

Supplementary Material

Experiment 1

Supplementary Methods

Video Ratings

To assess whether self-other control training influenced subjective ratings of the pain and touch videos, following completion of TMS, participants were asked to rate each video using a visual analogue scale across two self-oriented and two other-oriented questions [1]: “How intense was the pain for the model?”; “How unpleasant was the pain for the model?”; “How much did the video grab your attention?”; and “How much does the video upset you?” Each question was presented for each video (pain and touch) in a random order.

Supplementary Results

Control Muscle

Previous literature reports mixed results regarding whether corticospinal empathy is [2,3] or is not [4] specific to the muscle in which painful stimulation is observed; therefore we did not have a clear prediction regarding whether training should affect corticospinal empathy in the target muscle alone or in the control muscle as well. To test for the specificity of the training effect, we repeated the MEP analysis for the control ADM muscle. There were no significant differences between groups in the control muscle (increased self-other control $-1.9 \pm 3.4\%$, decreased self-other control $8.0 \pm 5.4\%$, $t(23)=1.516$, $p=.143$).

Video Ratings

Table S1 shows all subjective ratings for pain and touch videos in both groups. Responses to each question were made on a visual analogue scale and could range from 1-100. Bonferroni-corrected independent-samples t-test analyses revealed no significant differences between groups.

Control Response Time Task

Table S2 displays mean response times for the three stimulus types for each training group. Data analysis is described in the main text.

Experiment 2

Supplementary Methods

Imitation Control Task

Participants performed a simple response time task with blocked responses. On each trial, a resting hand with index and middle finger raised was presented for a variable duration (800-2000ms) before

the onset of a stimulus movement (a button-press movement of the index or middle finger). For each block of trials participants were instructed to make the same response (to press the “V” key with the index finger or the “B” key with the middle finger) on every trial, whenever they observed the hand on the screen move. On four trials per block the hand did not move; these ‘catch’ trials ensured that participants did not respond until they observed a movement. The correct response for each block alternated between index and middle finger in a counterbalanced order across participants, such that each participant completed two blocks of index and two of middle finger responses. Although the identity of the observed button press movements was formally task-irrelevant, the relationship between the observed movement and the instructed response resulted in two trial types. In ‘congruent’ trials, participants were required to perform a key press using the same finger as the observed movement, while on ‘incongruent’ trials, participants were required to control the tendency to imitate the observed movement and instead perform the alternative response. A total of 80 trials were presented randomly across four blocks, with a fully factorial combination of stimulus movement (index or middle finger press) and response movement (index or middle finger press) repeated 16 times across the experiment. Response times were measured from the onset of the stimulus finger movement. Trials with outlying response times (>2.5 SD from each participant’s mean [5]; $2.5 \pm 0.2\%$ of trials) were removed prior to analysis.

Supplementary Results

Imitation Control Task

Six participants (one from the increased self-other control group and five from the decreased self-other control group) with outlying response times on the imitation control task on Day 1 were removed. Change in ability to control imitation was calculated by subtracting pre-training imitation control ability (mean response time on congruent trials from that on trials requiring imitation control) from post-training values; as before, higher values reflect an increased failure of self-other control. An independent-samples t-test revealed that the increased self-other control group had a lower change in the imitation control effect (4 ± 4 ms) than the decreased self-other control group (20 ± 6 ms, $t(36)=2.267$, $p=.029$, $d=0.727$). These data suggest that participants trained to increase self-other control demonstrated an increased ability to control involuntary imitation, compared to those trained to decrease self-other control. An equivalent correlation analysis to that performed in Experiment 1 failed to reach significance. This may be due to the considerable vulnerability of the imitation control task to practice effects (response times were faster on Day 2, see Supplementary Table S4) which may mask the effects of individual differences.

