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Supplemental information

Enhancing musical pleasure through shared musical experience

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SUPPLEMENTAL INFORMATION

Figure S1. Normal Q-Q plots of the selected linear mixed models' residuals predicting Pleasure ratings.

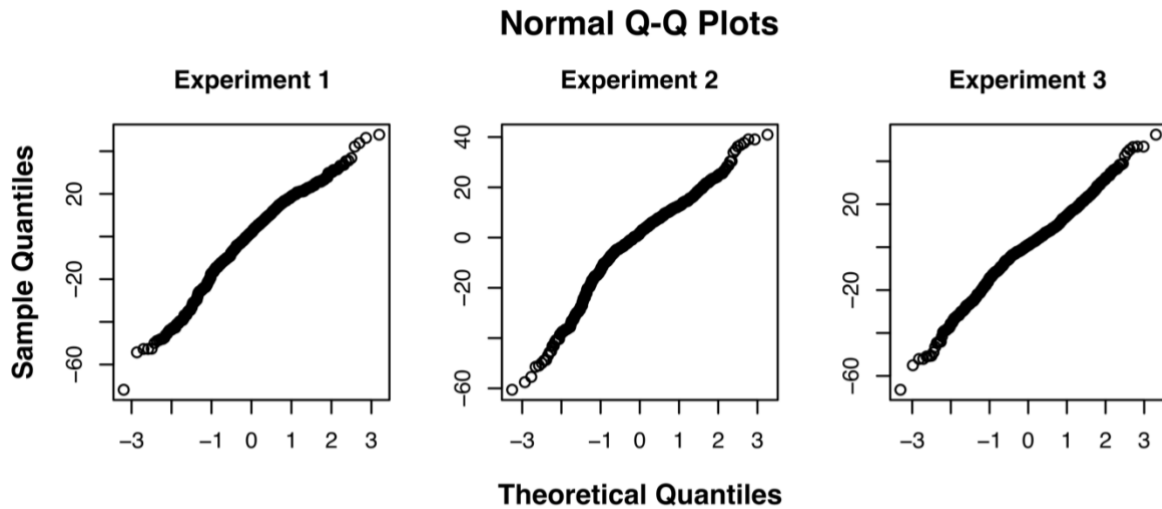


Table S1. Tested models for Pleasure ratings in Experiment 1. All models included the Participant variable as random intercept. In the formulas, ‘*’ = interaction. ‘df’ = degrees of freedom. BIC = Bayesian Information Criterion. $\Delta_i(\text{BIC})$ = difference between BIC for model i and best model’s BIC. LLi = natural logarithm of the maximum likelihood for model i. Likelihood ratio tests compare the goodness of fit of that particular model to the previous nested one (i.e., the model with the same structure minus the new predictor or interaction). Gender was not tested in interaction as not hypothesized in direct relationship with main predictors. The best model is highlighted in bold.

Fixed effects	df	Measures of fit			Likelihood Ratio Test		
		BIC	ΔBIC	LLi	χ^2	df	p
Social Condition	5	6683.0	310.8	-3325			
Social Condition + Gender	6	6681.2	309.0	-3321	8.37	1	0.004
Social Condition + Song Category	6	6374.3	2.1	-3167	315.33	1	< 0.001
Social Condition + Song Category + Gender	7	6372.2	0.0	-3163	8.64	1	0.003
Social Condition * Song Category	8	6384.7	12.5	-3166	2.69	2	0.260
Social Condition + Song Category + BMRQ+ Gender	8	6372.4	0.2	-3160	6.36	1	0.012
Social Condition * Song Category + Gender	9	6382.7	10.5	-3162	8.63	1	0.003
Social Condition * Song Category + BMRQ + Gender	10	6382.9	10.7	-3159	6.36	1	0.012
Social Condition * Song Category * BMRQ + Gender	15	6413.7	41.5	-3158	2.07	5	0.839

Table S2. Tested models for Pleasure ratings in Experiment 2. All models included the Participant variable as random intercept. In the formulas, ‘*’ = interaction. ‘df’ = degrees of freedom. BIC = Bayesian Information Criterion. $\Delta_i(\text{BIC})$ = difference between BIC for model i and best model’s BIC. LLi = natural logarithm of the maximum likelihood for model i. Likelihood ratio tests compare the goodness of fit of that particular model to the previous nested one (i.e., the model with the same structure minus the new predictor or interaction). Gender was not tested in interaction as not hypothesized in direct relationship with main predictors. The best model is highlighted in bold.

