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Supplementary Information for

Tactile suppression stems from specific sensorimotor predictions

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Supplementary Methods

Sample size considerations

The sample size was determined through an a priori power analysis based on the size of the congruency effect found in a previous pilot (*N* = 10). According to those data, to find an effect of congruency in the size of $\eta_p^2 = .21$, given $\alpha = .05$ at a power $(1-\beta) = .81$, 31 participants were needed (1). The sample size was eventually set to 32 to allow for even randomization of the sequences of the four blocks.

Stimulation amplitudes

The tactile stimulation device was activated via a serial port. The delay between activating the stimulation device and the output of the vibration was on average 1 ± 7 ms. We determined the stimulus amplitudes (see Table S1) for the 40 Hz and 240 Hz probe frequencies in two pilot studies. In a first pilot study (*N* = 10) with identical oscillation amplitudes for both probe frequencies, we observed higher detection thresholds and higher suppression of low than high frequency probes. This resulted in a high number of threshold estimations that exceeded the range of presented stimulus intensities and negatively affected threshold estimations. Therefore, in a second pilot study (*N* = 6), we tested separate amplitudes for each probe frequency in order to obtain threshold estimations approximately halfway the range of the presented stimulus amplitudes for each probe frequency.

Practice trials

Before the start of the first movement block, all participants performed two blocks of practice trials to train the stroking movements along an entirely smooth object at average speeds of 203 mm/s. In the first of these two practice blocks, no probes were presented. Otherwise, the procedure corresponded to the trials of the movement condition but included visual feedback: During the movement, the finger position was represented by a vertical, red line. To give participants online feedback on their movement, vertical, blue lines moved across the scene at the required speed, allowing for variations in reaction time. Thus, if participants moved at a constant pace relative to these blue lines, they were adhering to the appropriate speed. The second practice block did not include the above-mentioned visual feedback and was similar to the movement conditions, except that we presented probes of an intermediate frequency (140 Hz) at varying amplitudes combined with a smooth object. This frequency of 140 Hz was used for two reasons: first, to avoid pre-emptively giving participants practice with one of the frequencies used during the movement blocks. Second, to avoid presenting two frequencies within one practice block to be consistent with the upcoming movement blocks that contained probes of only one frequency each.

Protocol for online feedback and trial repetition

In the movement conditions and the practice blocks, trials were marked as invalid if participants moved either too fast (exceeding an average lateral velocity of 267 mm/s) or too slow (falling below an average lateral velocity 140 mm/s) along a section of the object (0.5 cm to the right of the go position until 1 cm to the left of the object's right border). These lower and upper speed limits were based on a pilot study (N = 10) in which different participants were asked to discriminate between the objects used in the present study and objects with higher and lower spatial frequencies. The limits were defined as speeds resulting in fundamental frequencies of 40 Hz (and 240 Hz respectively) ± 1.5 times the frequency necessary to discriminate between two objects as assessed in that pilot. Trials were also marked as invalid when the go position was crossed before the go cue was given. These invalid trials were repeated later by being randomly interleaved with the remaining trials of the block. On average, 9 ± 6% of trials were repeated in the four movement blocks. When an invalid trial occurred, as well as when the average stroking force fell below 1 N, the experimenter gave relevant verbal feedback: During the practice blocks, this feedback was given as needed. During the four movement blocks, the feedback was standardized and given after five mistakes had been made regarding the speed and the force, and after three mistakes when the movement onset was too early.

Calculation of kinematic parameters

Movement onset was defined by first determining the time when a position 0.5 cm to the right of the go position was crossed and then going backwards from this time point to identify when the lateral velocity had first exceeded 0.0067 mm/s. To determine the endpoint of the stroking movement, the Multiple Sources of Information method (2) was applied to look into all frames when the finger applied force to the texture, using probabilistic criteria: a frame was more likely to be defined as the movement end the lower its velocity was and the closer its lateral position was to the rightmost position. The end of the movement was defined as the first frame in which the product of the two above-mentioned criteria was highest.

