.

84 Experiment 1

85 The first experiment investigated whether the friction-induced vibration signal was sensitive to
86 differences in the toucher's tonicity during skin-to-skin tactile interaction. Pairs of participants
87 touched either their own or someone else's index finger, gently or firmly.

88 **Methods**

89 **Participants.** Eighteen healthy right-handed participants were recruited (ten females, mean
90 age: 22.8 years, $SD = 3.4$). Participants were invited to take part in the experiment in dyads,
91 but did not know each other. Half of the dyads were gender matched. In this and in all the
92 experiments reported here, participants were naïve to the purpose of the experiment. Partic-
93 ipants provided informed consent in accordance with the ethical standards outlined by the
94 Declaration of Helsinki (1991). All experiments received approval from the university's ethical
95 committee. Each experiment took approximately 30 minutes to complete and the participants
96 received payment for their participation.

97 **Procedure.** Participants were seated opposite each other on each sides of a table approxi-
98 mately one meter apart. Using micropore tape, the experimenter fixed the accelerometer ven-
99 trally to the proximal phalanx of the right index finger of one of the two participants. The
100 'toucher' was then instructed to stroke her or his own left index finger ('self' condition) or the
101 finger of the other participant ('other' condition). They used a precision grip posture such that
102 the right index finger always touched the ventral glabrous region of the left index finger held
103 upright, as illustrated in Fig. 2a. Participants always started the stroke from the fingertip of the
104 target finger. One stroke consisted of one back and forth movement from the fingertip to the
105 proximal phalanx and back.

106 Before starting the experiment, participants completed randomised practice trials of each
107 condition. They tried to maintain a constant pace of about one stroke per second by following
108 a metronome (sixty beats per minutes). During the experiment, a brief sound signal (80 Hz)
109 cued the participants to start stroking until the signal was heard again after ten seconds. Before
110 each trial, participants were told which target to touch, their own or the other participant's
111 index finger, and how much to press, gently or firmly. They were free to determine what for
112 them was gentle or firm. Each condition was randomly repeated ten times for a total of forty
113 trials. Between each bloc, participants interchanged their places and the accelerometer was
114 fixed to the other participant's index finger.

115 **Data analysis.** Only the high frequency content of the acceleration signal was considered for
116 analysis since the low-frequency content arises from whole limb movements and changes of
117 orientation with respect to gravity (Morris, 1973), thus mostly holding kinematic information.
118 The first second of each trial was excluded from the analyses to eliminate the effect of the burst
119 of signal at the transition from a static contact to a sliding contact (see Fig. 1). To minimise
120 transducer noise, the signal was band-pass filtered in the range 35–300 Hz which is within the

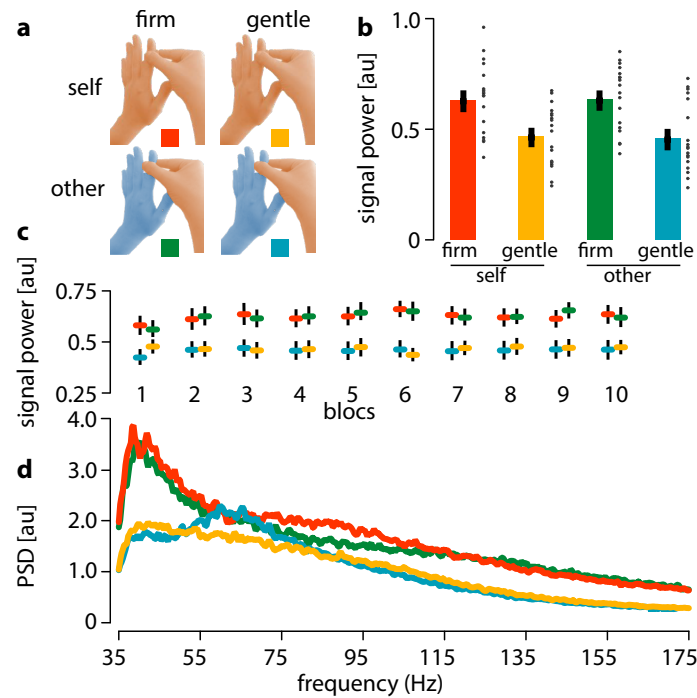


Fig. 2 Experiment 1. **a:** Experimental design: Tonicity could be ‘firm’ or ‘gentle’, target could be ‘self’ or ‘other’; resulting in four conditions (colour coded). **b:** Total signal power of frictional fluctuations per target and tonicity conditions. Black dots show individual results. Error bars show standard error of the mean (SEM). **c:** Evolution of the average signal power by bloc number. **d:** Averaged power spectral density (PSD) over all trials and participants for each condition.