Fixed effects	df	Measures of fit			Likelihood Ratio Test		
		BIC	ΔBIC	LLi	χ^2	df	p
Social Condition	5	8056.2	574.1	-4011			
Social Condition + Song Category	6	7482.1	0.0	-3721	580.89	1	< 0.001
Social Condition + Gender	7	8068.8	615.4	-4011	0.987	2	0.611
Social Condition + Song Category + Gender	8	7494.5	12.4	-3720	581.10	1	< 0.001
Social Condition * Song Category	8	7495.4	13.3	-3721	0.309	2	0.857
Social Condition + Song Category + BMRQ+ Gender	9	7499.4	17.3	-3719	1.84	1	0.175
Social Condition * Song Category + Gender	10	7507.7	25.6	-3720	1.19	2	0.551
Social Condition * Song Category + BMRQ + Gender	11	7512.7	30.6	-3719	0.309	2	0.857
Social Condition * Song Category * BMRQ + Gender	16	7544.6	62.5	-3718	2.07	5	0.839

Table S3. Tested models for Ultimatum Game's offers in Experiment 2. All models included the Participant variable as random intercept. In the formulas, '*' = interaction. 'df' = degrees of freedom. BIC = Bayesian Information Criterion. $\Delta_i(\text{BIC})$ = difference between BIC for model i and best model's BIC. LLi = natural logarithm of the maximum likelihood for model i. Likelihood ratio tests compare the goodness of fit of that particular model to the previous nested one (i.e., the model with the same structure minus the new predictor or interaction). Gender was not tested in interaction as not hypothesized in direct relationship with main predictors. The best model is highlighted in bold.

Fixed effects	df	Measures of fit			Likelihood Ratio Test		
		BIC	ΔBIC	LLi	χ^2	df	p
Social Condition + Pleasure	6	8603.9	0.0	-4281			
Social Condition + Pleasure + Gender	8	8614.9	11.0	-4280	2.88	2	0.237
Social Condition * Pleasure	8	8613.8	9.9	-4279	4.04	2	0.133
Social Condition + Pleasure + BMRQ + Gender	9	8618.6	14.7	-4278	3.30	1	0.069
Social Condition * Pleasure + Gender	10	8625.1	21.2	-4278	2.67	2	0.264
Social Condition * Pleasure + BMRQ + Gender	11	8628.5	24.6	-4276	3.54	1	0.060
Social Condition * Pleasure * BMRQ + Gender	16	8656.7	52.8	-4273	6.68	5	0.246

Table S4. Tested models for Pleasure ratings in Experiment 3. All models included the Participant variable as random intercept. In the formulas, '*' = interaction. 'df' = degrees of freedom. BIC = Bayesian Information Criterion. $\Delta_i(\text{BIC})$ = difference between BIC for model i and best model's BIC. LLi = natural logarithm of the maximum likelihood for model i. Likelihood ratio tests compare the goodness of fit of that particular model to the previous nested one (i.e., the model with the same structure minus the new predictor or interaction). Gender was not tested in interaction as not hypothesized in direct relationship with main predictors. The best model is highlighted in bold.

Fixed effects	df	Measures of fit			Likelihood Ratio Test		
		BIC	ΔBIC	LLi	χ^2	df	p
Social Condition	4	9058.0	0	-4515			
Social Condition + Gender	5	9063.6	5.6	-4514	1.31	1	0.253
Social Condition + BMRQ + Gender	6	9070.5	12.5	-4514	0.05	1	0.825
Social Condition * BMRQ + Gender	7	9077.2	19.2	-4514	0.24	1	0.624

Table S5. Tested models for Pleasure ratings in the IPD Meta-Analysis. All models included the Participant variable and Experiment as random intercepts. In the formulas, “*” = interaction. ‘df’ = degrees of freedom. BIC = Bayesian Information Criterion. $\Delta_i(\text{BIC})$ = difference between BIC for model i and best model’s BIC. LLi = natural logarithm of the maximum likelihood for model i. Likelihood ratio tests compare the goodness of fit of that particular model to the previous nested one (i.e., the model with the same structure minus the new predictor or interaction).

