Face-hand interactions revealed by afferent inhibition

Electrocutaneous stimulation to the face inhibits motor evoked potentials in the hand: face-hand interactions revealed by afferent inhibition

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Abstract

Reorganization of the sensorimotor cortex following amputation and other interventions has revealed large-scale plastic changes between the hand and face representations. To investigate whether hand-face interactions are also present in the normal state of the system we measured sensorimotor interactions between these two areas using an afferent inhibition transcranial magnetic stimulation (TMS) protocol in which the TMS motor evoked potential (MEP) is inhibited when it is preceded by an afferent stimulus. We hypothesized that if hand-face interactions exist in the normal state of the system then stimulation of the face would inhibit hand MEPs. In two separate experiments we delivered an electrocutaneous stimulus to either the right upper lip (Experiment 1) or right cheek (Experiment 2) and recorded muscular activity from the right first dorsal interosseous (FDI). Both lip and cheek stimulation inhibited FDI MEPs. To investigate the specificity of this effect we conducted two additional experiments in which cutaneous stimulation was applied to either the right forearm (Experiment 3) or right arm (Experiment 4). Neither forearm nor arm stimulation inhibited FDI MEPs. These data provide the first evidence for face-to-hand afferent inhibition and we suggest that the mechanisms underlying these sensorimotor interactions could contribute to face/hand interactions observed following sensorimotor reorganisation.

Introduction

The sensory and motor cortices contain somatotopic maps of body areas and muscles. The medio-lateral organization of these maps is such that the lower limb is represented medially followed by the trunk, upper limb, and most laterally the hand and face. The face and hand representations differ from those of other body parts because their proximity within the maps contrasts starkly with their separation in the physical body. Furthermore, the extensive area devoted to processing stimuli or controlling musculature from these two body parts is disproportionate to their physical size [1,2].

The physical proximity of the face and hand within somatosensory and motor maps is thought to underlie the plasticity that has been documented following a reduction of sensorimotor inputs from the hand. For example, many studies have found that amputation or temporary nerve block of the hand induces an enlargement and shift of the face's sensorimotor representation [3–7]. This plasticity is paralleled by behavioural changes like referred sensations in the phantom hand following face stimulation in hand amputees [5,8], phantom limb pain (Karl et al. 2001), face-hand somatosensory extinction after hand allograft [9], or improved two-point discrimination in the upper lip after anaesthesia of hand nerves (median and radial nerves) [4]. While this plasticity has typically been interpreted as resulting from the reduction of inputs, an alternative hypothesis posits that it is driven instead by increased input from other body parts, for example by overuse of the non-amputated hand following upper-limb amputation [10].

In line with the idea that plasticity can also be induced by increased input, our group has demonstrated in healthy subjects that plasticity between the face

and hand is not restricted to instances of reduced input, but can also occur after an *increase* in somatosensory inputs. Using repetitive somatosensory stimulation at the right index finger tip Muret et al. (2014) found improved two-point discrimination at the stimulated fingertip but also on the cheek and upper lip. This "transfer" of behavioural improvement was accompanied by alterations in both hand and face representations in the sensory cortex [12].

Face-hand interactions at the somatosensory level are not restricted to situations involving plasticity, but also occur when the system is in its "normal" state. For example, Tanosaki et al., (2003) found that somatosensory evoked magnetic fields induced by electrical stimulation of the thumb were altered when there was concurrent tactile stimulation of the upper face. These findings raise the question of whether face-hand *sensorimotor* interactions might also exist in physiological conditions, in which case they could represent one of the mechanisms underlying both large-scale amputation-induced plasticity as well as temporary, experimentally-induced plasticity, like that observed after repetitive somatosensory stimulation or anaesthesia.

We assessed Short-latency Afferent Inhibition (SAI) to test for the existence of face-hand sensorimotor interactions under normal physiological conditions. SAI is the reduction in the amplitude of a muscle response (evoked by TMS of the motor cortex) when motor cortex stimulation is preceded by an afferent stimulus [14–25]. This protocol can provide information about latent sensorimotor interactions between body parts [26–29], and has been widely used to examine sensory interactions *within* the same body part. For example, hand muscle responses are strongly inhibited following stimulation of hand nerves or the skin on the fingertip [14,15,24,25,27,28,16–23], especially when the stimulus

is given close to the target muscle [30], and topographic information can be preserved in the sensory-to-motor inhibitory pattern [31]. Similarly, stimulation of the shoulder area inhibits responses in the shoulder muscle infraspinatus [32], and stimulation of the dorsal surface of the foot inhibits responses in the leg muscle tibialis anterior [29]. Afferent inhibition can also occur when the muscle of interest and the sensory stimulation site are within the same body part but anatomically separate. For example, stimulation of the index fingertip inhibits various muscles of the arm and forearm on the same side as the fingertip stimulation [28], and can also inhibit hand muscles on the opposite side of the body [29].

