The Role of Cognitive Reappraisal and Expectations in Dealing with Social Feedback - Supplementary Materials: Pupil Data

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Recording and preprocessing

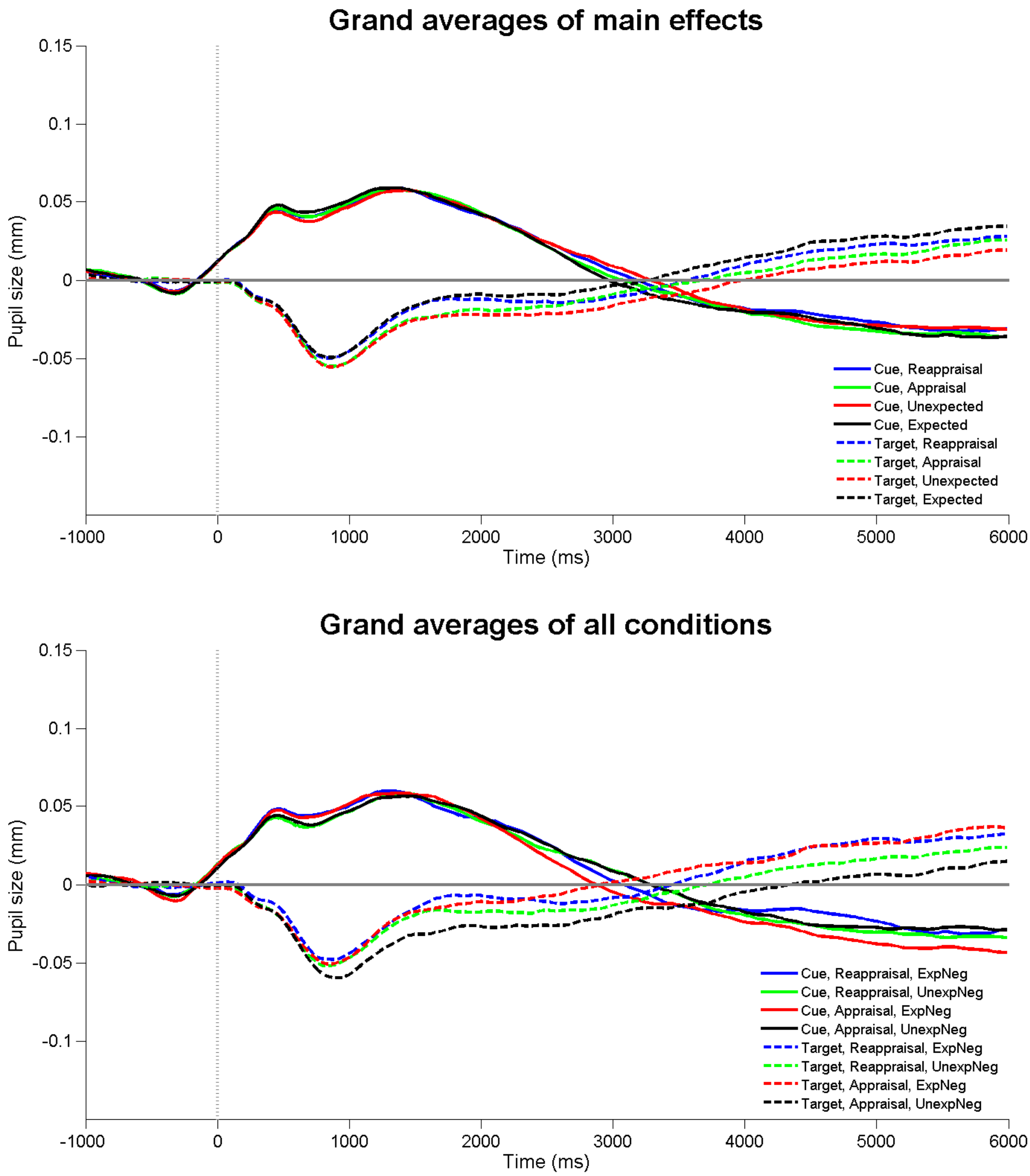
Pupil dilation (PD) was recorded by means of Tobii TX-300 (Tobii AB, Danderyd, Sweden). Via a video camera and an infrared light source pointed at the participant's eye, the eye-tracker tracked the position and size of the pupil at a sampling rate of 300 Hz. Data was digitally transferred from the pupillometer to a computer together with markers signaling stimulus onset and offset. Participants sat circa 60 cm from the screen; to calibrate the eye tracker, they were asked to orient their gaze towards five dots, one at each corner of the screen and one in its center.

PD data preprocessing was carried out in BrainVision Analyzer 2.0 (Brain Products GmbH, Munich, Germany). First, data points were down-sampled from 300 Hz to 60 Hz. Blinks were replaced by linear interpolation, and trials with blinks forming more than 30% of their total length were excluded from the analyses. A 5-point moving average was applied twice and linear trends over blocks were removed. Finally, we created segments extending from −1000 to +6000 ms after cue and target onset, and baseline correction was applied using the prestimulus interval.

Time domain analyses

Grand-average waveforms were calculated using MATLAB® R2012b (The MathWorks, Inc., Natick, MA) and functions included in EEGLAB v13.2.1 (Delorme & Makeig, 2004). Eight waveforms were created to investigate the main effects of expectation and ER strategy (Cue Reappraisal, Cue Appraisal, Cue Expectation, Cue No Expectation, Target Reappraisal, Target Appraisal, Target Expectation, Target No Expectation; see *Supplementary Figure 1*, upper panel), and eight to explore their interaction (Cue Expected Negative Appraisal, Cue Unexpected Appraisal, Cue Expected Negative Reappraisal, Cue Unexpected Reappraisal, Target Expected Negative Appraisal, Target Unexpected Negative

Appraisal, Target Expected Negative Reappraisal, Target Unexpected Negative Reappraisal; see *Supplementary Figure 1*, lower panel).



Supplementary Figure 1. Changes in pupil size relative to baselines across time for cues (continuous lines) and targets (dotted lines). The upper panel displays the PD waveforms segregated by expectation and ER strategy. the lower panel displays the PD waveforms of each condition separately.

To detect the precise onset and offset time of the differences in pupil size across conditions, we employed the Mass Univariate ERP Toolbox (Groppe, Urbach, & Kutas, 2011a, 2011b) to conduct point-by-point *t*-tests with Benjamini-Hochberg control of the false discovery rate (FDR; Benjamini & Hochberg, 1995) and identify the time windows in which two waveforms differed significantly from each other ($p_{FDR} < .05$). We opted for such a procedure because it is suitable for "exploratory studies of focally and/or broadly distributed effects" in which it is critical not to have Type II errors (Groppe et al., 2011a, Table 2). This method has already been used in the analyses of PD when it was deemed important to explore time-dependent PD modulations as a function of experimental manipulations while statistically controlling for the proportion of false positives (e.g., Stone et al., 2015). Since, for the present study, it was particularly relevant to investigate pupillary responses as an index of sustained emotional/cognitive processing, analysis of PD peaks or averages would not have been suitable. These analyses were run on the whole time-window (i.e., 0 to 6000 ms after cue or target). Similarly to our previous study (Nasso et al., 2015), we also investigated the interplay between anticipatory and online social feedback processing.