Gender was not tested in interaction as not hypothesized in direct relationship with main predictors. The best model is highlighted in bold.

Fixed effects	df	Measures of fit			Likelihood Ratio Test		
		BIC	ΔBIC	LLi	χ^2	df	p
Social Condition	5	23939.7	984.4	-11950			
Social Condition + Song Category	6	22955.3	0.0	-11454	992.26	1	< 0.001
Social Condition + Gender	7	23953.0	998.0	-11949	2.85	2	0.241
Social Condition * Song Category	7	22963.0	7.7	-11454	< 0.001	1	0.977
Social Condition + Song Category + Gender	8	22968.8	13.5	-11453	2.25	2	0.324
Social Condition + Song Category + BMRQ + Gender	9	22972.7	17.4	-11451	4.02	1	0.045
Social Condition * Song Category + Gender	9	22977.0	21.7	-11453	2.25	2	0.324
Social Condition * Song Category + BMRQ + Gender	10	22980.6	25.3	-11451	4.02	1	0.045
Social Condition * Song Category * BMRQ + Gender	13	23002.9	47.6	-11450	1.34	3	0.719

Table S6. Individual differences (BMRQ for sensitivity to music reward, HEXACO and CAPRARA for prosocial traits) between the three groups in Experiment 2. Mean = the mean value of all subjects in a group. CI = Confidence Interval. BF_{01} value reflects the probability of the data given H_0 relative to H_1 , that is, the strength of the evidence supporting that the tested groups are equal against the hypothesis that they are different (e.g., a $BF_{01} = 2$ can be interpreted as the data being twice more likely under H_0 than under H_1).

	Group 1 (Non-Social)		Group 2 (Low-Social)		Group 3 (High-Social)		BF_{01}
	$n = 40$		$n = 34$		$n = 37$		
	Mean	CI	Mean	CI	Mean	CI	
BMRQ	82.33	[80.08, 84.57]	80.65	[78.62, 82.68]	81.51	[78.99, 84.04]	7.56
HEXACO	3.71	[3.53, 3.89]	3.86	[3.70, 4.02]	3.70	[3.50, 3.91]	5.79
CAPRARA	3.95	[3.76, 4.14]	3.70	[3.50, 3.91]	3.91	[3.75, 4.07]	2.22

Table S7. Experimenter-selected songs in Experiment 2. Musical features were extracted using the Sort Your Music web app. BPM = Beats Per Minute (tempo). All ratings, except BPM, are based on a 0-100 scale and describe music in terms of Energy (arousal, relaxing vs exciting), Dance (danceability), Valence (negative/sad vs positive/happy) and Pop (popularity).

Music Genre	Artist	Title	BPM	Energy	Dance	Valence	Pop
Alternative	The Do	On My Shoulders	116	70	72	52	41
	The Limiñanas (feat. Emmanuelle Seigner)	Shadow People	93	62	47	50	31
	Woodkid	Land of All	127	39	34	8	41
Blues	Cecil Barfield	Georgia Blues	167	66	36	58	39
	Muddy Waters	Forty Days And Forty Nights	89	41	60	81	28
	Brother Dege	Hard Row to Hoe	118	84	65	30	34
Classic	Brahms	Symphony No. 3 in F Major, Op. 90 - 1. Allegro con brio	179	10	16	6	36
	Chopin	Waltz in E Minor, Op. Posth.	130	7	28	20	32
	Grieg	Holberg Suite, Op.40 - 1. Präludium	136	6	24	26	37
Country	Nick Nolan	Wanted Man	100	86	56	63	30
	Jason Aldean	Any Ol' Barstool	144	72	54	50	39
	The Heavy Horses	Pale Rider	139	41	62	52	35
Folk	Anna Leone	Wondering	89	19	29	10	22
	Axel Flóvent	Sea Creatures	73	23	46	8	46
	Keilan Creech	Honey Waits	124	29	51	24	31
Gospel	LaShun Pace	There's A Leak In This Old Building	172	40	59	62	36
	The Golden Gospel	Oh Freedom!	95	29	33	19	30

