

# Harnessing Tactile Waves to Measure Skin-to-Skin Interactions

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## 1 Abstract

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

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

## 16 Introduction

17 Skin-to-skin touch has broad implications for the sense of self (Merleau-Ponty, 1962; Crucianelli  
18 et al., 2013), body representation (Schütz-Bosbach and Haggard, 2009; van Stralen et al., 2014),  
19 affective touch (McGlone et al., 2014; Cascio et al., 2019) and motor control (Blakemore et al.,  
20 2000; Bays, 2008). It is thus connected to intriguing problems across the domains of philosophy,  
21 psychology, and neuroscience. However, to date, no empirical method is capable of measuring  
22 how we touch the skin of a living person. Even a seemingly straightforward parameter such as  
23 the tonicity of skin-to-skin touch is outside the reach of objective measurement.

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

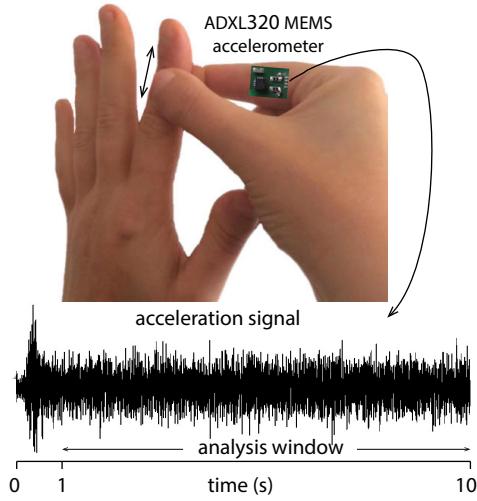
33 When the touched surface is the skin, it is not possible to measure the interaction by in-  
34 terposing an instrumented membrane between the skins since the properties of the skin con-

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

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

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

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

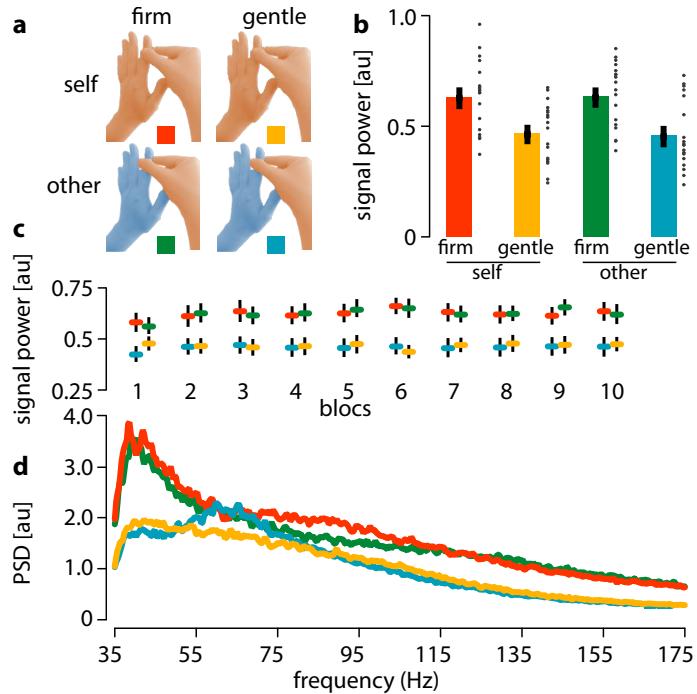
## 88 Methods

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. Participants  
93 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 (Wiertlewski 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 ( $F(1, 17) = 2.942, p = 0.011, \eta_p^2 = 0.148$ ). Follow-up tests showed a significant effect of tonicity for all bands above 95 Hz  
146 (all  $p < 0.001$ ), as well as effects for the 35–55 Hz and 75–95 Hz bands (respectively:  $F(1, 17) = 9.301, p = 0.007, \eta_p^2 = 0.354$  and  $F(1, 17) = 8.966, p = 0.008, \eta_p^2 = 0.345$ ), but there was no  
147 significant differences in the 55–75 Hz band ( $F(1, 17) = 1.130, p = 0.303, \eta_p^2 = 0.062$ ).

