Supplementary Material

The autonomic pain relief response is independent of self or social influence on pain

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1 Additional Analyses

1.1 Ratings during learning phase

1.1.1 Participants

The same sample is considered as the one indicated in the main text.

1.1.2 Statistical Analysis

Analysis of variance (ANOVA) with block (Block1, Block2, Block3, Block4) as within-subjects factor and group (no-influence, self-influence, social-influence) as between-subjects factor were calculated separately for valence and US-expectancy ratings. The alpha (α) level was set at 0.05 for all analyses. The effect size is reported as partial η^2. In case of violation of the sphericity assumption, the Greenhouse-Geisser test was applied. As post-hoc tests for significant interactions, we used simple contrasts, which were Bonferroni-corrected if necessary.

1.2 Startle responses

1.2.1 Participants

We additionally excluded six participants because they were non-responders (mean raw startle amplitude across all conditions < 5 μV) for the analysis of the startle response. Only for this analysis, we considered 91 female participants.

1.2.2 Data reduction

Startle response was measured using electromyography (EMG) at the left *orbicularis oculi* muscle with two 5 mm Ag/AgCl electrodes. According to the guidelines (Blumenthal et al., 2005), one electrode was positioned under the pupil and the second one 1 cm laterally. The ground and the reference electrodes were placed on the right and left mastoids, respectively. Before attaching the electrodes, the skin was slightly abraded and cleaned with alcohol to keep the impedance below 10 kΩ. EMG activity was continuously recorded with a sampling rate of 400 Hz. The electromyographic signal was offline-filtered with a 28 Hz low cut-off filter and a 400 Hz high cut-off filter as well as with a 50 Hz notch filter. Then, the EMG signal was rectified and a moving average of 51 ms was applied. As a baseline, we used the 50 ms before startle probe onset (Grillon & Davis, 1997). Responses to startle probes were

then scored manually, and trials with excessive baseline shifts (5 µV) were excluded from further analysis. The peak amplitude was defined as the maximum peak relative to baseline during the 20-120 ms time window after startle probe onset.

1.2.3 Verification of ITI startle-probes

	Six ITI-probes	Twelve ITI-probes
No-influence Grp.	6	23
Self-influence Grp.	20	9
Social-influence Grp.	22	11

Supplementary Table 1. Number of participants per group with either six or 12 startle probes during the ITIs.

Due to an error in the programming, we noticed that for 43 participants, six additional startle probes were presented during the ITIs. This means that 48 participants had six startle probes, while 43 participants had 12 startle probes during the ITIs (see Supplementary Table 1). To verify whether this larger amount of startle probes might have influenced our results, we compared the results for those participants with six ITI-probes and those with 12 ITI-probes.

We did three types of analysis. First, we considered only those participants with the larger amount of startle probes and compared the startle responses during the ITIs across the no-influence, self-influence, and social-influence groups. A 3 (between-subjects factor: group) x 6 (within-subject factor: trial) ANOVA was calculated. We averaged two consecutive startle responses resulting in six levels for the within-subject factor trial. Second, we compared the startle responses during the ITIs between those individuals with the larger amount of startle probes and those with the planned amount of startle probes (i.e., six startle probes during the ITI). To this purpose, we averaged all the available startle responses for each condition, i.e., $_{relief}$CS, control, and ITI. A 3 (between-subjects factor: group) x 2 (between-subjects factor: ITI-probes) x 3 (within-subject factor: stimulus) ANOVA was calculated. Third, we wanted to verify whether the larger number of startle responses had influenced the skin conductance

responses. To this end, we ran the same ANOVA as described in the main manuscript adding the ITI-probe (6 ITI-startle-probes, 12-ITI-startle-probes) as the between-subjects factor.

1.2.4 Statistical analyses

The raw data were then normalized within-subjects using *z*-scores and then T-scores to reduce the large individual variability (Blumenthal et al., 2005). The T-scores were averaged for each condition ($_{relief}$CS, control, and ITI).

As for the other variables, data were analyzed with IBM SPSS Statistics for Windows (Version 26), calculating ANOVA with stimulus ($_{relief}$CS, control, ITI) as within-subjects factor and group (no-influence, self-influence, social-influence) as between-subjects factor. The alpha (α) level was set at 0.05 for all analyses. The effect size is reported as partial η^2. In case of violation of the sphericity assumption, the Greenhouse-Geisser test was applied. As post-hoc tests for significant interactions, we used simple contrasts, which were Bonferroni-corrected if necessary. The data are available at https://github.com/Marthe-Gruendahl/pain_relief.