	Tye Tribbett	Anyhow	152	43	42	39	34
Hip-hop	D'Angelo	Left and Right	92	40	84	83	42
	Terrell Morris	Roxy	105	54	47	51	29
	The Pharcyde	Ya Mama	90	79	83	74	43
Jazz	Anthony Lazaro	Someone Like You	80	22	64	38	20
	Sarah Vaughan	Tenderly	66	12	20	7	26
	Peggy Lee	Why Don't You Do Right	124	25	71	65	43
Metal	Bloodbath	Eaten	148	97	41	20	43
	Mercyful Fate	Come to the Sabbath	134	81	26	43	41
	Gorgoroth	Radix Malorum	105	86	32	31	37
Pop	Alice on the roof	How Long	127	78	57	30	22
	LP	Tightrope	160	82	47	41	45
	Jeremy Zucker	Sinking	109	35	75	77	33
R&B	Kelly Rowland	Dirty Laundry	120	45	68	68	35
	Trey Songz (feat. Swae Lee)	Rain	138	42	62	40	27
	Vedo	As Long As You Know	81	39	62	47	30
Rap	Scylla	Et toi	101	28	62	39	40
	Lil'J Kasino	Dirty Game Attack	128	48	87	10	50
	Suprême NTM	That's My People	88	57	75	52	46
Reggae	Alborosie	Unprecedented Time	132	61	79	86	31
	Israel Vibration	Back Stabba	74	54	76	89	52
	Naâman	Time Is To Rebel	172	60	67	73	24
Rock	KO KO MO	Last Night a DJ Saved my Life	107	73	57	32	45
	Lonely The Brave	Open Door	130	81	51	60	20
	Pærish	Violet	173	85	34	62	21
Soul	Malford Milligan	Arms Around the World	91	72	71	92	22
	Otis Redding	A Change Is Gonna Come	89	30	43	33	36
	Cleo Sol	Sideways	125	24	44	38	41
Techno/ House	Âme	No War - Ry X Remix	125	92	69	6	34
	Ba:sen	In Deep We Trust (Pool Party Dub Mix)	120	71	85	27	36
	Vatican Shadow	Egyptian Journalists Syndicate	130	70	70	4	28
Variety	Pomme	Adieu mon homme	109	32	47	32	26
	Alt-J (feat. Lomepal)	3WW	144	51	52	24	54
	Charles Aznavour	La Mamma	104	44	46	36	39

Table S8. Mean values of BPM (Beats Per Minute), Energy (arousal), Dance (danceability), and Pop (popularity) between the experimenter-selected songs listened in the 3 conditions of Experiment 2. All ratings were extracted using the Sort Your Music web app. CI = Confidence Interval. BF_{01} = Bayes Factor.

	Group 1 (Non-Social) <i>n</i> = 40		Group 2 (Low-Social) <i>n</i> = 34		Group 3 (High-Social) <i>n</i> = 37		BF_{01}
	Mean	CI	Mean	CI	Mean	CI	
BPM	119.39	[99.49, 138.15]	118.87	[98.99, 137.70]	116.19	[97.11, 135.81]	6.00
Energy	52.74	[27.14, 78.15]	51.73	[26.56, 77.68]	51.89	[26.58, 77.62]	6.58
Dance	54.58	[40.88, 67.71]	53.68	[40.22, 67.00]	54.14	[40.51, 67.30]	6.56
Pop	35.77	[32.73, 38.44]	34.15	[31.48, 37.19]	35.33	[32.31, 38.06]	4.84

Table S9. Experiment 2. Distribution of time availability in the different Social conditions (Groups).

Time availability (minutes)	Group 1 (Non-Social) <i>n</i> = 40		Group 2 (Low-Social) <i>n</i> = 34		Group 3 (High-Social) <i>n</i> = 37	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
0	1	2.5%	0	0.0%	0	0.0%
5	3	7.5%	7	20.6%	2	5.4%
10	4	10.0%	4	11.8%	3	8.1%
20	32	80.0%	23	67.7%	32	86.5%

Table S10. Experiment 2. Distribution of donation amounts in the different social conditions (groups).