## 150 Experiment 2

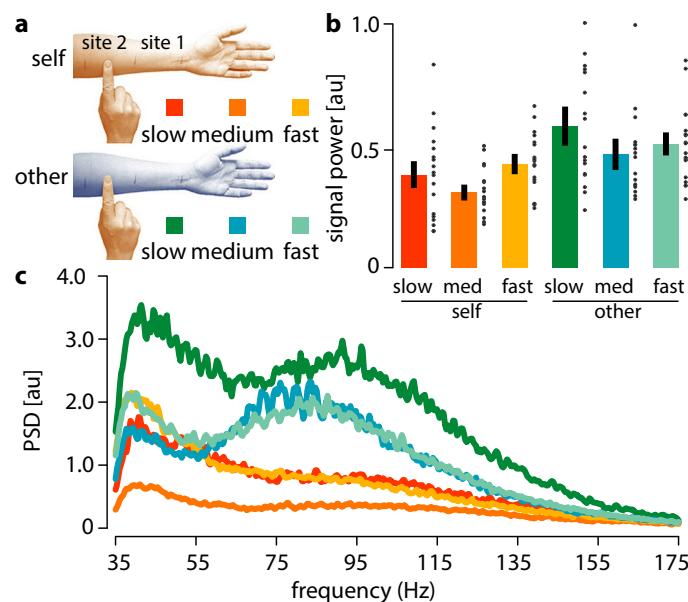
151 The second experiment was designed to determine whether skin-to-skin, friction-induced vi-  
152 brations were sensitive to differences in the magnitude of the sliding speed.

## 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 Bonferroni correction ( $\alpha = 0.0074$ ) in  
192 any of the bands.

### 193 Experiment 3

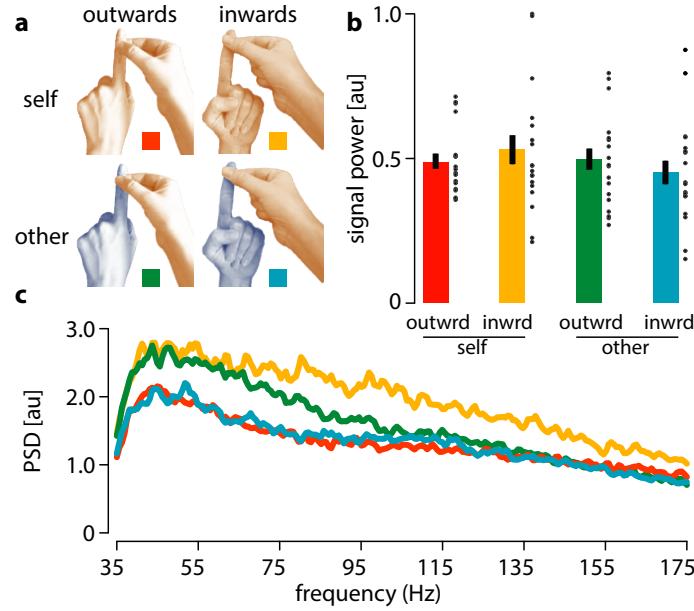
194 Experiment 3 investigated whether the signal varied with the orientation of the target hand  
195 since the location of the sensor relative to target may have influenced the signal.

### 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 tonicity 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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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](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.

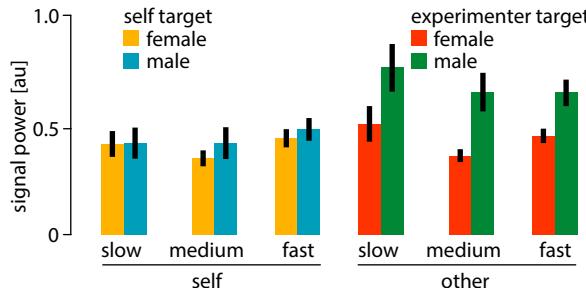


Fig. S1 Experimenter effect in Experiment 2.