121 textural information frequency range (Wiertelowski et al., 2010). A discrete-time estimate of the
 122 average signal power was computed for each condition by assuming that the signal window
 123 was sufficiently long, a condition largely fulfilled by the audio rate sampling of 44.1 kHz. The
 124 estimates were calculated according to,

$$125 \quad \hat{P}_{\text{cond}} = \frac{1}{M} \sum_{i=1}^M \left[\frac{1}{N} \sum_{k=1}^N |a_k|^2 \right]_i, \quad (1)$$

126 where M was the number of trials per condition and N the number of samples in the analysis
 127 window. A repeated-measure ANOVA on these averages was conducted to compare the four
 128 conditions. In addition to the analysis of signal power across the 35–300 Hz range, the power
 129 spectral density of the signal was estimated using Welch’s method to probe differences in the
 130 spectral content profiles across conditions. The analysis was applied to the averaged power
 131 spectral density of the signal in 20 Hz bands (35–55, 55–75, 75–95, 95–115, 115–135, 135–155,
 132 and 155–175 Hz). Any significant interaction was followed by post-hoc t -tests. All tests were
 133 Bonferroni-corrected for multiple comparisons.

134 Results

135 A main effect of tonicity was observed ($F(1, 17) = 32.70, p < 0.001, \eta_p^2 = 0.658$); with higher
136 signal power obtained when the touch was firm rather than gentle, see Fig. 2b. Thus, the
137 measure was sensitive to differences in tonicity. No effect of the target nor interaction with
138 the target were found ($F(1, 17) = 0.009, p = 0.924, \eta_p^2 = 0.001, F(1, 17) = 0.150, p = 0.703,$
139 $\eta_p^2 = 0.009$, respectively). It is to note that this difference was stable over time as shown in
140 Fig. 2c.

141 The difference between a gentle touch and a firm touch could also be clearly observed by
142 inspection of the averaged power spectra over all trials and participants, see Fig. 2d, while a
143 difference of target was not. An analysis by 20 Hz frequency bands revealed a significant effect
144 of tonicity ($F(1, 17) = 22.616, p < 0.001, \eta_p^2 = 0.571$), bands ($F(1, 17) = 40.391, p < 0.001,$
145 $\eta_p^2 = 0.704$), and an interaction between bands and tonicity ($F(1, 17) = 2.942, p = 0.011, ,$
146 $\eta_p^2 = 0.148$). Follow-up tests showed a significant effect of tonicity for all bands above 95 Hz
147 (all $p < 0.001$), as well as effects for the 35–55 Hz and 75–95 Hz bands (respectively: $F(1, 17) =$
148 $9.301, p = 0.007, \eta_p^2 = 0.354$ and $F(1, 17) = 8.966, p = 0.008, \eta_p^2 = 0.345$), but there was no
149 significant differences in the 55–75 Hz band ($F(1, 17) = 1.130, p = 0.303, \eta_p^2 = 0.062$).

150 Experiment 2

151 The second experiment was designed to determine whether skin-to-skin, friction-induced vi-
152 brations were sensitive to differences in the magnitude of the sliding speed.

153 Methods

154 **Participants.** A new group of eighteen healthy right-handed individuals completed this ex-
155 periment (ten females, mean age: 23.21 years, SD=2.55). Half of the dyads were gender matched,
156 and gender was balanced when unmatched: half of the participants were tested by a female
157 experimenter and the other half by a male experimenter.

158 **Procedure.** Participants were seated to the right of the experimenter who placed the accelerom-
159 eter on the participant's right index finger. With a pen, the experimenter marked three spots on
160 the ventral region of the participant's left forearm, each separated by nine centimetres (creating
161 two sites of stimulation, site 1 and site 2; see Fig.3a). These marks were identical to those made
162 beforehand on the experimenter's right forearm. Participants stroked with their right index
163 finger the skin of their own forearm or that of the experimenter; alternating between site 1 and
164 site 2, to avoid habituation. It is to note that no skin difference was expected between sites 1

165 and 2, so data from these two sites was averaged in the analysis. One stroke consisted of one
166 back and forth movement between two marks. The participants synchronised their movements
167 to a metronome set to induce three different velocities. With a 0.33 Hz beat, the average speed
168 was low, 3.0 cm/s. At 1.0 Hz the average speed was medium, 9.0 cm/s. At 2.0 Hz, the average
169 speed was fast, 18.0 cm/s. Each trial lasted nine seconds and each condition was repeated ten
170 times in a randomised order, for a total of sixty trials. Participants practiced each condition for
171 a total of six trials before data were recorded.