To date, there is no evidence for the existence of SAI between body parts, although the only combinations examined have been the lower and upper limbs [28]. Here we investigated if and when SAI exists between the face and the hand, as it is known that these anatomically distant body parts have strong interactions both under normal physiological conditions and following a plasticity-inducing manipulation. SAI is typically considered to occur at a latency related to the delay of arrival of the afferent information at the motor cortex. For example, following fingertip stimulation, maximal inhibition is observed between 25 and 35 ms. This assumption is based upon within-body part SAI, however, there are currently no data indicating whether a similar rule applies for SAI between body parts. Furthermore, the results of the only study that investigated SAI within the face suggest that face stimulation might not follow this same rule, as there was some evidence of face-face SAI at 30ms but none at shorter (expected) ISIs [22]. Thus, the aim of the experiments presented here was to 1) establish **if and when** afferent inhibition exists between two anatomically separate body parts: the face

and the hand; and 2) whether this between body-part inhibition is specific to the face and the hand or is also present between the forearm or upper-arm and the hand.

Materials and Methods

Participants

Forty-four healthy right-handed volunteers were included in four separate experiments. It is important to note that each experiment was independent of the others, as the aim of this study was to investigate if and when SAI exists between a given body part and the right FDI, not to compare the amount or latency of SAI between the four stimulated sites. Fourteen individuals participated in Experiment 1 (mean age of 22.7 ± 7.1 years, 5 males), 12 in Experiment 2 (mean age of 23.7 ± 6.7 years, 3 males), 15 in Experiment 3 (mean age of 25.5 ± 6.4 years, 2 males) and 13 in Experiment 4 (mean age of 24.8 ± 3.9 years, 3 males). Four subjects participated in two experiments (1 & 2 (n=2); 1 & 3 (n=1); 3 & 4 (n=1)) and 3 subjects participated in 3 experiments (1, 2 & 3 (n=1); 1, 3 & 4 (n=1); 2, 3 & 4 (n=1)). All participants gave written informed consent. The protocol was approved by the ethical committees of the Grenoble University Hospital (ID RCB: 2016-A01668-43) and the *Comité de protection des personnes* (CPP) SUD EST IV (ID RCB: 2010-A01180-39) and conformed to the ethical aspects of the Declaration of Helsinki.

General experimental procedures

149 In each of the four experiments participants were comfortably seated with
150 their arm resting on an armrest (elbow flexed at 90°) and a single tactile electrical
151 stimulus was applied prior to a single transcranial magnetic stimulation pulse over
152 the hand area of the left motor cortex. The tactile stimulus was applied to the right
153 upper lip (Experiment 1), right cheek (Experiment 2), right forearm (Experiment
154 3), or right arm (Experiment 4). In all four experiments electromyographic activity
155 was recorded from the right first dorsal interosseous (FDI) and the inter-stimulus
156 intervals (ISIs) between the electrocutaneous stimulus and the TMS pulse were
157 15, 25, 35, 45, 55, 65, 75 and 85 ms. In all four experiments 14 trials of each ISI
158 plus 34 TMS-only trials were presented in a random order with an inter-trial
159 interval between 5 and 8 seconds. Every 24 trials the experiment was paused to
160 give a short break to the participant. Experiments 1 and 2 were conducted in the
161 IMPACT team (Lyon, France) and Experiments 3 and 4 in the IRMaGe MRI and
162 Neurophysiology facilities (Grenoble, France).
163