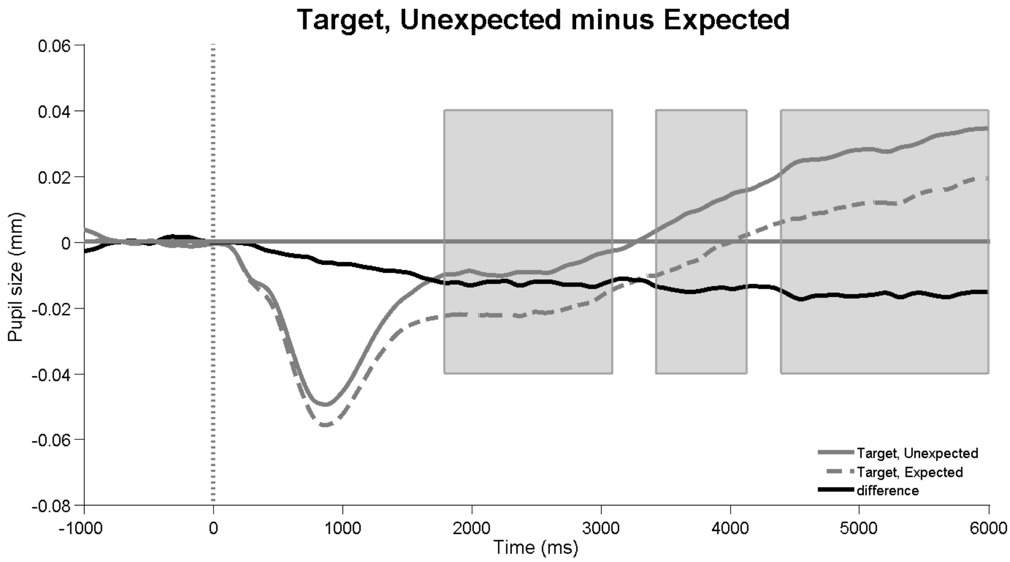
Results

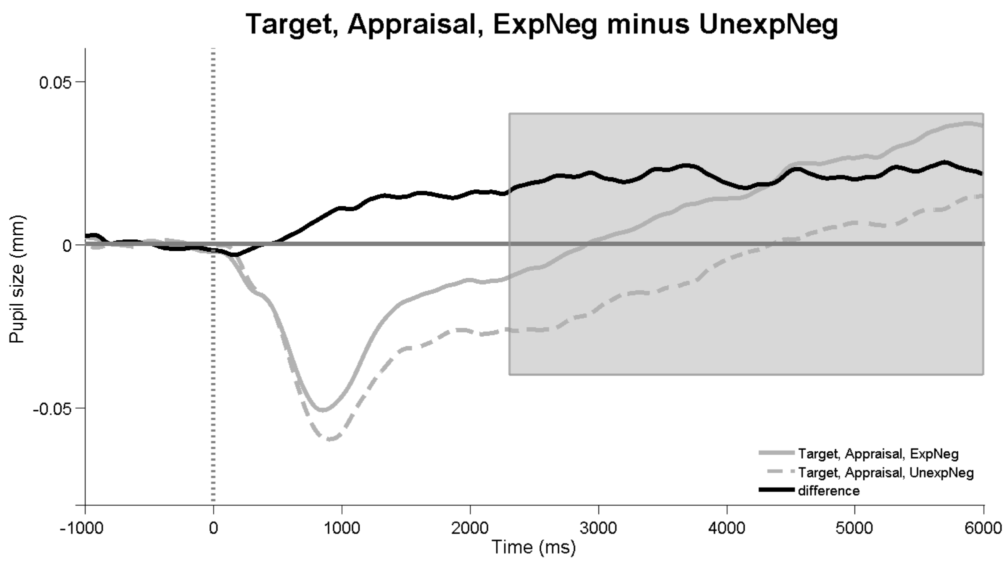
Cue. No significant results were observed at the level of the cue. Specifically, PD during feedback anticipation was not affected by our manipulation of ER strategy, expectation, or by their interaction.

Target. At the target level[1], we found no main effect of ER strategy on PD in response to negative social feedback, while expectation significantly influenced pupillary changes (see *Supplementary Figure 2*, upper panel). Specifically, PD was significantly larger in response to expected as compared to unexpected negative feedback approximately between 1780 and 3080 ms, 3420 and 4120 ms, and 4380 and 6000 ms.

[1] As for the EMG corrugator responses, the baseline used to correct PD during the target period corresponded to the PD during the last 1000 ms of the cue period. However, because no significant differences were observed across cues of different conditions at any time-point, such overlap should not influence the analyses on the target period.

A more detailed exploration of our data revealed that PD was significantly larger, approximately between 2300 and 6000 ms, after expected as compared to unexpected negative feedback within the appraisal blocks (*Supplementary Figure 2*, lower panel). In contrast, expected and unexpected negative feedback did not differ significantly in PD within the reappraisal blocks. Finally, pupillary responses in response to expected as well as unexpected negative feedback were not significantly affected by appraisal and reappraisal instructions.





(b)

Supplementary Figure 2. The gray-shaded areas indicate the time windows in which the difference waves (black lines) differ significantly from zero when using the FDR method. The difference wave is calculated by subtracting one waveform from the other (grey lines). The upper panel displays the main effect of expectation during the target period (Unexpected minus Expected, respectively, continuous and dotted line). The lower panel displays the effect of expectation during the target period within the appraisal blocks (Appraisal Expected Negative minus Appraisal Unexpected Negative, respectively, continuous and dotted line).

Discussion

In contrast with our hypothesis, the cognitive/emotional processing deployed *in anticipation of social feedback* (i.e., cue phase) was not affected by our manipulation of ER strategy, expectation, or by their interaction. Instead, the cognitive/emotional processing deployed *in response to social feedback* (i.e., target phase) was sensitive to the interaction of these two factors. Specifically, PD was larger during expected as compared to unexpected negative feedback during the appraisal (but not during the reappraisal) blocks.

Because of the increased cognitive load associated with uncertainty (maintenance of different outcomes and coping strategies), we predicted that participants would need greater emotional/cognitive processing during feedback anticipation when having no expectations about its valence (Nasso et al., under review). However, even though two outcomes were possible after an uninformative cue (i.e., negative and positive feedback), no preparation was needed in anticipation of positive emotional events (i.e., the ER instructions applied only to negative feedback). Therefore, participants needed to prepare to deal only with negative social feedback, just like during an informative cue. It is thus possible that informative and uninformative cues (independent of ER strategy) elicited similar proactive cognitive effort.