The reaction time referred to the time between the auditory go cue and the movement onset and the movement duration to the time between the onset and the end of the movement. The force was calculated as follows. First, we filtered the force data to counteract noise: Any frames with force values exceeding 12 N or falling below –2 N were removed. To deal with oscillations, we applied a simple moving average filter with a window size of 60 ms. We then averaged the force data across the entire movement, i.e. from movement onset until movement end. The velocity was defined as the difference in x-position from one frame to the next and divided by the sampling interval of 3 ms. As the force, the velocity data was averaged across the entire movement. The acceleration was defined as the derivative of the velocity, and was averaged across the acceleration phase of the entire movement, i.e. the phase before maximum velocity, and likewise, the deceleration was averaged across the remaining deceleration phase.

Figure S1.

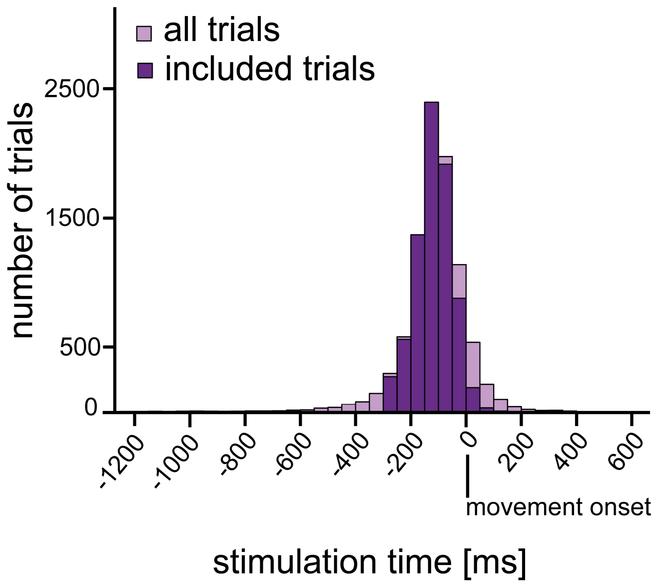


Fig. S1. Stimulation times in relation to movement onset (0 ms). The stimulation times included in the analysis occurred no earlier than 300 ms before movement onset. To avoid any possible backward masking of the probe by the texture, stimulations ending less than 150 ms before the finger reached the texture were excluded (3).

Table S1.

Peak-to-peak displacements of the probe stimuli

40 Hz	140 Hz	240 Hz
7.18 μm	15.17 μm	1.61 μm
15.46 μm	32.95 μm	3.23 μm
23.22 μm	50.82 μm	4.84 μm
30.99 μm	67.50 μm	6.46 μm
38.79 μm	88.14 μm	8.07 μm
46.61 μm	106.30 μm	9.69 μm
54.45 μm	123.25 μm	11.31 μm

Supplementary Results

Signal detection analysis

We calculated the sensitivity measure *d'* (4) separately for each stimulation amplitude in each of the four movement conditions. Extreme response rates of either 0 or 1 were corrected to $\frac{0.5}{n}$ and $\frac{n-0.5}{n}$ respectively, with *n* being the number of stimulation trials (5). To obtain a single measure of *d'* for each movement condition, we averaged *d'* across the stimulation amplitudes and performed a 2 (probe frequency: low vs. high) by 2 (congruency: congruent vs. incongruent) repeated-measures ANOVA. In accordance with our psychometric results, the analysis of the sensitivity measure *d'* confirmed stronger suppression, i.e. lower *d'*, in congruent compared to incongruent conditions (F [1,31] = 3.32, P = .039, η_G^2 = .005, one-sided), while neither the main effect of probe frequency (F [1,31] = 1.02, P = .319, η_G^2 = .006), nor the interaction (F [1,31] = 0.20, P = .655, η_G^2 < .001) reached significance (see Figure S2). Please note that a one-sided interpretation of the congruency effect corresponds to the directed hypothesis about the increased suppression when the predicted frequency generated on the stroking finger matches the frequency of the probe stimulus.

Kinematic parameters

The averaged kinematic parameters in the four movement conditions are depicted in Figure S5. The movement duration averaged across trials and the kinematic parameters averaged across the normalized time courses in the four movement conditions are depicted in Figure S6. None of these measures differed significantly between the probe stimulation frequencies or the congruency (see main text for statistical results).

Figure S2.