164 ## Electrical Stimulation

165 Single pulse electrocutaneous stimuli (square wave, 200 μs) were
166 delivered via a constant current stimulator (DS7A, Digitimer Ltd, UK) using bipolar
167 adhesive electrodes (Neuroline 700, Ambu, Copenhagen, Denmark) placed on
168 the face (Experiments 1 & 2) or the upper limb (Experiments 3 & 4). The sensory
169 perception threshold (SPT) for each stimulation site was determined as the
170 minimum stimulation intensity at which the subject reported feeling the stimulation
171 on 2 out of 3 trials. Sensory afferent inhibition protocols always use non-painful
172 stimuli and typically use intensities between 2 and 3 times SPT [14,26,28,31,33].
173 Tamburin et al. (2001) showed that stimulation applied to the tip of the little finger

174 at 3xSPT produced inhibition in abductor digiti minimi comparable to that
175 recorded at 5xSPT, and Bikmullina et al. (2009) showed that when stimulation
176 was applied to the index finger inhibition in arm and forearm muscles was greater
177 at 3xSPT than at 1x or 2x. The electrocutaneous stimulus intensities used in each
178 experiment are shown in Table 1 and the Kruskal-Wallis test by ranks revealed
179 no difference between the absolute stimulus intensity used in each of the four
180 experiments (p= 0.15).

181

182 **Table 1. Average electrocutaneous and TMS stimulus intensities used in**
183 **each of the four experiments, plus average TMS-only amplitude of FDI**
184 **MEPs (mean ± SEM).**

Exp.	ES location	ES intensity (mA)	rMT (%MSO)	1mV intensity (%MSO)	TMS-only (mV)
1	Upper Lip	4.1 ± 0.5	40 ± 1.0	44 ± 2.0	0.9 ± 0.1
2	Cheek	5.0 ± 0.4	39 ± 0.1	43 ± 0.2	1.0 ± 0.2
3	Forearm	4.6 ± 0.2	45 ± 3.6	57 ± 4.6	1.1 ± 0.1
4	Arm	4.1 ± 0.3	47 ± 2.8	59 ± 3.6	1.1 ± 0.1

185 ES: Electrocutaneous Stimulation; rMT: resting Motor Threshold; MSO:
186 Maximum Stimulator Output; TMS-only: FDI MEP amplitude in the absence of
187 electrocutaneous stimulation.

188

189 Experiment 1: SAI between the right upper lip and the right FDI

190 Two electrodes were placed side-by-side horizontally, separated by 1 cm,
191 over the right upper lip with the more medial electrode close to the phitral ridge.

Stimulation was delivered at 2xSPT because higher intensities were reported as painful in the majority of subjects.

Experiment 2: SAI between the right cheek and the right FDI

Two electrodes were placed 1 cm apart vertically, at the approximate midpoint between the right ear and the right corner of the mouth. As for the upper-lip, stimulation was delivered at 2xSPT because higher intensities were reported as painful in the majority of subjects.

Experiment 3: SAI between the right forearm and the right FDI

Electrodes were placed 1 cm apart on the anterolateral face of the forearm in the middle of the proximal third of the forearm on the skin overlying the extensor carpi radialis. Stimulation was delivered at 3xSPT.

Experiment 4: SAI between the right arm and the right FDI

Electrodes were placed 1.5 cm apart on the medial face of the arm in the middle of the proximal third of the upper arm on the skin overlying the border between the biceps and the triceps. As for the forearm, the stimulation was delivered at 3xSPT.

Transcranial magnetic stimulation (TMS) and electromyography (EMG)

TMS was applied over the left motor cortex and EMG activity was recorded from the right FDI via surface electrodes (DE-2.1, Delsys, Massachusetts, USA)

placed on the muscle belly. EMG activity was recorded at 2000 Hz, digitized (Power 1401II, Cambridge Electronics Design, Cambridge, UK) and stored on a computer for off-line analysis (Spike 2 or Signal, Cambridge Electronics Design, Cambridge, UK). In Experiments 1 and 2 TMS was applied using a 9 cm figure-of-eight coil and a Magstim 200 stimulator (Magstim, Carmarthenshire, UK). In Experiments 3 and 4 TMS was applied using a 7.5 cm figure of eight coil and a MagPro x100 stimulator (Magventure, Skovlunde, Denmark).