During the target phase, PD did not differ significantly between expected and unexpected negative feedback during the reappraisal blocks. It is possible that, because participants prepared to deal with negative social feedback during the anticipation phase independent of the informative value of the cue, they might have been able to regulate expected and unexpected negative social feedback equally well. In contrast, instructions not to control one's emotional response (i.e., during the appraisal blocks) led to larger pupil size in response to expected than unexpected negative feedback. Hence, more emotional/cognitive processing was deployed to negative feedback when it was expected. Even though no difference was observed at the cue level, it appears that contextual information allowed participants to deploy more resources to its processing.

It could also be argued that greater PD during expected vs. unexpected negative feedback during the appraisal blocks may be a correlate of higher arousal (Bradley et al., 2008). Conversely, pupillary constriction during unexpected negative feedback processing may indicate cognitive overload (van Steenbergen, Band, & Hommel, 2015) and therefore a hindered coping ability. However, neither of these propositions is supported by the participants' EMG corrugator responses (see main text), which failed to reveal any significant impact of expectation on the participants' affective responses.

Concerning the lack of effect of ER strategy at the cue as well as at the target level, a possible explanation is that pupil dilation, associated with both arousal and cognitive effort, might not be sensitive enough to discern them in a paradigm that investigates the regulation of emotional responses. In other words, while pupil size was mostly influenced by cognitive effort under reappraisal instructions, under appraisal instructions arousal was its main influencing factor. As a consequence, no statistical difference in pupil size could be observed between ER blocks. Alternatively, PD can be interpreted as an index of the cognitive effort exerted by participants to comply with the ER instructions (both appraisal and reappraisal). It is plausible that not only reappraising, but also appraising negative social feedback required top-down cognitive effort. In other words, we could tentatively speculate that experiencing unpleasant emotions with the instruction not to change them requires inhibition of the individuals' natural tendency to regulate distress. Consistently with this hypothesis, Shafir and colleagues (2015) found that using counter preferential (compared to preferential) ER strategies required increased cognitive effort. In addition, other possibilities – e.g., the association between cognitive effort and arousal, methodological differences from previous studies, or low statistical power – might explain this lack of effect of emotion regulation on PD.

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Analysis EMG

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Code can be inspected here: https://github.com/aschetti/reappraisal-expectation-nasso-2020.

Table 1: Descriptive statistics of EMG amplitude, separately for each condition.

Stimulus	ER_Strategy	Expectation	median	mad
cue	Reappraisal	Unexpected	0.00129	0.0033
cue	Reappraisal	Expected	0.00069	0.0027
cue	Appraisal	Unexpected	-0.00065	0.0042
cue	Appraisal	Expected	0.00114	0.0040
target	Reappraisal	Unexpected	-0.00022	0.0030
target	Reappraisal	Expected	0.00055	0.0027
target	Appraisal	Unexpected	0.00129	0.0053
target	Appraisal	Expected	0.00054	0.0040

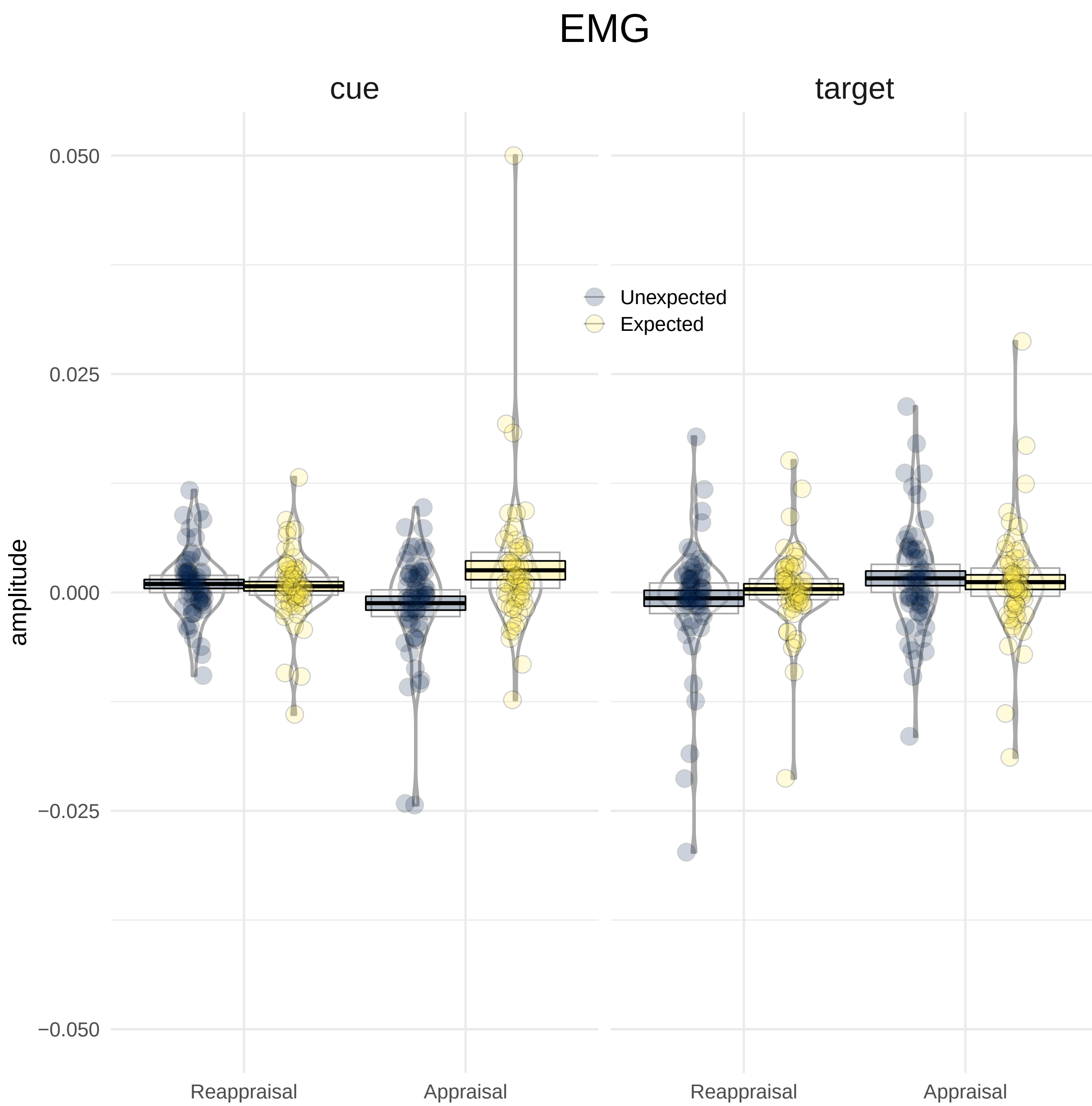

Figure 1: EMG amplitude in response to cue and target. *Note*: 18 values are outside the plot.

Table 2: Repeated measures nonparametric ANOVA (Aligned Rank Transform).