Donation amount (€)	Group 1 (Non-Social) <i>n</i> = 40		Group 2 (Low-Social) <i>n</i> = 34		Group 3 (High-Social) <i>n</i> = 37	
	<i>Frequency</i>	<i>Percentage</i>	<i>Frequency</i>	<i>Percentage</i>	<i>Frequency</i>	<i>Percentage</i>
0	9	22.5%	7	20.6%	12	32.4%
10	7	17.5%	6	17.6%	3	8.1%
20	7	17.5%	5	14.7%	5	13.5%
30	5	12.5%	2	5.9%	3	8.1%
40	2	5.0%	0	0.0%	0	0.0%
50	10	25.0%	14	41.2%	14	37.9%

Table S11. Playlists in Experiment 3. Music extracts were rated in terms of Pleasure (general pleasantness), Arousal, Valence, and Familiarity on a 1-5 scale by an independent sample of participants (see²).

Playlist	Compositor	Title	Arousal	Valence	Familiarity	Pleasure
A	Tomaso Albinoni	Sonata No. 9 in G Major, Op. 6: III. Adagio	2.06	2.06	1.53	3.18
	Carl Friedrich Abel	Sonata for violoncello and basso continuo in G Major, WKO 147: III. Rondeau	3.71	3.41	1.71	2.82
	Johann Sebastian Bach	Viola da gamba Sonata No. 3 in G Minor, BWV 1029: II. Adagio	2.35	2.71	1.71	2.59
	Alban Berg	Sarabande in F Major	3.35	3.18	1.47	2.94
	Tomas Breton	4 Spanish Pieces: No. 3. Bolero	2.59	3.12	1.47	3.12
	Louis-Nicolas Clerambault	Le Triomphe d'Iris, Entree I: Overture	3.35	2.88	1.59	2.41
	Leoš Janáček	Nursery Rhymes, JW V/17: I. Introduction	2.88	3.06	1.53	2.35
	Felix Mendelssohn	Piano Concerto No. 2 in D Minor, Op. 40, MWV O 11: II. Adagio. Molto sostenuto	1.53	2.12	1.59	3.29
	Richard Strauss	Stimmungsbilder, Op. 9, TrV 127: III. Intermezzo	2.47	2.47	1.35	2.59
	Dmitri Shostakovich	The Gadfly Suite, Op. 97a: VIII. Romance	2.12	2.94	1.82	3.24
Matthew Locke	For Several Friends: Suite in G Major-minor: I. Fantazie	3.18	3.29	1.47	2.53	
Frederick Delius	3 Small Tone Poems: I. Summer Evening	2.00	2.82	1.53	2.71	
B	Arcangelo Corelli	Violin Sonata in D Minor, "Follia", Op. 5 No. 12	2.41	2.76	1.47	2.35
	Léo Delibes	Coppélia / Tableau 2 - 17. Gigue	3.47	3.35	1.71	3.29
	Dvořák	Serenade for Strings in E Major, Op. 22, B. 52: II. Tempo di valse	3.18	3.18	1.82	3.76
	Enrique Granados	Valses Poeticos - 5 Allegretto	3.12	3.47	1.59	3.18
	Leoš Janáček	Lachian Dances, JW VI/17: No. 6, Saw Dance	3.12	3.59	1.71	3.24
	Tchaikovsky	Souvenir de Florence, Op. 70, TH 118 - IV. Allegro vivace	3.24	2.82	1.65	3.35
	Franz Joseph Haydn	Symphony No. 78 in C minor	3.29	3.06	1.59	3.24
	Charles Ives	Symphony No. 4: III. Fugue: Andante moderato con moto	2.47	2.65	1.65	2.59
	Johann Strauss II	Un ballo in maschera, Quadrille, Op. 272	4.47	3.82	1.76	2.94
	Johann Strauss II & Josef Strauss	Pizzicato Polka	2.53	3.18	1.41	2.31
Gustav Mahler	Symphony No. 4 - III. Ruhevoll, poco adagio	1.82	1.94	1.47	3.00	