The coil was positioned over the hand area of the primary motor cortex and the optimal point for stimulating FDI was found by stimulating at a slightly suprathreshold intensity and identifying the point with the largest, most stable responses. To enable the experimenter to accurately maintain the coil over the optimal position throughout the experiment this point was recorded in a neuro-navigation system (Brainsight, Rogue Resolutions, Cardiff, UK (Experiments 1 & 2), Localite neuronavigation system, Localite GmbH, Sankt Augustin, Germany (Experiments 3 & 4)). The resting Motor Threshold (rMT) was determined as the minimum stimulator intensity necessary to evoke MEPs of at least 50 μV (peak-to-peak amplitude) on at least 5 out of 10 trials. The TMS pulse intensity used during the experiment was adjusted to produce MEPs in the control condition (TMS-only) with a mean amplitude of approximately 1mV. The average rMT and intensity that produced a MEP of approximately 1mV (both expressed as a percentage of the maximum stimulator output (%MSO)) are shown separately for each experiment in Table 1. A Kruskal-Wallis test revealed no difference between the amplitude of the TMS-only MEPs in each of the four experiments ($p= 0.46$).

Throughout the experiment, the baseline EMG signal was constantly monitored to ensure that the muscle was completely relaxed. If muscle activity

was detected the subject received a verbal instruction to relax the hand. Trials contaminated by muscle contraction in the 500ms before the TMS pulse were excluded from further analyses.

Statistical analysis

Data from each of the four experiments were analysed separately. Peak-to-peak MEP amplitudes (mV) were measured off-line using custom-written Spike 2 or Signal scripts (Cambridge Electronics Design, Cambridge, UK). Trials were excluded if they were contaminated by muscle contraction or if their amplitudes were greater than or less than 1.96 SDs from the mean of that condition for that subject. On average 16 (± 1.1 SEM) trials were excluded for each subject. The mean MEP amplitude for each condition was then calculated. D'Agostino-Pearson omnibus tests were applied to verify if the data came from an approximately normal distribution. Since the data for some conditions were not normally distributed, a Friedman repeated measures, non-parametric rank test with one factor (ISI) was applied to the raw MEP amplitudes (mV) to compare the mean amplitudes across conditions. Dunn's Multiple Comparison post-hoc tests comparing the control condition (TMS-only) with each ISI (15 to 85ms) were applied if the factor ISI was significant with a significance level of 0.05. Data were analysed using Prism 5 (GraphPad Software, Inc., California, USA). For each subject, mean MEP amplitude values for each ISI were normalized to the mean of the TMS-only condition and these normalized data were used to graphically represent the results but all analyses were conducted on raw MEP amplitudes.

Results

Hand muscle inhibition following electrocutaneous stimulation on the face

Experiment 1

Fig 1A shows that electrocutaneous stimulation of the right upper lip inhibited right FDI MEPs by between 20 and 30% at the 45, 55, and 65ms ISIs. A Friedman test on the mean MEP amplitude for each subject in each condition revealed a significant main effect of ISI (χ^2 (8) = 21.20; p = 0.007). Dunn's post-hoc tests comparing the mean MEP amplitude at each ISI against the mean TMS-only MEP amplitude revealed that inhibition was significant only at the 45ms ISI.

Fig 1. Normalized mean MEP amplitudes in the right FDI after electrocutaneous stimulation of the right upper lip – Experiment 1 (A), right cheek – Experiment 2 (B), right forearm – Experiment 3 (C) and right arm – Experiment 4 (D). Bars represent the standard error of the mean. The black dashed lines represent the TMS-only MEP amplitude. Asterisks represent significant Dunn's post-hoc tests ($p < 0.05$) comparing mean TMS-only amplitude with mean amplitude at each ISI. Note that statistical tests were performed on non-normalized data (S1 Appendix).

Experiment 2

Fig 1B shows that electrocutaneous stimulation of the right cheek produced a similar pattern and amount of inhibition as lip stimulation (between 20 and 30% at the 45, 55, and 65ms ISIs). A Friedman test on the mean MEP

290 amplitude for each subject in each condition revealed a significant main effect of
291 ISI (χ^2 (8) = 16.44; p = 0.036). Dunn's post-hoc tests comparing the mean MEP
292 amplitude at each ISI against the mean TMS-only MEP amplitude revealed that
293 this inhibition was significant only at the 55ms ISI.
294

295 Hand muscle inhibition following electrocutaneous
296 stimulation on the arm

297 Experiment 3

298 Fig 1C shows that electrocutaneous stimulation of the right forearm
299 inhibited right FDI MEPs by between 10 and 20% at the 25 and 55ms ISIs. A
300 Friedman test on the mean MEP amplitude for each subject in each condition
301 revealed no main effect of ISI (χ^2 (8) = 8.34; p = 0.401).
302