Term	Df	Df.res	F	p.value	eta.sq.part
Stimulus	1	420	1.7	0.199	0.004
ER_Strategy	1	420	1.5	0.223	0.004
Expectation	1	420	2.0	0.156	0.005
Stimulus:ER_Strategy	1	420	3.7	0.056	0.009
Stimulus:Expectation	1	420	1.3	0.248	0.003
ER_Strategy:Expectation	1	420	0.0	0.947	0.000
Stimulus:ER_Strategy:Expectation	1	420	11.2	0.001	0.026

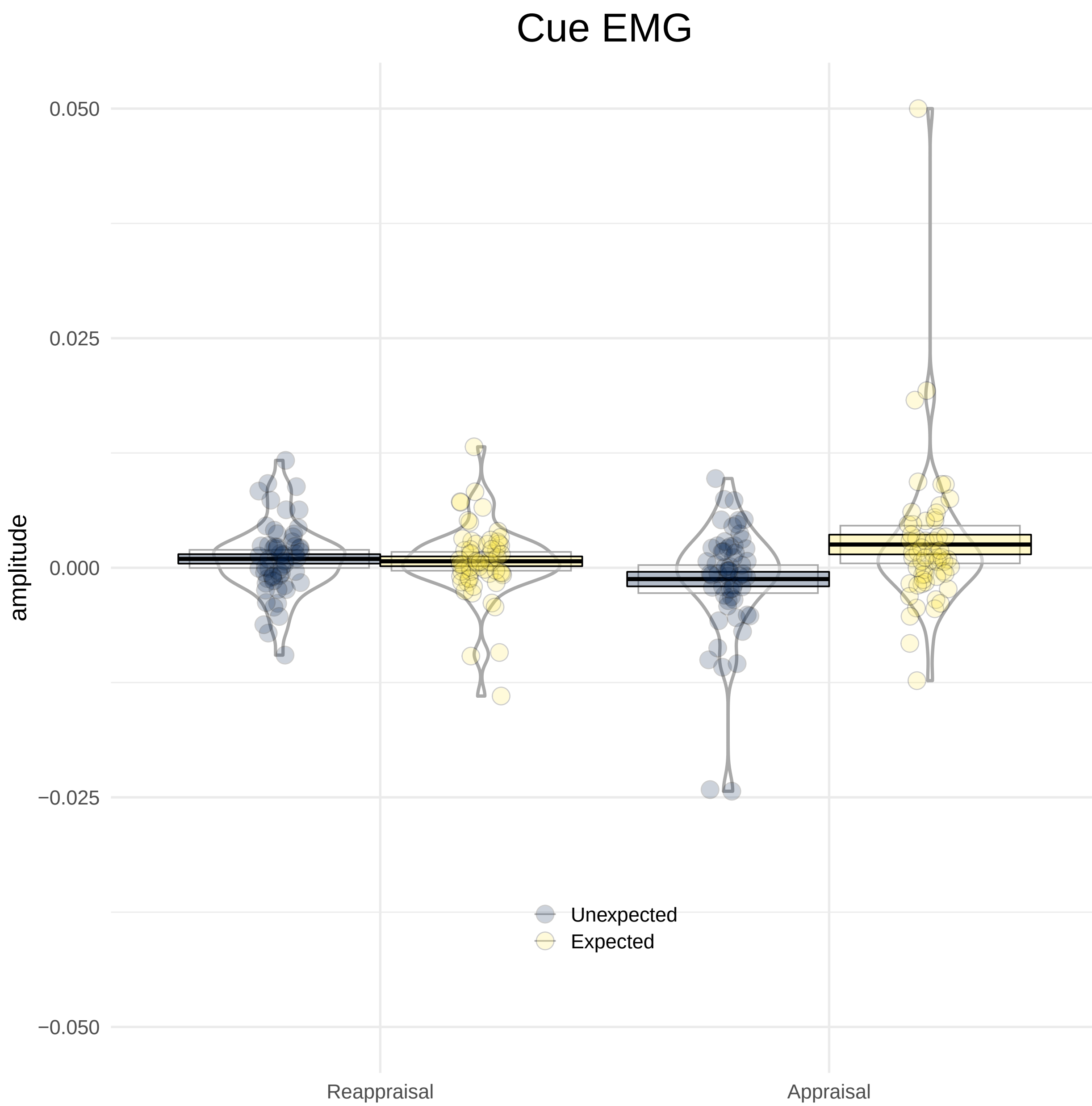

Figure 2: EMG amplitude in response to cue. *Note*: 9 values are outside the plot.

Table 3: Responses to Cue. Repeated measures nonparametric ANOVA (Aligned Rank Transform).

Term	Df	Df.res	F	p.value	eta.sq.part
ER_Strategy	1	180	0.36	0.552	0.002
Expectation	1	180	4.51	0.035	0.024
ER_Strategy:Expectation	1	180	7.86	0.006	0.042

Table 4: Responses to Cue. Post-hoc Repeated Samples Wilcoxon tests (Bonferroni-Holm p-value correction), bootstrapped effect size.

comparison	V	p	r	CI95_lower	CI95_upper
Appraisal, Expected vs. Unexpected	1369	0.008	-0.39	-0.58	-0.15
Reappraisal, Expected vs. Unexpected	919	0.853	0.02	-0.24	0.27
Expected, Appraisal vs. Reappraisal	1144	0.312	-0.18	-0.41	0.07
Unexpected, Appraisal vs. Reappraisal	660	0.120	0.26	0.00	0.47

