

Supplemental Material

Supplemental material contains

- *Table S1 with effect sizes and confidence intervals of reported effects*
- *additional SCR analyses and further discussion*
- *additional IBI analyses*

Table S1: F-statistics, effect sizes and confidence intervals for significant ($p < .05$) and marginally significant ($p < .1$) ANOVA effects involving the factors Cue Type or CS Type

Phase	Dependent variable	ANOVA Effect	F-value ¹⁾	p-value	η^2_p	95% CI of the pairwise difference		
						aversive vs. neutral	aversive vs. nothing	neutral vs. nothing
Acquisition (Study 1)	Response to Cue							
	Unpleasantness rating	Cue	219.00	.001	.83	[4.90, 6.39]	[5.81, 7.32]	[.39, 1.46]
	IBI-A1	Cue	3.15	.048	.07	[2.74, 16.66]	[-14.14, 3.64]	[-2.96, 11.87]
	SCR	Cue	5.61	.010	.11	[0.001, 0.030]	[0.002, 0.03]	[-0.01, 0.01]
	Response to CS							
	Fear rating	CS Type	9.45	.001	.18	[.24, .96]	[.33, 1.18]	[-.15, .47]
	Anger rating	CS Type	11.67	.001	.21	[.27, .97]	[.37, 1.14]	[-.12, .39]
	Disgust rating	CS Type	5.08	.009	.10	[-.16, .59]	[.20, .95]	[.01, .72]
	Arousal rating	CS Type	12.25	.001	.22	[.45, 1.09]	[.34, 1.22]	[-.31, .33]
	Valence rating	CS Type	10.45	.001	.19	[.23, 1.01]	[.49, 1.49]	[-.06, .80]
IBI-D1	Block x CS Type	3.94	.023	.08	[-7.72, 6.00] ³⁾ [1.91, 17.60]⁴⁾	[-3.44, 9.00] ³⁾ [-4.31, 10.40]⁴⁾	[-5.62, 12.90] ³⁾ [-12.95, -4.77]⁴⁾	
Extinction (Study 1)	Fear rating	CS Type	4.38	.016	.09	[-.04, .55]	[.12, .77]	[-.09, .47]
	Anger rating	CS Type	7.43	.003 ²⁾	.14	[.19, .85]	[.15, .90]	[-.22, .22]
	Disgust rating	CS Type	3.55	.033	.08	[-.28, .52]	[.11, .87]	[-.01, .74]
	Arousal rating	CS Type	5.02	.010	.10	[.09, .80]	[.12, .90]	[-.25, .39]
	Valence rating	CS Type	8.56	.001	.16	[.11, .90]	[.43, 1.42]	[-.05, .87]
Acquisition vs. Extinction (Study 1)	Fear rating	Phase x CS Type	5.16	.008	.11	[.27, 1.07]⁴⁾ [-.16, .48] ⁵⁾	[.27, 1.24]⁴⁾ [.04, .67]⁵⁾	[-.24, .42] ⁴⁾ [-.09, .49] ⁵⁾
	Arousal rating	Phase x CS Type	3.84	.026	.08	[.54, 1.33]⁴⁾ [.07, .82]⁵⁾	[.41, 1.41]⁴⁾ [.06, .87]⁵⁾	[-.36, .32] ⁴⁾ [-.37, .41] ⁵⁾
Acquisition (Study 2)	Response to Cue							
	Unpleasantness rating	Cue	163.22	.001	.80	[5.07, 6.76]	[5.18, 7.01]	[-0.32, 0.69]
	IBI-A1	Cue	5.18	.013 ²⁾	.12	[-29.03, -2.38]	[-34.28, -3.96]	[-12.55, 5.82]
	Response to CS							
	Arousal rating	CS Type	4.31	.017	.10	[0.08, 0.91]	[0.07, 0.83]	[-0.35, 0.25]
	Valence rating	CS Type	2.70	.074	.07	[0.06, 1.11]	[-.27, .80]	[-.80, .15]
	IBI-D1	Block x CS Type	2.76	.070	.07	[-8.70, 12.18] ³⁾ [-3.38, 19.09] ⁴⁾	[-1.74, 15.19] ³⁾ [-15.80, 9.26] ⁴⁾	[-4.00, 13.97] ³⁾ [-22.34, .09] ⁴⁾
Fear-potentiated startle	CS Type	3.51	.037	.11	[-0.20, 22.53]	[1.67, 20.34]	[-8.97, 8.65]	
Extinction	Arousal rating	CS Type	6.08	.004	.14	[.17, .95]	[.12, .83]	[-.39, .21]

(Study 2)

Notes: Confidence intervals excluding zero (i.e. indicating a significant t-value for pairwise comparison) are in bold. ¹⁾ for all shown F-values, between-subjects degrees of freedom are $df = 2$ and within-subjects degrees of freedom of studies 1 and 2 are $df = 88$ and $df = 80$, respectively. Due to the exclusion of non-responders the within-subjects degrees of freedom for fear-potentiated startle are $df = 56$; due to missing ratings of one participants in study 2, degrees of freedom for arousal and valence ratings in study 2 are $df = 78$. ²⁾ value after Greenhouse-Geisser correction; ³⁾ 95% CI for the first acquisition block, ⁴⁾ 95% CI for the second acquisition block, ⁵⁾ 95% CI for the second extinction block.