303 Experiment 4

304 Fig 1D shows that electrocutaneous stimulation of the right arm also
305 inhibited FDI MEPs by between 10 and 20% at the 35 to 65ms ISIs, but similar to
306 the forearm, a Friedman test on the mean MEP amplitude for each subject in
307 each condition revealed no main effect of ISI (χ^2 (8) = 8.96; p = 0.345).
308
309

310 Discussion

311 Face stimulation can inhibit hand MEPs

312 Face-hand sensorimotor interactions are clearly important for feeding,
313 grooming, non-verbal communication and many other activities of daily life [34].

314 These interactions exist at a fundamental level in the nervous system in the form
315 of reflexes. For example, the Babkin reflex in neonates occurs when palm
316 pressure evokes mouth opening [35], and the palmomental reflex occurs in adults
317 when thenar eminence stimulation evokes contraction of the mentalis muscle of
318 the chin [36]. Higher-order face-hand interactions have also been documented
319 under situations of plasticity, but evidence for non-reflexive interactions under
320 normal, physiological conditions in the adult is rare. Here, we present the first
321 evidence of sensorimotor afferent inhibitory interactions between the face and the
322 hand. We found that electrocutaneous stimulation of the right upper lip
323 (Experiment 1) and right cheek (Experiment 2) significantly inhibited MEP
324 amplitudes in the right FDI. Interestingly, this between body part SAI appears to
325 be specific to the face and the hand, as despite being anatomically closer to the
326 FDI, forearm (Experiment 3) and arm (Experiment 4) stimulation did not alter the
327 amplitude of FDI MEPs.

328 These results provide the first evidence for sensorimotor afferent inhibitory
329 interactions between the face and the hand. These findings reinforce the idea
330 that there are privileged interactions between the face and the hand and that such
331 interactions are not limited to reflexes or situations in which the system is
332 perturbed.

333 The temporal dynamics with which touch on the face inhibited hand muscle
334 responses suggest that face-hand afferent inhibition mechanisms differ from
335 those underlying hand-hand inhibition. For example, most studies examining
336 fingertip or median nerve stimulation show that inhibition of hand muscle MEPs
337 begins just after the arrival of the afferent volley in the primary somatosensory
338 cortex (S1) – at an ISI of approximately 25ms [14,23,27,28]. Many studies even

339 use electroencephalography to measure the latency of this afferent volley and
340 then choose their sensory-TMS ISIs so that the TMS pulse arrives at the time
341 when the sensory information is presumed to have been transferred to the motor
342 cortex i.e. several milliseconds after the arrival of the afferent volley in S1
343 [20,21,37–40]. This technique is based upon the hypothesis that afferent
344 inhibition results from the activation of direct inhibitory connections from the
345 primary sensory to primary motor cortices. If face-hand afferent inhibition were
346 based upon the same mechanisms as hand-hand afferent inhibition we would
347 have observed it around 15ms, not 45 or 55 ms [41,42]. Interestingly, in a study
348 of face-face afferent inhibition, Pilurzi et al., (2013) found no statistically
349 significant inhibition, but visual inspection of their results (see Fig 5, page 1898)
350 suggests that some inhibition might be present around 30ms – later than would
351 be expected based upon the arrival of the afferent volley in S1 - but similar to the
352 delay we observed for inhibition between the face and the hand. This suggests
353 that the ISIs at which we observed significant face-hand inhibition might not be
354 attributable to the fact that the AI was between two body parts, but might instead
355 be a feature of AI involving face stimulation.

356 When a somatosensory stimulus arrives in the S1 cortex, it evokes a series
357 of positive (P) and negative (N) deflections. Face stimulation evokes
358 somatosensory evoked potentials (SEPs for EEG) or somatosensory evoked
359 fields (SEFs for MEG) between 15ms (N15) and 65ms (P65) [41–45]. Other
360 deflections are also measurable at longer latencies (70-120ms), and these are
361 thought to reflect later stages of somatosensory processing within the secondary
362 somatosensory cortices [45–47]. The posterior parietal cortex also plays a role in
363 this later processing, starting at approximately 90ms for upper limb stimulation