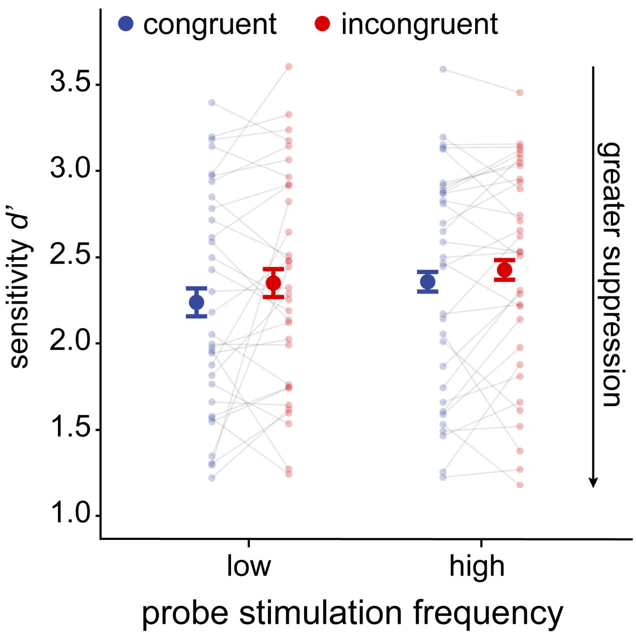


Fig S2. Sensitivity *d'* averaged across participants in all movement conditions and individual data (transparent data points; *n* = 32). Lower values represent greater suppression. The error bars display 95% Cousineau-Morey confidence intervals for the difference between congruent and incongruent conditions within each probe stimulation frequency (6, 7).

Figure S3.