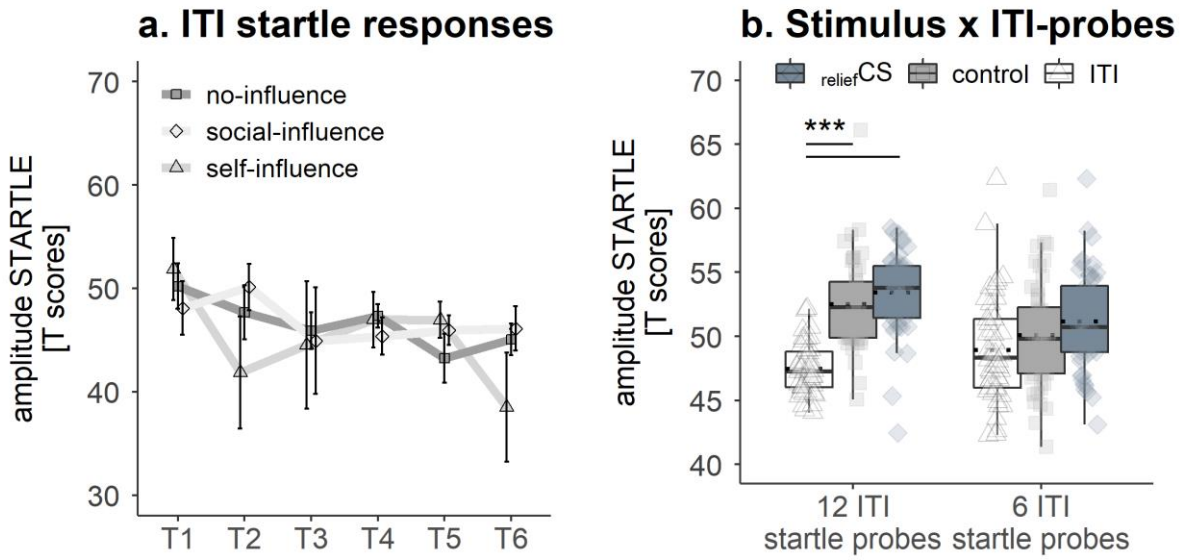
2 Results

2.1 Ratings during learning phase

The main effect block were significant for valence (F(2.71, 254.70) = 3.25, p = 0.026, partial η^2 = 0.033) and narrowly failed to reach significance for US-expectancy (F(2.59, 243.89) = 2.60, p = 0.061, partial η^2 = 0.027). Bonferroni-corrected post-hoc tests revealed that the valence ratings for $_{relief}$CS were equal between Block1 (M = 4.82, SD = 1.35) and Block2 (M = 4.86, SD = 1.44), but became more positive in Block3 (M = 5.15, SD = 1.45) compared to Block2 and remained comparably positive in Block4 (M = 4.98, SD = 1.53). No effects involving the factor group were found (all p values > 0.216).

2.2 Verification of ITI startle probes

The first ANOVA returned no significant effects (all p values > 0.122) meaning that the startle responses during ITI for the three groups did not differ (see Supplementary Figure 1a).

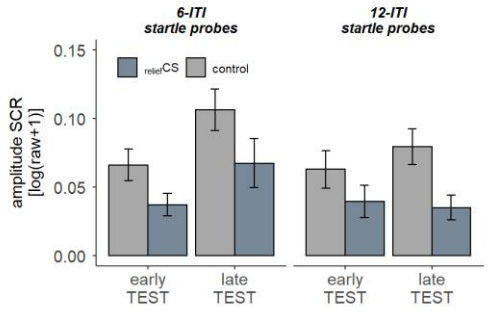


Supplementary Fig. 1. a. Startle responses (with standard errors) during ITIs for those participants with a larger number of startle probes. The three groups did not differ regarding their startle responses. b. Boxplot (with black solid line for the medians, and black dotted line for the means) of the startle responses separately for participants, who received 12 startle probes during the ITIs and those participants, who received six startle probes. Startle responses were significantly lower for the participants with a larger number of startle probes possibly due to greater habituation processes. Moreover, these participants showed significant startle potentiation to both $_{relief}$CS and control as compared to the ITI. (***) p < 0.001, post-hoc simple contrasts for significant interactions.

The second ANOVA returned significant main effects for ITI-probes (F(1, 85) = 23.59, p < 0.001, partial η^2 = 0.217) and stimulus (F(1.95, 166.00) = 15.95, p < 0.001, partial η^2 =

0.158), as well as their interaction (F(1.95, 166.00) = 5.32, p = 0.006, partial η^2 = 0.059; Supplementary Figure 1b). No other effect was found to be significant (all p values > 0.654). Post-hoc simple contrasts (Bonferroni-corrected, α < 0.008) separated for ITI-probes groups revealed that individuals with a larger number of startle probes responded with significantly larger startle responses to both the $_{relief}$CS (F(1, 85) = 33.44, p < 0.001) and the control stimulus (F(1, 85) = 25.56, p < 0.001) as compared to ITI, while startle responses across the three conditions did not differ for participants with six startle probes during the ITI (all p values > 0.121). Conceivably, the significantly lower startle responses during ITI in participants with a larger number of startle probes might be due to larger habituation effects related to the bigger number of startle-eliciting stimuli.