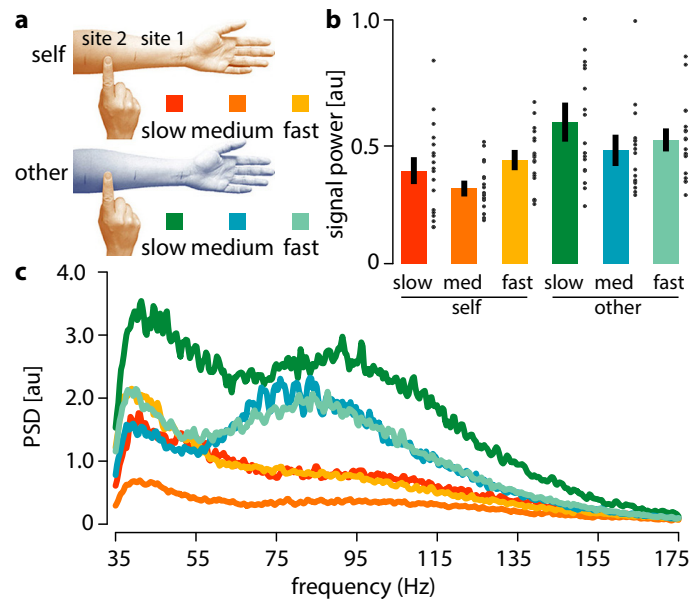


Fig. 3 Experiment 2. a: Experimental design: Touching was performed at three different speeds ('slow', 'medium', 'fast'), in random order between site 1 and 2; The target could be either 'self' or 'other'; resulting in six conditions (colour coded). **b:** Total signal power of frictional fluctuations per target and speed condition. Black dots show individual results. Error bars show standard error of the mean (SEM). **c:** Averaged power spectral density (PSD) across all trials and participants over all targets and speeds.

172 **Results.** Overall, a main effect of speed was observed ($F(1.457, 24.768) = 6.350, p = 0.011,$
173 $\eta_p^2 = 0.272$) with more signal power at the highest speed, a main effect of target ($F(1, 18) =$
174 $12.489, p = 0.003, \eta_p^2 = 0.424$), with more signal power when touching another person rather
175 than the self, but no significant interaction ($F(1.352, 22.980) = 2.910, p = 0.091, \eta_p^2 = 0.146$;
176 Fig. 3b). Differences between slow and medium speeds and between medium and fast speeds
177 were found ($t(18) = 3.042, p = 0.007; t(18) = -4.772, p < 0.001$, respectively). The effect of tar-
178 get obtained here was likely due to an experimenter bias since additional analysis revealed an
179 interaction between experimenter and target difference ($F(1, 16) = 11.757, p = 0.003, \eta_p^2 = 0.424$)
180 as well as a marginal main effect of target ($F(1, 16) = 3.583, p = 0.077, \eta_p^2 = 0.183$); with higher

181 power associated with one of the two experimenters (see Supplementary Fig. S1).

182 A frequency band analysis indicated a main effect of bands ($F(1.846, 31.389) = 12.606$,
183 $p < 0.001$, $\eta_p^2 = 0.426$), a main effect of target ($F(1, 17) = 9.202$, $p = 0.007$, $\eta_p^2 = 0.351$), a main
184 effect of speed ($F(1.407, 23.913) = 5.566$, $p = 0.018$, $\eta_p^2 = 0.247$), an interaction between target
185 and bands ($F(2.082, 35.394) = 6.176$, $p = 0.005$, $\eta_p^2 = 0.266$), an interaction between speed and
186 bands ($F(2.411, 40.992) = 4.232$, $p = 0.016$, $\eta_p^2 = 0.199$) but no interaction between target and
187 speed and no three-way interaction with bands ($F(1.972, 33.521) = 1.690$, $p = 0.200$, $\eta_p^2 = 0.090$,
188 see Fig. 3c). The self-other difference was seen in the bands between 55 Hz and 155 Hz (55–
189 75 Hz: $F(1, 17) = 11.197$, $p = 0.004$, $\eta_p^2 = 0.397$; 75–95 Hz: $F(1, 17) = 11.993$, $p = 0.003$, $\eta_p^2 =$
190 0.414 ; 95–115 Hz: $F(1, 17) = 10.635$, $p = 0.005$, $\eta_p^2 = 0.385$). However, the effect of speed and
191 the interaction between speed and target did not survive Bonferonni correction ($\alpha = 0.0074$) in
192 any of the bands.