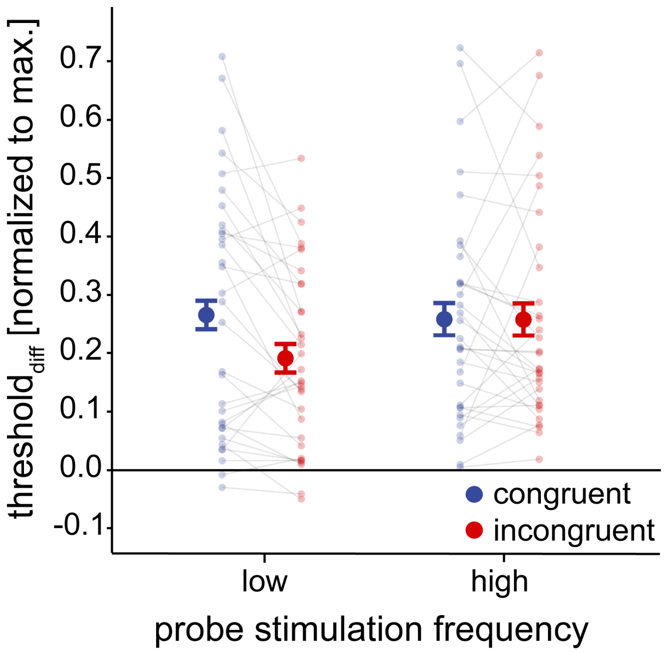
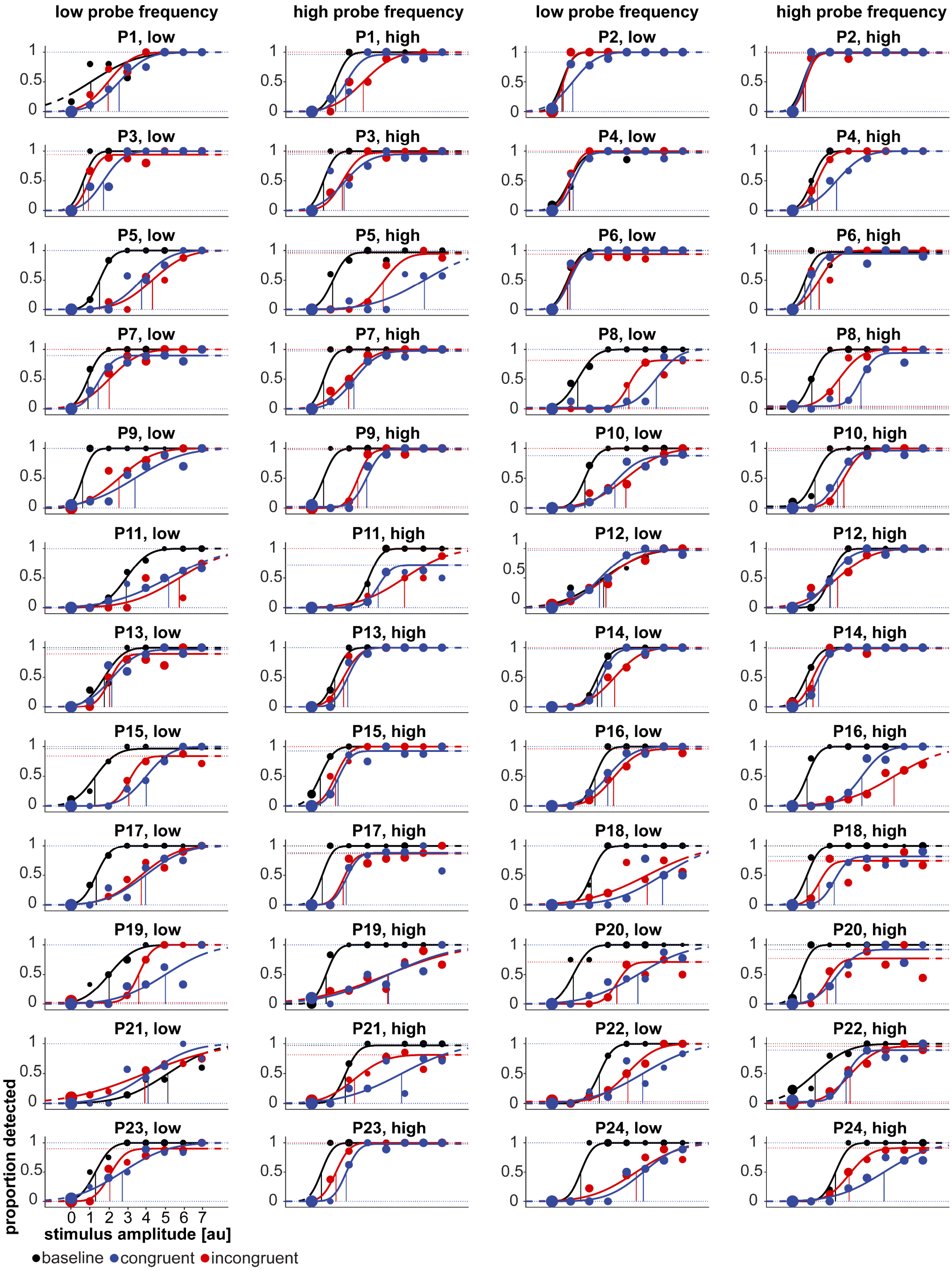


Fig. S3. Thresholds$_{diff}$ without trial exclusion averaged across participants for all movement conditions as well as individual data (transparent data points; *n* = 32). Please note that in the majority of excluded trials, the probe stimulation occurred in close temporal proximity to the object's texture. This influenced the detection of probes in the high frequency incongruent condition in particular, since a larger proportion of trials (77,3%) from that condition was excluded due to the proximity of the probe to the texture than in the other three conditions (low frequency congruent: 74,5%, low frequency incongruent: 73,7%, high frequency congruent: 73,5%). This possible effect of the texture highlights the importance of only including trials outside the influence of backward masking. The error bars display 95% Cousineau-Morey confidence intervals for the difference between congruent and incongruent conditions within each probe stimulation frequency (6, 7).