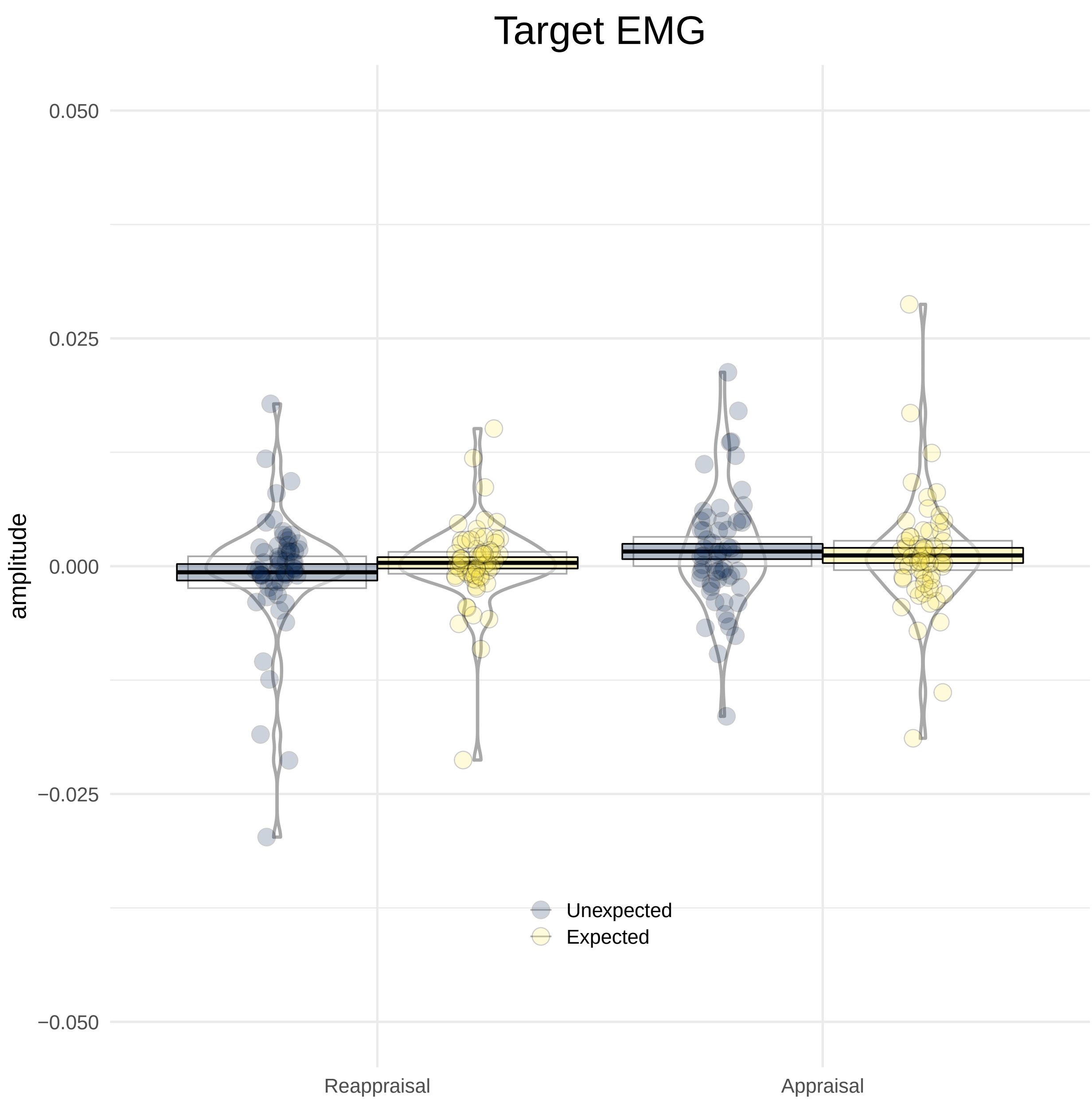

Figure 3: EMG amplitude in response to target. *Note*: 9 values are outside the plot.

Table 5: Responses to Target. Repeated measures nonparametric ANOVA (Aligned Rank Transform).

Term	Df	Df.res	F	p.value	eta.sq.part
ER_Strategy	1	180	5.7	0.018	0.031
Expectation	1	180	0.0	0.987	0.000
ER_Strategy:Expectation	1	180	7.3	0.007	0.039

Table 6: Responses to Target. Post-hoc Repeated Samples Wilcoxon tests (Bonferroni-Holm p-value correction), bootstrapped effect size.

comparison	V	p	r	CI95_lower	CI95_upper
Appraisal, Expected vs. Unexpected	778	0.593	0.15	-0.10	0.39
Reappraisal, Expected vs. Unexpected	1126	0.593	-0.17	-0.40	0.09
Expected, Appraisal vs. Reappraisal	1038	0.593	-0.08	-0.34	0.18
Unexpected, Appraisal vs. Reappraisal	1377	0.007	-0.40	-0.59	-0.15

Table 7: Split-plot ANOVA, control for block order (Appraisal first or Reappraisal first).

Effect	p	p<.05
start_block	0.701	
Stimulus	0.811	
ER_Strategy	0.112	
Expectation	0.936	
start_block:Stimulus	0.473	
start_block:ER_Strategy	0.411	
Stimulus:ER_Strategy	0.657	
start_block:Expectation	0.318	
Stimulus:Expectation	0.433	
ER_Strategy:Expectation	0.539	
start_block:Stimulus:ER_Strategy	0.097	
start_block:Stimulus:Expectation	0.954	
start_block:ER_Strategy:Expectation	0.734	
Stimulus:ER_Strategy:Expectation	0.015	*
start_block:Stimulus:ER_Strategy:Expectation	0.807	

Table 8: Correlation: difference between Appraisal and Reappraisal during anticipation vs. difference between Appraisal and Reappraisal during target.