193 Experiment 3

194 Experiment 3 investigated whether the signal varied with the orientation of the target hand
195 since the location of the sensor relative to target may have influenced the signal.

196 Methods

197 **Participants.** A new group of eighteen right-handed participants completed the experiment
198 (nine females, mean age: 23.6 years, SD = 3.6). Participants were invited to take part in the
199 experiment in dyads, but they did not know each other. As in Experiments 1 and 2 gender was
200 balanced across dyads.

201 **Procedure.** As in Experiment 1, participants were seated opposite each other on either side
202 of a table approximately one meter apart. The accelerometer was placed on the right index
203 finger of one participant of the dyad, who would be the participant performing the touch. The
204 accelerometer was fixed in the same position as in Experiments 1 and 2, thus distance between
205 the sensor and the regions of contact varied with target orientation. Participants performed the
206 same action as in Experiment 1 (precision grip), with the sole difference being the orientation
207 of the touched index finger (i.e. target orientation; see Fig 4a). In the ‘outwards’ condition,
208 the palm of the target hand faced away the toucher (i.e. the active index of the toucher was
209 in contact with the glabrous skin on the ventral side of the target finger, and the thumb with
210 the hairy skin on the dorsal side). In the ‘inwards’ condition, the palm of the target hand
211 faced towards the toucher (i.e. the reversed configuration). As in Experiment 1 and 2, the

212 'toucher' was instructed to stroke their own left index finger ('self' condition) or the finger
213 of the other participant ('other' condition). No tonicity instruction was given. Participants
214 were encouraged to keep a constant speed by the same method as in Experiment 1. Each
215 condition was repeated ten times for a total of forty randomised trials. After those trials, the
216 two participants interchanged places and the accelerometer was attached to the new toucher.

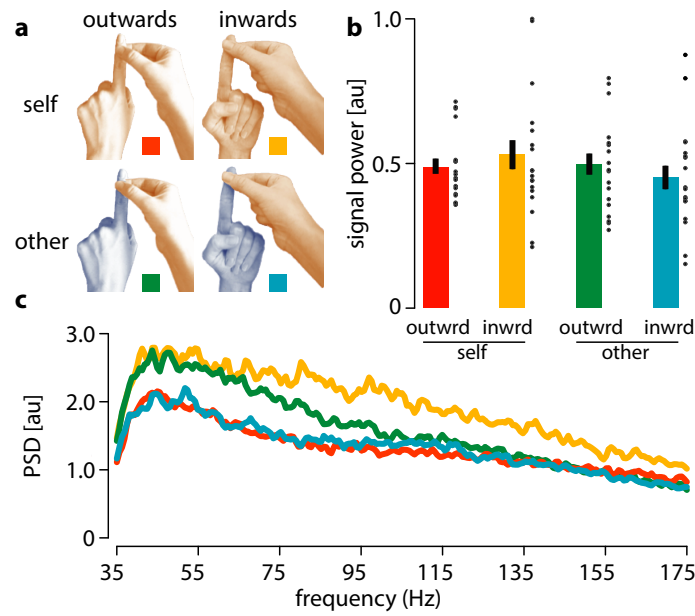


Fig. 4 Experiment 3. **a:** Experimental design: Target orientation could be 'outwards' or 'inwards', target could be either 'self' or 'other'; resulting in four conditions (colour coded). **b:** Total signal power of frictional fluctuations per target and target orientation; Black dots show individual results. Error bars show standard error of the mean (SEM). **c:** Averaged power spectral density across all trials for each condition.