Figure S4.



low probe frequency
high probe frequency
low probe frequency
high probe frequency
P1, low
P1, high
P2, low
P2, high
P3, low
P3, high
P4, low
P4, high
P5, low
P5, high
P6, low
P6, high
P7, low
P7, high
P8, low
P8, high
P9, low
P9, high
P10, low
P10, high
P11, low
P11, high
P12, low
P12, high
P13, low
P13, high
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P14, high
P15, low
P15, high
P16, low
P16, high
P17, low
P17, high
P18, low
P18, high
P19, low
P19, high
P20, low
P20, high
P21, low
P21, high
P22, low
P22, high
P23, low
P23, high
P24, low
P24, high
1
0.5
0
0 1 2 3 4 5 6 7
stimulus amplitude [au]
proportion detected
baseline congruent incongruent

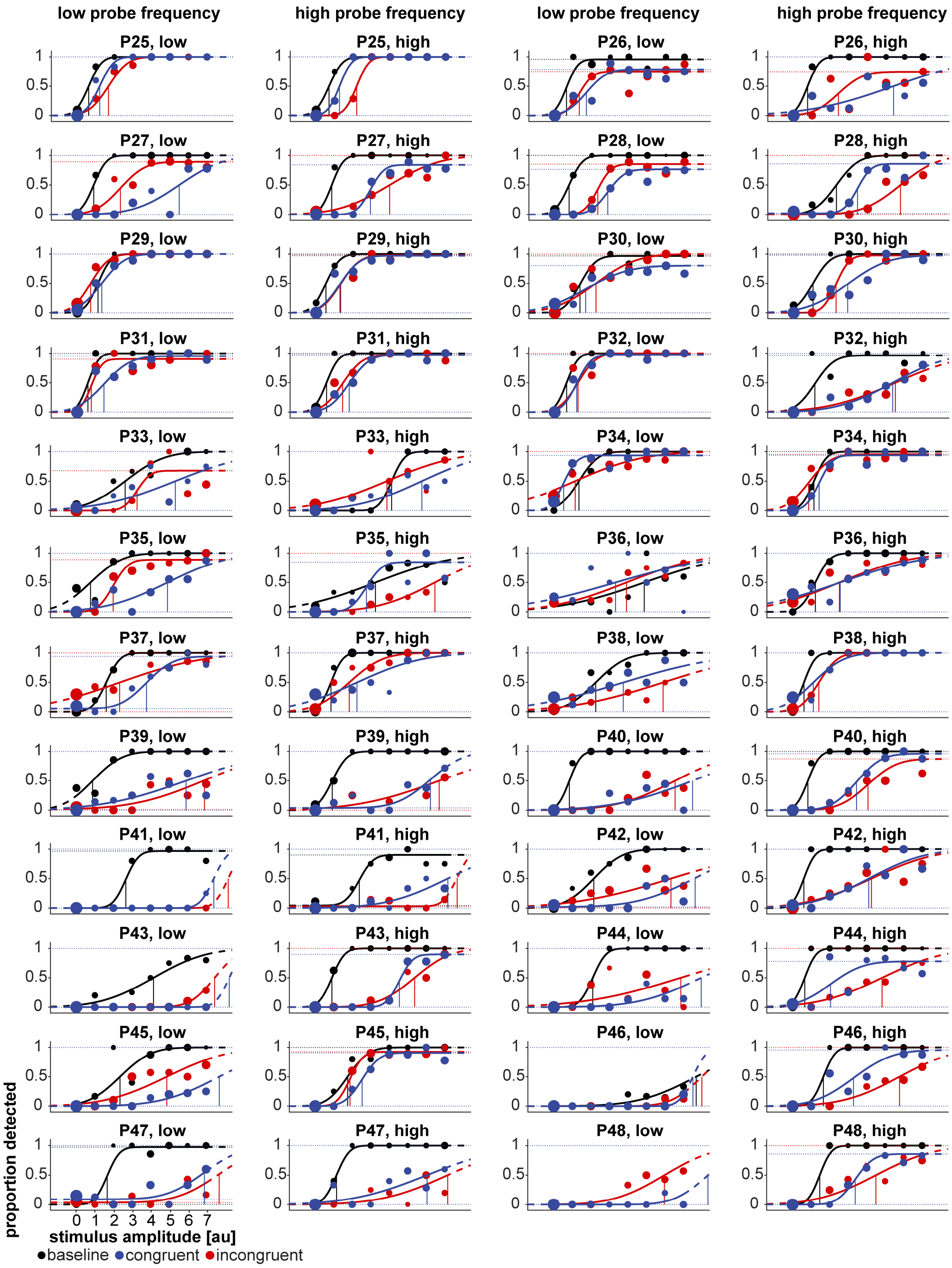

Fig. S4. Individual psychometric functions for all four movement conditions and the respective baseline conditions of all 48 participants. For all participants, trials were excluded according to the exclusion criteria described in the main text (see Material and Methods – Quantification and Statistical Analysis) before fitting the psychometric functions. Some data points or lines may not be visible due to overlap. Participants 1-32 were