rho	p-value
40138	0.64

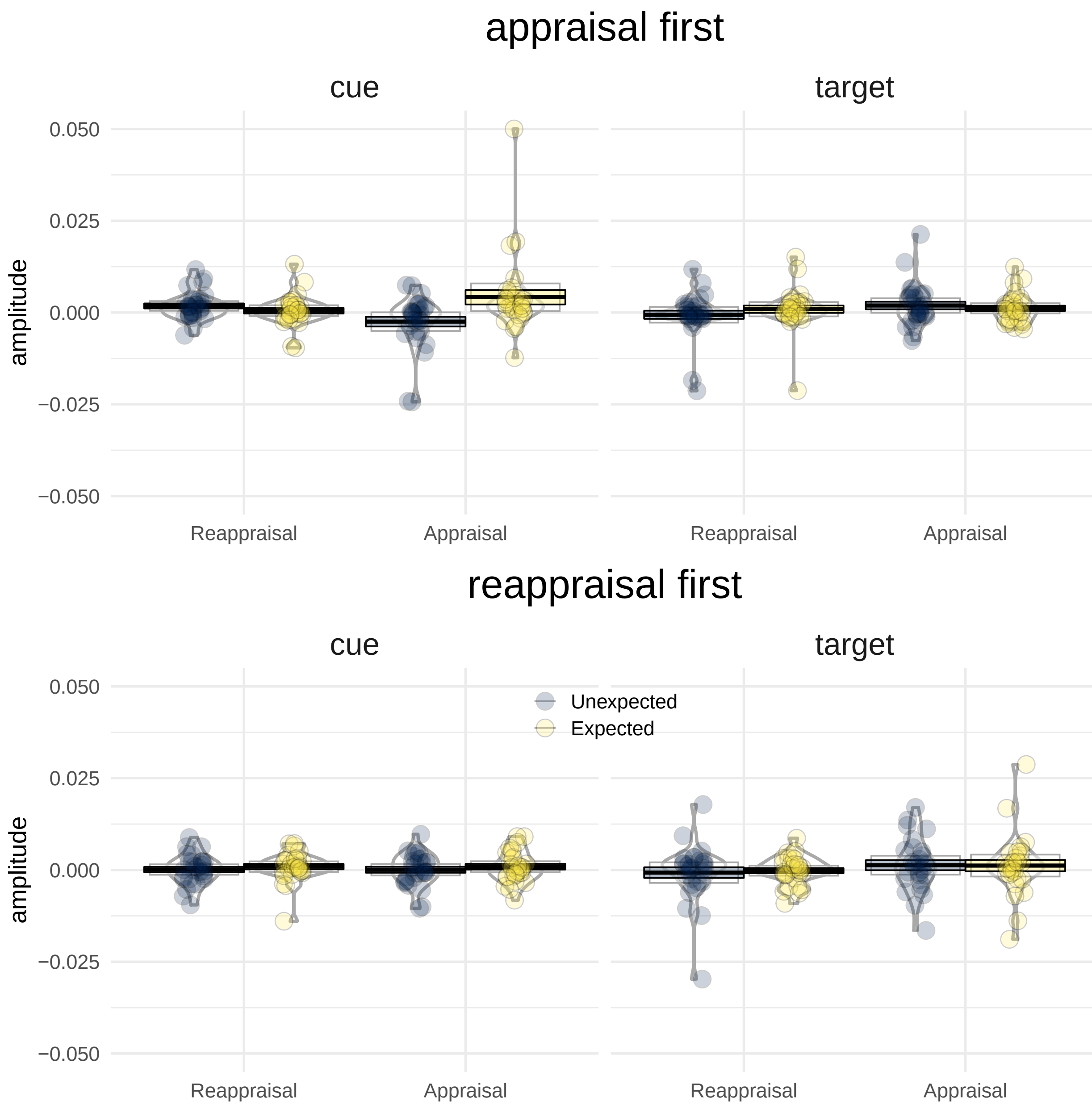

Figure 4: EMG amplitude in response to cue and target, separately for participants who started with Appraisal vs. Reappraisal blocks. *Note*: 9 values are outside the plot.

Analysis EMG (no outliers)

Antonio Schettino

2020-03-23

Eleven participants did not believe the experimental manipulation, and the responses of 3 participants are missing. Here we confirm that the results are qualitatively similar with and without these 14 outliers.

Code can be inspected here: https://github.com/aschetti/reappraisal-expectation-nasso-2020.

Table 1: Descriptive statistics of EMG amplitude, separately for each condition.

Stimulus	ER_Strategy	Expectation	median	mad
cue	Reappraisal	Unexpected	0.00099	0.0032
cue	Reappraisal	Expected	0.00056	0.0025
cue	Appraisal	Unexpected	-0.00065	0.0043
cue	Appraisal	Expected	0.00112	0.0042
target	Reappraisal	Unexpected	-0.00022	0.0029
target	Reappraisal	Expected	0.00037	0.0024
target	Appraisal	Unexpected	0.00153	0.0051
target	Appraisal	Expected	0.00122	0.0036

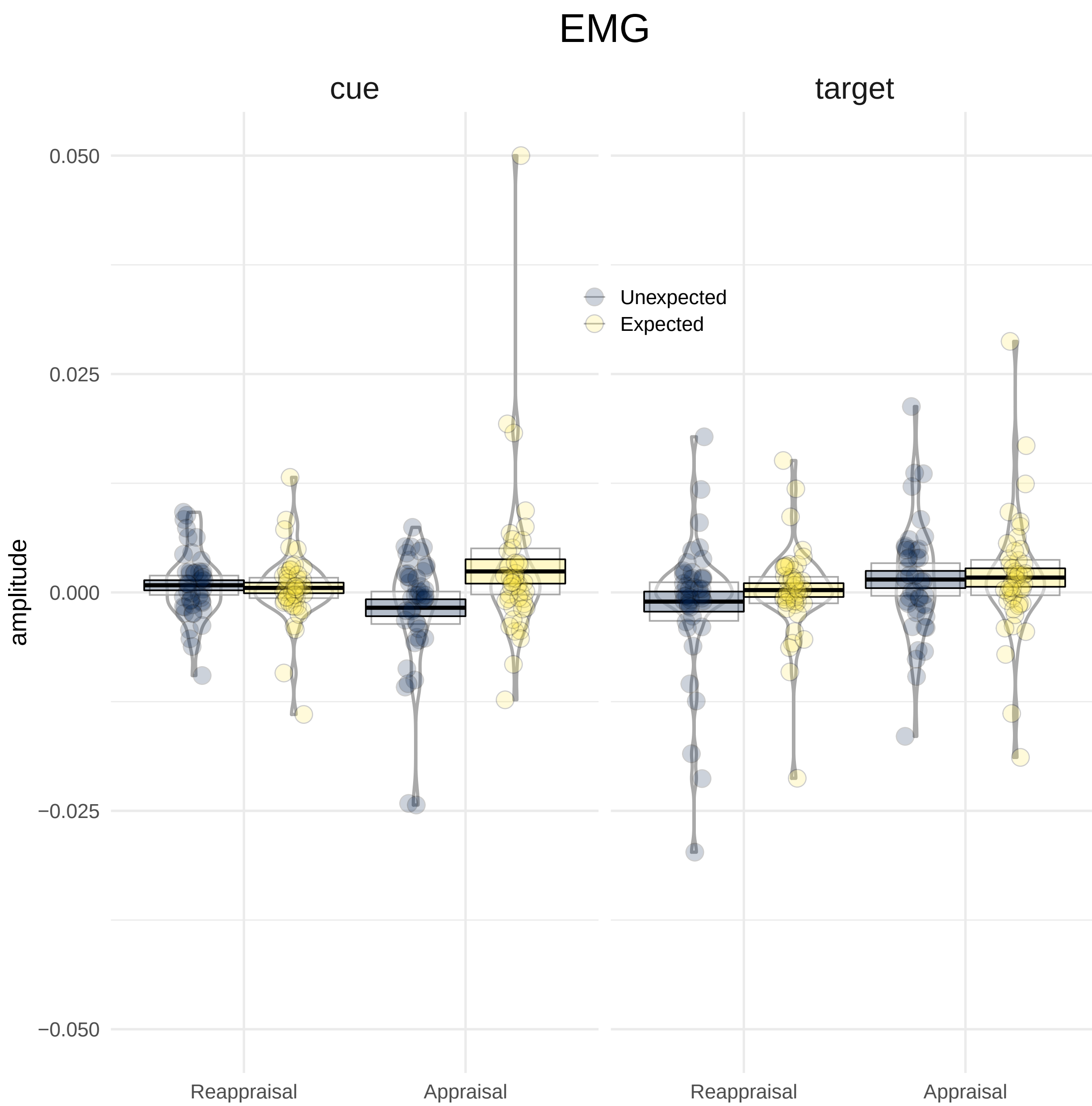

Figure 1: EMG amplitude in response to cue and target. *Note*: 18 values are outside the plot.

Table 2: Repeated measures nonparametric ANOVA (Aligned Rank Transform).