2) SCR: Additional exploratory analyses and further discussion

As suggested by a reviewer we performed additional analyses of SCR in which we (a) excluded individuals who showed no measurable SCRs (i.e., no SCRs $> 0.01 \mu\text{S}$) during acquisition, (b) removed the SCR to the first trial of acquisition (when no learning had yet occurred), (c) averaged SCRs for the remaining trials across three equally sized sets of trials (each set consisting of six trials for Study 1 and of three trials for Study 2 because trials with a startle burst were excluded), (d) performed a range correction for SCRs by dividing each single-trial SCR magnitude by the maximum response across all conditions (Lykken & Venables, 1971) and (d) specifically looked at SCR effects toward the middle and end of acquisition when learning effects should be more pronounced.

CS Type ANOVAs for the first set of trials (Study 1: $F(2,86) = 1.46, p = .24$; Study 2: $F(2,58) = .12, p = .89$), second set (Study 1: $F(2,86) = .28, p = .76$; Study 2: $F(2,58) = .416, p = .66$) and third set (Study 1: $F(2,86) = .76, p = .47$; Study 2: $F(1,58) = 1.72, p = .19$) bin did not reach significant main effects. This did not change when the general response magnitude was entered as a covariate. However, direct pairwise comparisons between the CS_{+aversive} and the CS₋ yielded a significant t-value for the last acquisition trial set in Study 2, if one accepts one-sided testing, $t(29) = 1.83, p < .039$. A direct comparison between the CS_{+aversive} and the CS_{+neutral} was not significant, $t(29) = .44, p = .67$.

In general, we thus found no strong evidence for an effect of CS Type on SCR. This can be explained by the fact that SCR predominantly indicates contingency awareness rather than valence (Hamm & Weike, 2005) and that each of the three CSs (even the CS₋) was followed by one of three different visual stimuli types (i.e., the “cues”). Participants may thus be similarly “contingency aware” for all three CS types and hence show similar responses. Note, that this aspect of the conditioning design is in contrast to “conventional” fear conditioning studies – in which the CS₋ is paired with no further stimulus – which typically find differences between CS₊ and CS₋.

3) IBI: additional analyses of mean IBI

In addition to analyzing cardiac components D1, A1 and D2 in response to the CS, we also analyzed the mean IBI during the entire post-stimulus epoch (i.e., 7 s in Study 1 and 5 s in Study 2).

The Block x CS Type ANOVA in Study 1 yielded a marginally significant Block x CS Type interaction, $F(2,88) = 2.98, p = .06$. In the second block, the CS_{+aversive} yielded stronger overall deceleration than the CS_{+neutral}, $t(44) = 2.29, p = .027$, and the CS_{+neutral} yielded stronger acceleration than the CS₋, $t(44) = 2.37, p = .022$. The Block x CS Type ANOVA in Study 2 yielded a non-significant Block x CS Type interaction, $F(2,88) = 2.30, p = .11$. In the second block, the CS_{+aversive} yielded descriptively stronger overall deceleration than the CS_{+neutral}, $t(44) = 1.13, p = .27$ and the CS_{+neutral} yielded descriptively stronger acceleration than the CS₋, $t(44) = 1.58, p = .12$. While the Block x CS Type interactions were not significant for these analyses, the overall patterns are similar across studies and mirror the findings for the D1 component. They suggest that the fear bradycardia to the CS_{+aversive} started within the first 1-2 s (i.e., during the D1 time window) and persisted throughout CS presentation. This time course of fear bradycardia mirrors fear conditioning studies with a physical aversive US (Panitz, Hermann, & Mueller, 2015; Panitz et al., 2018).

References

- Hamm, A. O., & Weike, A. I. (2005). The neuropsychology of fear learning and fear regulation. *International Journal of Psychophysiology*, *57*, 5-14. doi:10.1016/j.ijpsycho.2005.01.006
- Lykken, D. T., & Venables, P. H. (1971). Direct measurement of skin conductance: A proposal for standardization. *Psychophysiology*, *8*, 656-672. doi: 10.1111/j.1469-8986.1971.tb00501.x
- Panitz, C., Hermann, C., & Mueller, E. M. (2015). Conditioned and extinguished fear modulate functional corticocardiac coupling in humans. *Psychophysiology*, *52*, 1351-1360. doi: 10.1111/psyp.12498
- Panitz, C., Sperl, M. F., Hennig, J., Klucken, T., Hermann, C., & Mueller, E. M. (2018). Fearfulness, neuroticism/anxiety, and COMT Val158Met in long-term fear conditioning and extinction, 155, 7-20. *Neurobiology of learning and memory*. doi:10.1016/j.nlm.2018.06.001