included in the analysis. Participant 33 was excluded because in one movement condition less than 60% of trials remained after trial exclusion. Participants 34-39 were excluded because they had false alarm rates of 20% or more in any of the conditions considering all performed trials. Participants 40-48 were excluded since they showed detection thresholds that exceeded the range of stimulation in one condition or more. Please note that the low frequency baseline condition of participant 48 could not be plotted because too many trials were missing.

Figure S5.

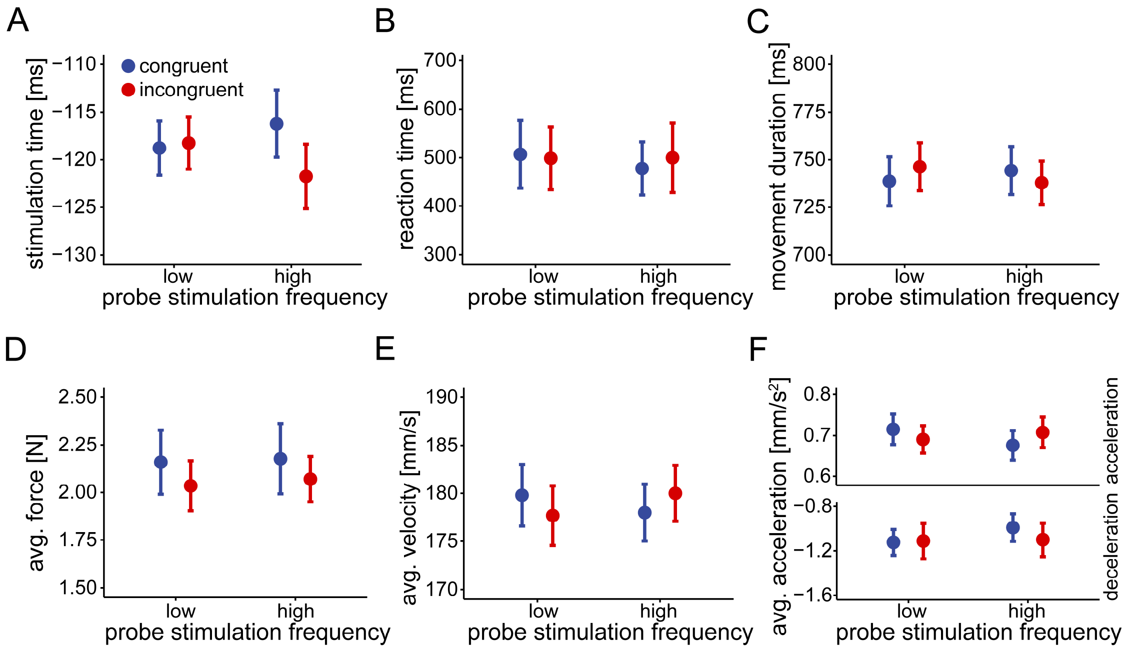

Fig. S5. Kinematic parameters averaged across participants and movement conditions. The error bars display 95% Cousineau-Morey confidence intervals for the differences between all four conditions (6, 7). *(A)* Stimulation time relative to movement onset. *(B)* Reaction time. *(C)* Movement duration. *(D)* Force averaged across the movement. *(E)* Velocity averaged across the movement. *(F)* Averaged acceleration and deceleration. None of these movement parameters showed statistically significant differences between the conditions.

Figure S6.