Term	Df	Df.res	F	p.value	eta.sq.part
Stimulus	1	322	2.29	0.131	0.007
ER_Strategy	1	322	1.58	0.210	0.005
Expectation	1	322	3.56	0.060	0.011
Stimulus:ER_Strategy	1	322	3.46	0.064	0.011
Stimulus:Expectation	1	322	0.43	0.513	0.001
ER_Strategy:Expectation	1	322	0.01	0.909	0.000
Stimulus:ER_Strategy:Expectation	1	322	7.72	0.006	0.023

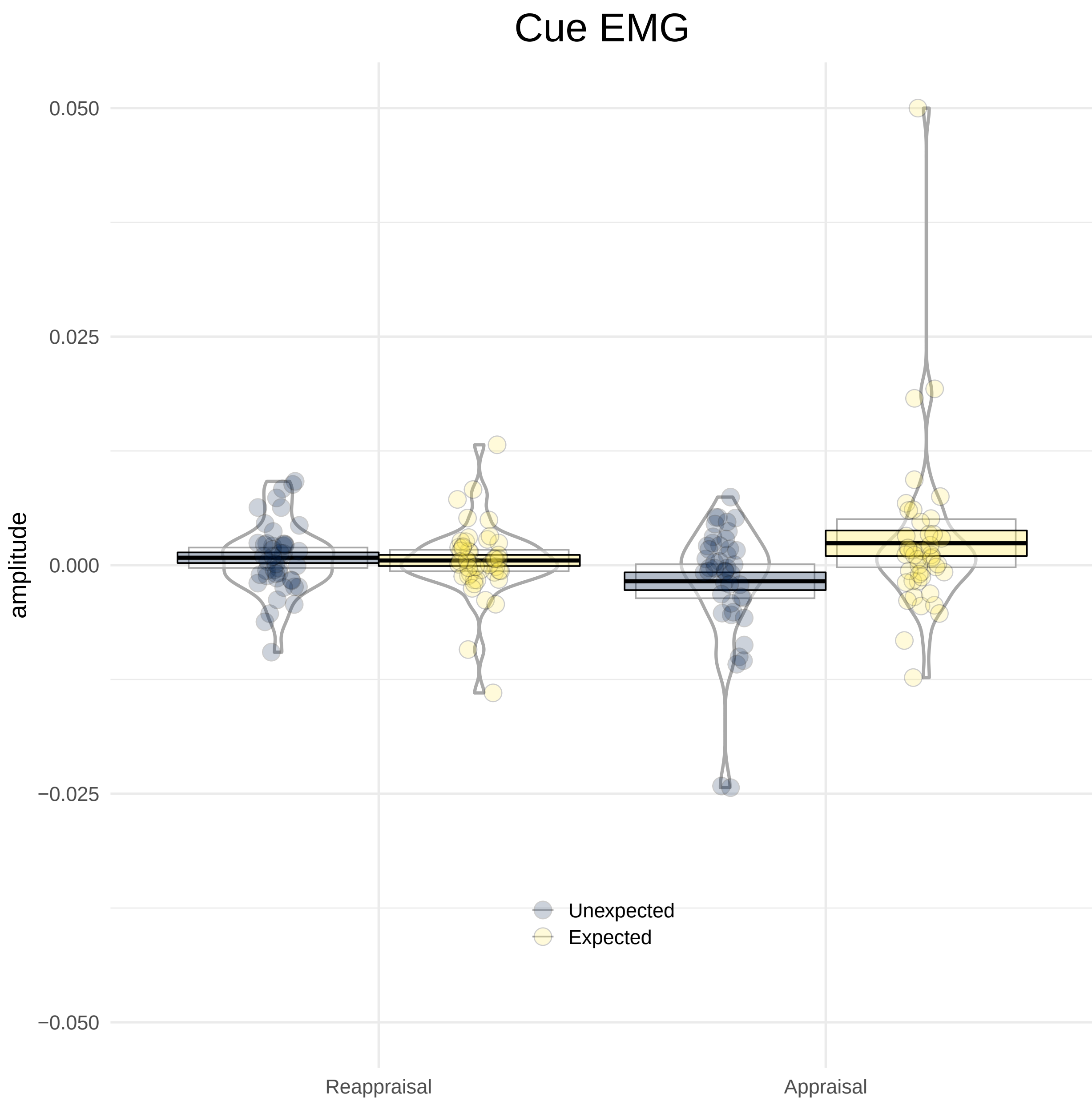

Figure 2: EMG amplitude in response to cue. *Note*: 9 values are outside the plot.

Table 3: Responses to Cue. Repeated measures nonparametric ANOVA (Aligned Rank Transform).

Term	Df	Df.res	F	p.value	eta.sq.part
ER_Strategy	1	138	0.38	0.539	0.003
Expectation	1	138	4.21	0.042	0.030
ER_Strategy:Expectation	1	138	6.53	0.012	0.045

Table 4: Responses to Cue. Post-hoc Repeated Samples Wilcoxon tests (Bonferroni-Holm p-value correction), bootstrapped effect size.

comparison	V	p	r	CI95_lower	CI95_upper
Appraisal, Expected vs. Unexpected	802	0.044	-0.37	-0.59	-0.08
Reappraisal, Expected vs. Unexpected	529	0.738	0.05	-0.24	0.34
Expected, Appraisal vs. Reappraisal	650	0.738	-0.13	-0.41	0.15
Unexpected, Appraisal vs. Reappraisal	370	0.119	0.30	0.02	0.55