The third ANOVA returned no significant effect for the factor ITI-probe (all p values > 0.180) suggesting that the SCR was not affected by the number of startle probes (see Supplementary Figure 2). Except for the significant main effect of stimulus (F(1, 85) = 16.38, p < 0.001, partial η^2 = 0.162), no other significant effects were observed (all p values > 0.100).

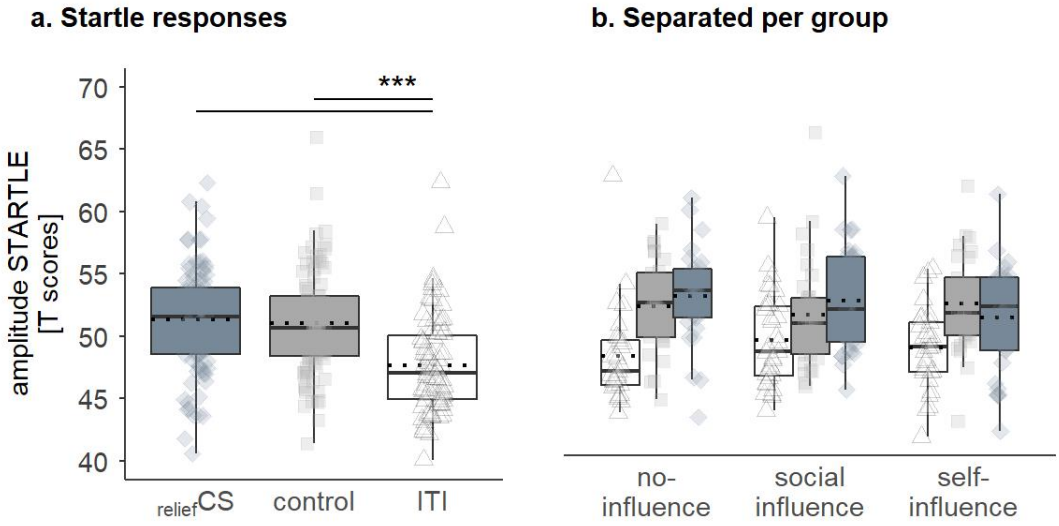


Supplementary Fig. 2. Skin conductance responses (with standard errors) to either $_{relief}$CS (blue bars) or control (grey bars) separately for those participants with a larger number of ITI startle probes (i.e., 12) and participants with less ITI startle probes (i.e., 6). The different amount of startle probes did not impact the SCR to the two visual stimuli.

2.3 Startle responses

Neither the main effect for group (F(2, 88) = 0.62, p = 0.539, partial η^2 = 0.014) nor the Stimulus x Group interaction (F(4, 176) = 0.90, p = 0.467, partial η^2 = 0.020, Supplementary Figure 3b) was found to be significant. The main effect for stimulus was significant (F(2, 176) = 22.57, p < 0.001, partial η^2 = 0.204, Supplementary Figure 3a). Post-hoc simple contrasts (Bonferroni-corrected, α < 0.017) returned significantly lower startle amplitude for ITI as compared to both $_{relief}$CS (F(1, 88) = 42.72, p < 0.001, partial η^2 = 0.327) and control (F(1, 88)

= 20.17, $p < 0.001$, partial $\eta^2 = 0.186$), while no significant difference between $_{relief}$CS and control were found ($F(1, 88) = 2.70$, $p = 0.104$, partial $\eta^2 = 0.030$).



Supplementary Fig. 3. Boxplot (with medians, black solid line, and means, black dotted line) of the startle responses for (**a.**) all sample and (**b.**) separated per groups. Startle responses were comparable between $_{relief}$CS (blue grey bars) and control (grey bars), but significantly larger than to ITI (white bars). (***) $p < 0.001$, post-hoc simple contrasts for significant interactions.

References

Blumenthal, T. D., Cuthbert, B. N., Filion, D. L., Hackley, S., Lipp, O. V., & van Boxtel, A. (2005). Committee report: Guidelines for human startle eyeblink electromyographic studies. *Psychophysiology, 42*(1), 1-15. https://doi.org/10.1111/j.1469-8986.2005.00271.x

Grillon, C., & Davis, M. (1997). Fear-potentiated startle conditioning in humans: explicit and contextual cue conditioning following paired versus unpaired training. *Psychophysiology, 34*(4), 451-458. https://doi.org/10.1111/j.1469-8986.1997.tb02389.x