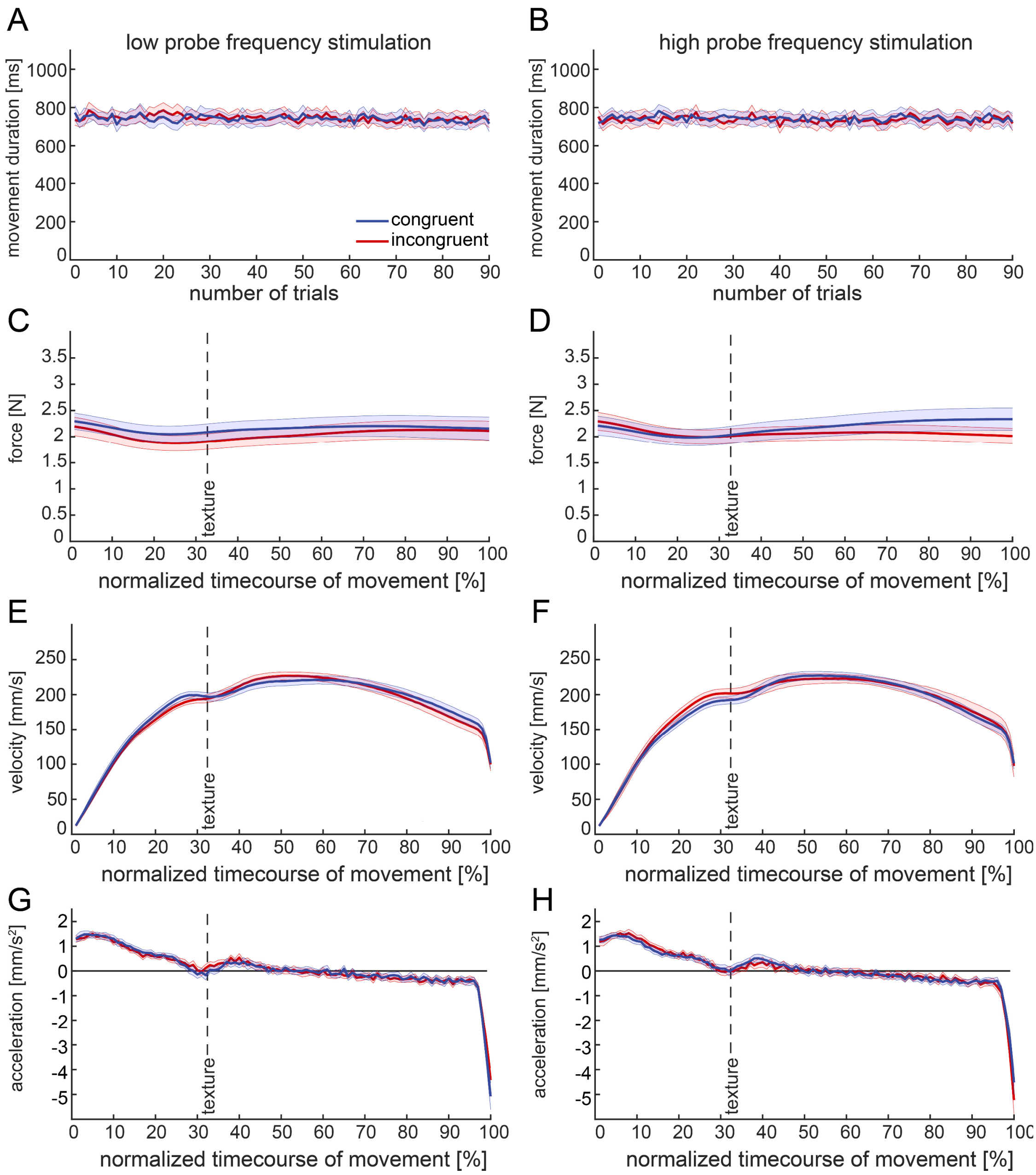

Fig. S6. The movement duration averaged across participants for each trial of the conditions involving (*A*) the low frequency probe stimulation and (*B*) the high frequency probe stimulation. The kinematic parameters averaged across participants for the normalized time course of the movement. (*C*) Force (low frequency probe stimulation conditions). (*D)* Force (high frequency probe stimulation conditions). (*E*) Velocity (low frequency probe stimulation conditions). (*F)* Velocity (high frequency probe stimulation conditions). (*G)* Acceleration (low frequency probe stimulation conditions). (*H*) Acceleration (high frequency probe stimulation conditions). The shaded error bars display 95% Cousineau-Morey confidence intervals for the differences between all four conditions (6, 7).

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