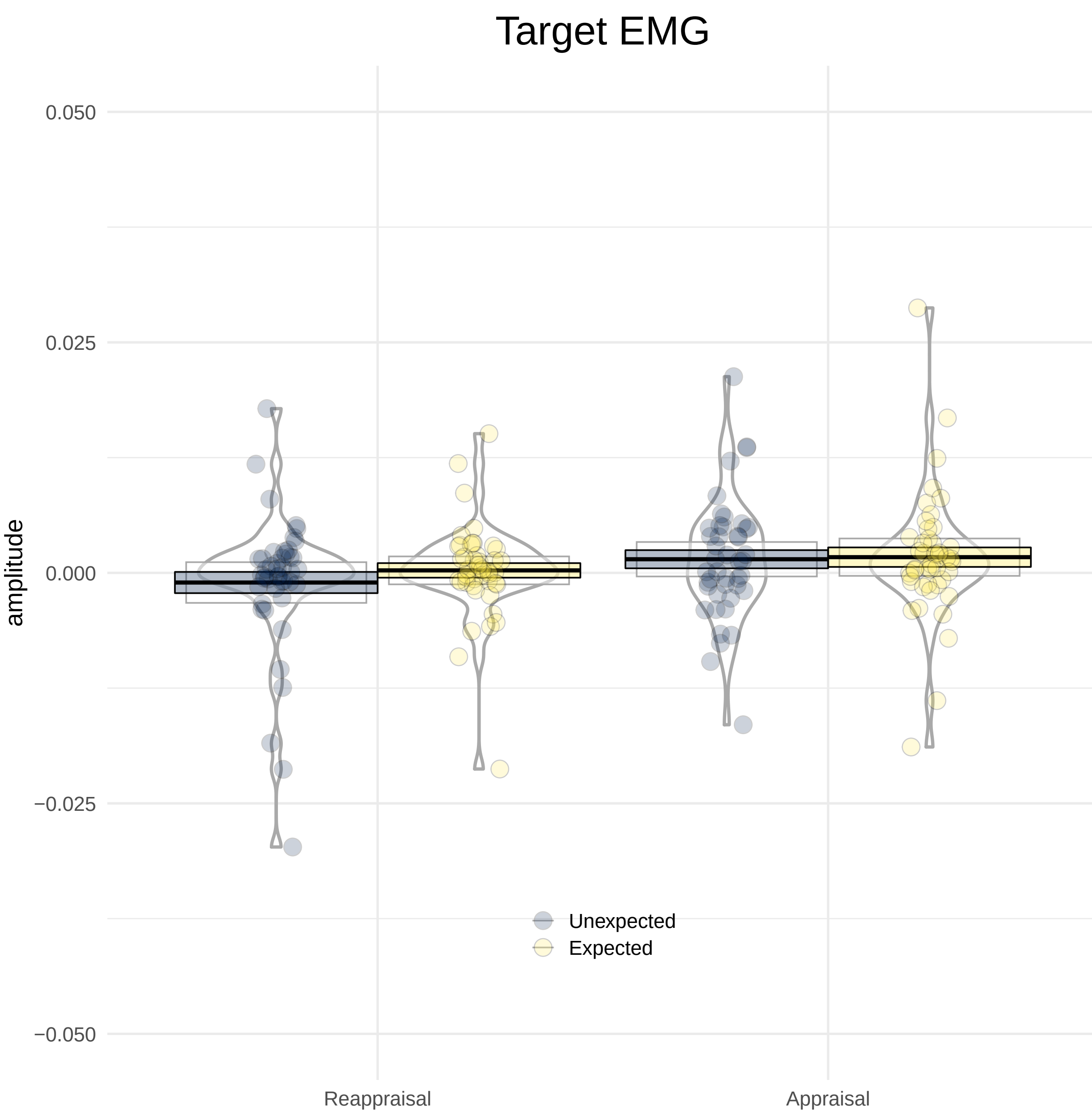

Figure 3: EMG amplitude in response to target. *Note*: 9 values are outside the plot.

Table 5: Responses to Target. Repeated measures nonparametric ANOVA (Aligned Rank Transform).

Term	Df	Df.res	F	p.value	eta.sq.part
ER_Strategy	1	138	5.58	0.020	0.039
Expectation	1	138	0.35	0.553	0.003
ER_Strategy:Expectation	1	138	4.36	0.039	0.031

Table 6: Responses to Target. Post-hoc Repeated Samples Wilcoxon tests (Bonferroni-Holm p-value correction), bootstrapped effect size.

comparison	V	p	r	CI95_lower	CI95_upper
Appraisal, Expected vs. Unexpected	514	0.604	0.08	-0.22	0.34
Reappraisal, Expected vs. Unexpected	667	0.562	-0.16	-0.43	0.13
Expected, Appraisal vs. Reappraisal	692	0.537	-0.20	-0.46	0.09
Unexpected, Appraisal vs. Reappraisal	836	0.014	-0.42	-0.62	-0.13

List of personality-trait descriptors used as social feedback

Negative personality-trait descriptors

List of negative adjectives and their affect rating (mean and standard deviation) selected from Hermans and De Houwer, 1994.

Adjective	Affect Mean	Affect SD
Afhankelijk	2.94	1.23
Agressief	1.89	1.21
Angstig	2.73	1.05
Asociaal	1.96	1.08
Bazig	2.21	1.01
Bedrieglijk	2.04	1.1
Bekrompen	1.88	1.12
Besluiteloos	2.86	0.82
Bevooroordeeld	2.29	0.92
Bot	1.98	0.97
Conservatief	3.19	1.06
Cynisch	2.99	1.12
Depressief	2.25	1.28
Droevig	2.51	1.16
Eenzaam	2.56	1.17
Egoïstisch	1.79	1.29
Gefrustreerd	2.01	0.98
Gesloten	3.2	1.02
Hebzuchtig	1.68	0.92
Hoogmoedig	2.28	1.12
Koel	2.81	1.2
Kwaad	2.35	1.41
Lichtgeraakt	2.46	0.81
Lui	2.47	1.23
Lusteloos	2.35	0.92
Materialistisch	2.48	1.16

Nalatig	2.58	0.96
Nonchalant	3.27	0.14
Onaangenaam	1.99	0.87
Onbetrouwbaar	1.69	1.27
Oneerlijk	1.52	0.71
Ongelukkig	1.96	1.34
Oninteressant	2.31	1.03
Onnauwkeurig	2.73	1.07
Onoplettend	2.79	0.88
Onredelijk	2.35	0.9
Onsympathiek	1.91	0.99
Onverdraagzaam	1.85	1.1
Onverschillig	2.44	1.06
Onvolwassen	2.98	1.14
Onvriendelijk	1.74	0.89
Oppervlakkig	2.51	0.95
Ouderwets	2.94	1.1
Passief	2.73	1.22
Pessimistisch	1.95	1.21
Prikkelbaar	2.4	0.96
Slordig	2.81	1.14
Streng	3.27	1.31
Tactloos	2.04	0.98
Teruggetrokken	3.3	1.02
Vals	1.48	1.09
Vergeetachtig	3.23	1.04
Verlegen	3.54	1.01
Verstrooid	3.44	0.96
Vervelend	2.09	1.07
Vijandig	1.8	1.11
Wantrouwig	2.01	0.72
Zelfvoldaan	3.22	1.39
Zenuwachtig	2.89	1.16
Zwak	2.53	1.01

Positive

List of positive adjectives and their affect rating (mean and standard deviation) selected from Hermans and De Houwer (1994).

Adjective	**Affect Mean**	**Affect SD**
Aangenaam	6.07	0.82
Begrijpend	5.86	1.1
Behulpzaam	5.98	1.02
Betrouwbaar	6.33	0.94
Breeddenkend	5.77	0.98
Creatief	5.91	1
Doorzettend	5.73	1.15
Eerlijk	6.4	0.86
Efficiënt	5.35	1.04
Enthousiast	5.91	1.1
Gelukkig	6.63	0.71
Goedgehumeurd	5.89	1.02
Grappig	6.02	1.08
Intellectueel	5.33	1.06
Interessant	5.69	1.08
Krachtig	5.16	1.03
Levendig	5.85	0.99
Onafhankelijk	5.21	1.15
Ondernemend	5.54	1.05
Ontspannen	6	1.12
Opgewekt	6.27	0.94
Oprecht	6.17	1.12
Optimistisch	6.36	0.93
Origineel	5.98	0.84
Positief	6.11	0.94
Rechtvaardig	6.28	0.91
Sympathiek	6.14	1.05
Verantwoordelijk	5.52	1.25
Vriendelijk	6.28	1

Vrijgevig	5.65	1.06

References

Hermans, D., & De Houwer, J. (1994). Affective and subjective familiarity ratings of 740 Dutch words. Psychologica Belgica, 34(2-3).