364 [46,48]. Our finding of significant face-hand inhibition at ISIs of 45 and 55 ms
365 suggests that afferent information from the face alters hand motor
366 representations during early somatosensory processing, albeit at a relatively
367 advanced stage of early processing. Indeed, since we observed face-hand
368 inhibition before 70ms it likely involves S1, and despite being later than hand-
369 hand inhibition, still reflects the phenomenon of short-latency afferent inhibition.
370 Had it occurred at longer ISIs (closer to 100ms) we would have suggested that
371 the inhibition reflected long-latency afferent inhibition and relied upon late
372 somatosensory processing involves structures such as bilateral secondary
373 somatosensory cortices and contralateral posterior parietal cortex
374 [16,17,19,22,25].
375

376 Arm and Forearm stimulation does not inhibit hand 377 MEPs

378 The majority of afferent inhibition studies have focused on the upper and
379 lower limbs, either looking at interactions within the same part of the limb (hand-
380 hand [14–16,18,19,23,24,27,28], shoulder-shoulder [32], leg-leg [49], or between
381 different limb segments (hand-arm, hand-forearm [26–28], foot-leg [29]). On the
382 basis of these studies, it is generally believed that afferent inhibition within the
383 upper limb is a robust phenomenon. Interestingly, however, we are only aware of
384 one other investigation of afferent inhibition between different parts of the upper
385 limb in which stimulation was not applied to the hand [28]. As in our study, they
386 observed no inhibition in hand (and other) muscles following forearm stimulation
387 at 3xSPT. Thus, it would appear that inhibition within the upper limb is not as

388 robust as previously thought, and instead is present only when the afferent
389 stimulation is on or near the hand.

390 One possible explanation for the absence of arm-hand afferent inhibition
391 might be that the higher sensitivity and larger cortical magnification of the hand
392 [1,2,50] leads to a larger cortical response to hand stimulation than to forearm or
393 arm stimulation. We believe this to be unlikely, however, as a stimulus on the arm
394 five times longer than that used in the present study still failed to inhibit hand
395 muscle responses [28]. Given our finding of face-hand inhibition, it is important
396 that future studies continue to investigate if and when arm-hand inhibition can be
397 evoked.

398 The inhibitory interaction between the face and hand revealed here might
399 constitute one of the sources of face-hand cortical interactions like those
400 observed after plasticity-inducing events [3,4,9]. As initially suggested by Jacobs
401 and Donoghue (1991), one possible mechanism of cortical reorganization is the
402 unmasking of pre-existing lateral excitatory connections by the reduction of
403 activity in intracortical inhibitory circuits. The inhibitory sensorimotor interaction
404 observed here might contribute to maintaining functional boundaries between
405 face and hand cortical territories. After a plasticity-inducing event (e.g.
406 deafferentation), activity in the inhibitory circuitry could be decreased, resulting in
407 the disinhibition of latent intracortical excitatory connections and a reduction in
408 SAI, as shown by Bailey et al., (2015) in patients with spinal cord injury. Another
409 possibility is that the face-hand sensorimotor inhibitory interactions reported here
410 are one of the potential physiological substrates upon which a multitude of
411 remotely represented body parts may enter a (missing) hand territory based upon

412 the frequency of usage of these body parts [10,53,54]. Were this case, however,
413 we should also have found AI between the arm and the hand.

414 In spite of increasing interest in afferent inhibition, its underlying function
415 remains unknown (reviewed in Turco et al., 2017). Some studies use it as a tool
416 to investigate the integrity of the cholinergic system [20,56], while others use it as
417 we did here: as a tool to probe sensorimotor interactions in neurologically healthy
418 individuals [15,16,22,24,25]. Participants in these studies are always seated
419 quietly and never perform any particular task. The experiments presented in this
420 paper constitute the first step in investigating the existence of SAI between the
421 face and the hand as the ISIs at which it is present. In the future, it will be
422 interesting to directly compare the amount and latency of SAI at various body
423 sites within the same participants, as well as to examine whether the face hand
424 interactions demonstrated here are altered as a function of the proximity of the
425 two body parts and/or their engagement in hand-to-mouth behaviours. These
426 types of experiments will not only shed more light on face-hand afferent inhibition,
427 but could also help us to better understand the functional importance of the
428 sensorimotor interactions that underlie afferent inhibition.