Supplementary References

1. Minio-Paluello I, Baron-Cohen S, Avenanti A, Walsh V, Aglioti SM. 2009 Absence of embodied empathy during pain observation in Asperger syndrome. *Biol. Psychiat.* **65(1)**, (55-62. doi:10.1016/j.biopsych.2008.08.006)

Supplementary material for: de Guzman, M., Bird, G., Banissy, M. J. & Catmur, C. (2015). Self-other control processes in social cognition: from imitation to empathy. *Phil. Trans. R. Soc. B.* doi: 10.1098/rtsb.2015.0079

2. Avenanti A, Minio-Paluello I, Bufalari I, Aglioti SM. 2006 Stimulus-driven modulation of motor-evoked potentials during observation of others' pain. *NeuroImage* **32(1)**, 316–24. (doi:10.1016/j.neuroimage.2006.03.010)
3. Fecteau S, Pascual-Leone A, Théoret H. 2008 Psychopathy and the mirror neuron system: preliminary findings from a non-psychiatric sample. *Psychiat. Res.* **160(2)**, 137–44. (doi:10.1016/j.psychres.2007.08.022)
4. Fitzgibbon BM, Enticott, PG, Bradshaw JL, Giummarra MJ, Chou M, Georgiou-Karistianis N, Fitzgerald PB. 2011. Enhanced corticospinal response to observed pain in pain synesthetes. *Cogn. Affect. Behav. Neurosci.* **12(2)**, 406–18. (doi:10.3758/s13415-011-0080-8)
5. Cook R, Press C, Dickinson A, Heyes CM. 2010. The acquisition of automatic imitation is sensitive to sensorimotor contingency. *J. Exp. Psychol. Human* **36**, 840-52.

Supplementary Tables

Table S1. Experiment 1: mean and standard error of the mean (*S.E.M.*) subjective ratings for touch and pain videos in each training group.

	Decreased self-other control Mean Rating (<i>S.E.M.</i>)		Increased self-other control Mean Rating (<i>S.E.M.</i>)	
	Touch	Pain	Touch	Pain
Self-oriented arousal (How much did the video grab your attention?)	38.0 (4.2)	68.6 (3.6)	39.3 (9.2)	83.6 (4.0)
Self-oriented aversion (How much does the video upset you?)	4.2 (1.7)	44.8 (5.1)	9.1 (5.9)	60.7 (8.1)
Other-oriented intensity (How intense was the pain for the model?)	5.4 (2.7)	70.5 (4.5)	8.1 (3.3)	79.6 (5.0)
Other-oriented unpleasantness (How unpleasant was the pain for the model?)	8.5 (4.0)	73.0 (3.7)	9.1 (2.8)	81.4 (4.8)

Table S2. Experiment 1, control response time task: response times (RT) for the three stimulus types for each training group.

Stimulus type	Decreased self-other control Mean RT, ms (<i>S.E.M.</i>)	Increased self-other control Mean RT, ms (<i>S.E.M.</i>)
Non-social control	246 (10)	270 (12)
Touch	259 (9)	287 (18)
Pain	247 (15)	274 (17)

Table S3. Experiment 1, imitation control task: response times and error rates for congruent and incongruent trials for each training group.

Trial type	Decreased self-other control		Increased self-other control	
	Mean RT, ms (<i>S.E.M.</i>)	Error rate, % (<i>S.E.M.</i>)	Mean RT, ms (<i>S.E.M.</i>)	Error rate, % (<i>S.E.M.</i>)
Congruent	458 (12)	1.8 (0.8)	516 (17)	1.5 (0.9)
Incongruent	553 (15)	13.5 (4.4)	569 (20)	4.9 (1.2)

Table S4. Experiment 2, imitation control task: response times and error rates for congruent and incongruent trials for each training group during the pre- and post-training sessions.

Session	Trial type	Decreased self-other control		Increased self-other control	
		Mean RT, ms (<i>S.E.M.</i>)	Error rate, % (<i>S.E.M.</i>)	Mean RT, ms (<i>S.E.M.</i>)	Error rate, % (<i>S.E.M.</i>)
Pre-training	Congruent	380 (8)	1.1 (0.4)	369 (7)	1.2 (0.8)
	Incongruent	365 (7)	0.4 (0.3)	366 (7)	0.3 (0.2)
Post-training	Congruent	327 (9)	0.2 (0.2)	328 (5)	1.2 (0.9)
	Incongruent	332 (9)	0.6 (0.3)	330 (6)	0.4 (0.2)