217 Results

218 The results showed no effect of target and no effect of target orientation (target: $F(1, 17) =$
219 $1.724, p = 0.207, \eta_p^2 = 0.092$; target orientation: $F(1, 17) = 0.002, p = 0.969, \eta_p^2 = 0.000$),
220 but they showed an interaction between target and skin type ($F(1, 17) = 6.393, p = 0.022,$
221 $\eta_p^2 = 0.273$), see Fig. 4b. However, none of the post-hoc t -test survived Bonferroni correction,
222 suggesting no significant impact of the orientation of the target.

223 An analysis by frequency bands, Fig. 4c, revealed a main effect of bands ($F(1.513, 25.725) =$
224 $27.472, p < 0.001, \eta_p^2 = 0.618$), an interaction between target and skin type ($F(1, 17) = 5.239,$
225 $p = 0.035, \eta_p^2 = 0.236$), and a three-way interaction with bands ($F(1.815, 30.860) = 5.221,$
226 $p = 0.013, \eta_p^2 = 0.235$). Follow-up analyses did not yield to any significant results (no main

227 effect of target, skin nor interaction survived the Bonferroni correction).

228 Discussion

229 Skin-to-skin touch is challenging to measure objectively, yet it presents a number of intriguing
230 problems that span neuroscience, psychology and philosophy. Here, we tested the efficacy of a
231 new measure of skin-to-skin tactile behaviour that took advantage of the frictional fluctuations
232 propagating in soft tissues (Shao et al., 2016, 2020). Participants were instructed to stroke skin
233 surfaces while an accelerometer was fixed to their touching finger. The recorded signal con-
234 tained information about the vibrations elicited during touch. Participants varied the tonicity
235 of their touch, their movement speed, the orientation of the target, as well as the target identity
236 (self-touch vs. touching another's skin).

237 The analysis relied on the total signal power and the distribution of this power in specific
238 frequency bands. The signal exhibited considerable variability between individuals, however
239 this limitation is shared by most other physiological signal measurements including pupil di-
240 lation, e.g. (Einhäuser et al., 2008; Wierda et al., 2012), skin conductance, e.g. (Tronstad et al.,
241 2010; van Dooren et al., 2012), electromyography, e.g. (Goldenberg et al., 1991), respiration,
242 e.g. (Boiten et al., 1994; Valderas et al., 2015) and heart-rate, e.g. (Appelhans and Luecken, 2006;
243 Garfinkel et al., 2015). Despite high inter-individual variability, useful information could be
244 extracted from the signal, allowing comparisons across experimental conditions.

245 Experiment 1 showed a clear effect of touch tonicity when participants were instructed to
246 apply either gentle or firm pressure. The signal power was significantly higher during firm
247 compared to gentle touch. This demonstrates that a consumer-grade accelerometer is able to
248 capture tactile signals and can be used as a proxy of the force applied during skin-to-skin touch.
249 Therefore, the method is able to detect differences in the tonicity of skin-to-skin touch.

250 Experiment 2 showed that the signal was sensitive to the speed with which participants
251 touched the skin. The relationship between sliding speed and signal power was however com-
252 plex. The medium speed (9 cm/s) elicited significantly lower signal power than the faster speed
253 (18 cm/s) and the slower speed (3 cm/s). There may be several reasons why the relationship
254 between movement speed and signal power was not monotonic. Participants probably moved
255 less smoothly at slower speeds (Guigon et al., 2019). Jerky movements may have caused bursts
256 of signal at the slowest speed. The observation of greater signal power at the highest speed
257 (18 cm/s) is in line with our initial hypothesis since greater frictional energy was dissipated
258 during the same time window.

259 The positioning of a single sensor relative to the source of contact may have had an effect

260 on the signal obtained, particularly with differences across experimental conditions. Experi-
261 ment 3 assessed the influence of target orientation on the signal obtained during skin-to-skin
262 touch. In Experiment 1, participants gripped the finger when it was oriented with the dorsal
263 surface facing towards them. In Experiment 3, the target orientation was manipulated to ei-
264 ther be the same, as in Experiments 1, or oriented with the ventral surface facing toward the
265 toucher. The signal power did not vary systematically with target orientation, suggesting that a
266 similar signal would have been obtained from a sensor placed on the active thumb rather than
267 active index finger. In practice, this means that experimenters are not constrained by specific
268 placements of the sensor on the hand.