429

430

431 # Acknowledgements

432

433 # References

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634 # Supporting information

S1 Appendix. Peak-to-peak mean MEP amplitudes (mV). Excel file with peak-to-peak mean MEP amplitudes (mV) values per condition per subject used to perform the statistical analysis.

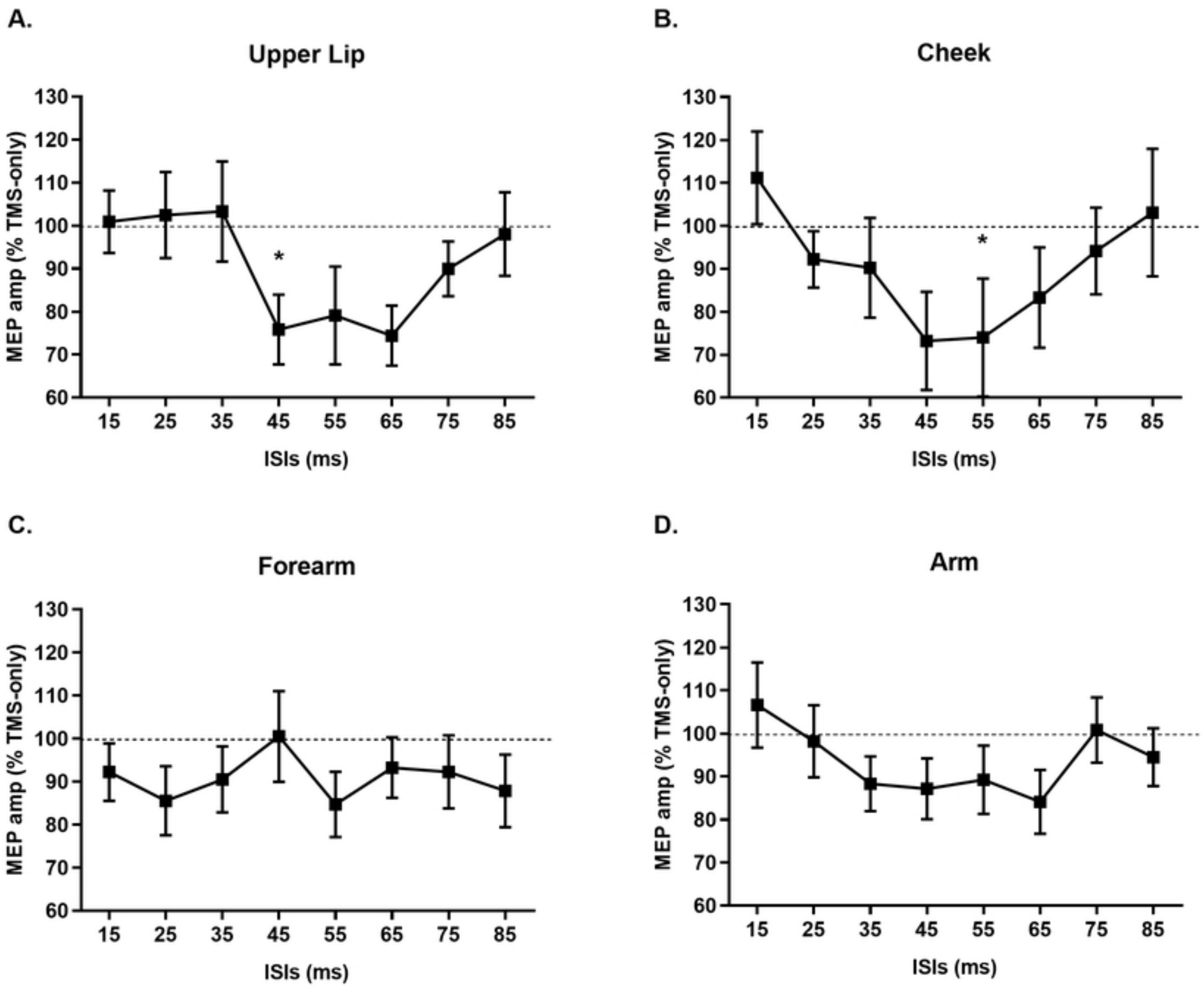
A.
Upper Lip
B.
Cheek
C.
Forearm
D.
Arm
MEP amp (% TMS-only)
130
120
110
100
90
80
70
60
15
25
35
45
55
65
75
85
ISIs (ms)
*

Figure 1