	Carl Nielsen	Symphony No. 1 in G minor, Op. 7, III. Allegro comodo - Andante sostenuto - Tempo 1	2.12	3.12	1.47	2.35
	Tomaso Giovanni Albinoni	Concerto for two oboes, strings & b.c. in C major (Op. 7 n. 2)	3.00	3.24	1.65	2.53
	Tomás Bretón	Symphony No.1 in F-major-II-Andante	2.71	3.24	1.47	3.12
	Arcangelo Corelli	Violin Sonata in D minor, Op.5 No.7	3.41	3.71	1.65	2.82
	Joseph Nicolas Pancrace Royer	Pièces de clavecin, Book 1: VI. L'aimable: Gracieux	2.35	2.65	1.29	2.65
	Frederick Delius	Two Aquarelles - Gaily, But Not Too Quick	2.59	2.82	1.47	2.59
C	Marin Marais	Suite in E minor - VII - Gigue La Resolue	3.24	3.41	1.47	2.41
	Alessandro Marcello	Trumpet Concerto in C Minor: I. Allegro moderato	2.88	3.18	1.59	2.82
	Felix Mendelssohn	Clarinet Sonata in E-flat major, BWV Q15, II. Andante	2.71	3.00	1.41	2.88
	W. A. Mozart	Rondo in D Major K. Anh. 184	2.65	3.06	1.71	2.76
	Francis Poulenc	Elégie (en accords alternés)	2.00	2.59	1.53	2.47
	Richard Strauss	Sonata for Piano in B Minor, Op. 5: II. Adagio cantabile	2.47	2.88	1.53	3.00
	Domenico Scarlatti	Sonata in D Major, K 491	2.82	3.18	1.65	3.18
	Léo Delibes	Coppélia, Act II: Scène et danse de la Poupée	3.18	3.06	1.65	2.88
	Enrique Granados	Goyescas - Suite - 3. El Fandango del Candil	2.41	2.88	1.35	2.53
	Domenico Scarlatti	Sonata in F minor, K.466	1.65	2.06	1.71	2.65
	Franz Schubert	Symphony No.10 in D (D. 936A) II. Andante	2.24	2.94	1.59	2.47
	Dmitri Shostakovich	Piano Concerto No. 2 in F Major, Op. 102: I. Allegro	3.53	3.71	1.41	2.53
	Alexander Scriabin	Deux Poèmes Op. 32 (n. 1 in F Major)	2.65	3.00	1.53	2.47
D	Tchaikovsky	Piano Trio in A Minor, Op. 50: II. Variazione VI (Tempo di valse)	3.41	2.76	1.47	2.59
	Richard Wagner	Parsifal-Paraphrase	2.12	2.18	1.71	2.88
	Friedrich Fasch	Overture (Suite) in D minor: V. Jardiniers	3.41	3.53	1.65	2.82
	Gabriel Faure	Masques et Bergamasques, Suite, Op.112 - IV. Pastorale	2.59	2.71	1.82	3.29
	Franz Joseph Haydn	String Quartet No. 63 in B-Flat Major, Op. 76, No. 4, Hob.III:78, "Sunrise": III. Menuetto: Allegro	3.18	3.41	1.59	2.82
	Johann Joachim Quantz	Flute Concerto in A Minor, QV 5:238: I. Allegretto	3.41	3.59	1.59	3.29

Table S12. Mean values of Arousal, Valence, Familiarity and Pleasure between the four Playlists presented in Experiment 3. CI = Confidence Interval. BF_{01} = Bayes Factor.

	Playlists								BF_{01}
	Playlist A		Playlist B		Playlist C		Playlist D		
	$n = 12$		$n = 12$		$n = 12$		$n = 12$		
	Mean	CI	Mean	CI	Mean	CI	Mean	CI	
Arousal	2.63	[2.21, 3.06]	2.94	[2.49, 3.39]	2.73	[2.49, 2.98]	2.82	[2.42, 3.21]	5.50
Valence	2.38	[2.56, 3.11]	3.08	[2.76, 3.39]	3.08	[2.88, 3.28]	2.97	[2.65, 3.32]	4.44
Familiarity	1.56	[1.48, 1.64]	1.60	[1.53, 1.69]	1.54	[1.46, 1.61]	1.59	[1.50, 1.67]	4.61
Pleasure	2.81	[2.60, 3.03]	2.97	[2.67, 3.26]	2.77	[2.61, 2.93]	2.77	[2.59, 2.95]	2.22

SI References

1. Lee, M.D., and Wagenmakers, E.-J. (2014). *Bayesian Cognitive Modeling: A Practical Course* (Cambridge University Press).
2. Ferreri, L., and Rodriguez-Fornells, A. (2017). Music-related reward responses predict episodic memory performance. *Exp. Brain Res.* 235, 3721–3731. [10.1007/s00221-017-5095-0](https://doi.org/10.1007/s00221-017-5095-0).