269 Several lines of evidence suggest that we may touch ourselves differently from others, this
270 is the case, for example in the “touchant-touché” phenomenon ([Husserl, 1989](#); [Merleau-Ponty,](#)
271 [1962](#); [Schütz-Bosbach and Haggard, 2009](#)). The literature also suggests that self-generated
272 touch is perceived to be less intense than externally generated touch ([Blakemore et al., 2000](#);
273 [Shergill et al., 2003](#); [Bays, 2008](#)). In Experiments 1 and 3, participants touched themselves or
274 another person in dyads. The target had no influence on signal power. In Experiment 2, one
275 of two experimenters was the ‘other’ target. Stronger signal power was found when partici-
276 pants touched another person. Further analyses revealed that the signal was higher with one
277 of the two experimenters. Overall, our results did not show clear differences between touching
278 one’s own skin compared to another person’s skin. This finding may seem surprising given the
279 known differences between touch applied to one’s own compared to another person’s skin ([Ver-](#)
280 [rillo et al., 2003](#); [Ackerley et al., 2012](#)). However, the lack of difference may reveal the existence
281 of a robust motor invariant that is insensitive to the target of touch, particularly under the
282 conditions of Experiment 1. Several motor invariants related to motor tonicities have been doc-
283 umented [Feldman \(1980\)](#); [Latash et al. \(2007\)](#). In Experiment 2, having only two ‘other’ targets
284 may have reduced variability and introduced additional factors such as skin hydration and also
285 possible gender effects (that were balanced in Experiment 1 and 3, as shown in Supplementary
286 Fig. S1). This result suggests that our method could be applied to differentiate between targets.
287 Future studies could investigate the relative advantages of various stroking actions to extract
288 specific types of information from the vibration signal.

289 Our results were obtained using spectral density analyses, including total signal power
290 and power spectral density in broad frequency bands. However, in natural touch, cutaneous
291 vibrations are almost always non-stationary signals, which means that the generating processes
292 varies over time. In our study, power spectral density analyses were adequate for the investi-
293 gated factors because the participants were instructed to repeat the same action over relatively
294 long periods of time. Future research based on the analysis of time-varying phenomena could

295 certainly be possible, for example, with short-time Fourier analysis.

296 Future research may be also be aimed at estimating the source of touch, or even the type of
297 action executed, from vibrations signals measured in the hands. Blind source separation anal-
298 ysis techniques (Comon and Jutten, 2010) could be used since the frictional fluctuations come
299 from sources arising from phenomena associated to different length scales. Another direction
300 would be to increase the number of accelerometer sensors across the hand as in Shao et al.
301 (2016, 2020) who used up to thirty sensors. Finally, an abundance of tools based on machine
302 learning techniques are now available that are able to extract information from complex sig-
303 nals. Such methods could be used to decode behavioural interactions from the resulting tactile
304 vibrations.

305 To conclude, the results demonstrated the direct measurement of cutaneous vibrations re-
306 sulting from friction elicited by skin-to-skin contact. We showed that the signal is primarily
307 sensitive to the tonicity and the speed of tactile interactions. The measure has significant po-
308 tential for probing behaviour during skin-to-skin tactile interactions, opening avenues for fu-
309 ture research investigating a variety of factors underlying self-touch as well as social touch and
310 motor control.

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313 Mastery” led by Alessandro Farné. The authors declare that no competing interests exist.

314 **Open practice statement** The data for all experiments are available on the OSF repository
315 and can be accessed via this link:

316 https://osf.io/7gw5z/?view_only=7d351d4a7b6a443392157da6bb643a90

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428 **Supplementary Information**

429 Half of the participants in Experiment 2 were tested with a male experimenter as target and
430 the other half with a female experimenter. Higher signal power was observed when the partic-
431 ipants touched the male experimenter compared to the female experimenter. Gender did not
influence how they touched their own forearm.

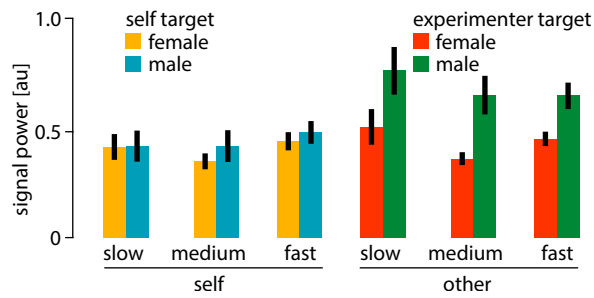


Fig. S1 Experimenter effect in Experiment 2.

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