Supplementary Material

The anger-infused Ultimatum Game: a reliable and valid paradigm to induce and assess anger

Gadi Gilam[1,2,*,‡], Rany Abend[1,2,3,*], Hagai Shani[1,2], Ziv Ben-Zion[1,4], Talma Hendler[1,2,4,5]

[*] This work reflects equal contribution of the first two authors

[1] Tel Aviv Center for Brain Function, Wohl Institute for Advanced Imaging, Tel Aviv Sourasky Medical Center, Weizmann 6, Tel Aviv, 64239, Israel

[2] School of Psychological Sciences, Tel-Aviv University, P.O. Box 39040, Tel Aviv 69978, Israel

[3] Section on Development and Affective Neuroscience, National Institute of Mental Health, Bethesda, MD 20892, USA

[4] Sagol School of Neuroscience, Tel-Aviv University, P.O. Box 39040, Tel Aviv 69978, Israel

[5] Sackler Faculty of Medicine, Tel-Aviv University, P.O. Box 39040, Tel Aviv 69978, Israel

Corresponding author: Gadi Gilam, Ph.D.

Tel Aviv Center for Brain Function, Wohl Institute for Advanced Imaging, Tel Aviv Sourasky Medical Center, Weizmann 6, Tel Aviv, 64239, Israel.

Phone: +972 (0)3 697 3549. Email: gadi.gilam@gmail.com.

[‡] Present address: Division of Pain Medicine, Systems Neuroscience and Pain Laboratory, Department of Anesthesiology, Perioperative and Pain Medicine, Stanford University School of Medicine, Palo Alto, CA, United States

Supplementary Materials and Methods

General Ultimatum Game (UG) procedure

Participants were instructed to play as the responder and decide whether to accept or reject the offers they receive. Similar to our own and others' previous procedures (Campanha, Minati, Fregni, & Boggio, 2011; Gilam et al., 2015), they were told that at the end of data collection, the three participants who completed both experimental tasks and earned the most money during a single experimental session would in fact receive their earnings. This was done to increase motivation of participants to be engaged in the task, to motivate return to the second experimental session and to enhance the personal cost of rejecting an offer. Similar to previous procedures (Crockett, Clark, Tabibnia, Lieberman, & Robbins, 2008; Riepl, Mussel, Osinsky, & Hewig, 2016; Veen & Sahibdin, 2011), each monetary offer was described as being randomly drawn from a database of real offers given by previous participants. The participants were then told they would provide their own UG offer subsequently. In actuality, all offers were predetermined as detailed below. Participants were also told that offers were made in percentages (e.g. 50% per player) but presented in varying sums ranging between 20-30 Israeli New Shekels (ILS; approximately 5.5-8.5 USD) as randomly decided by the computer. This was done to increase the pool of offers needed to generate two comparable sets of offers for the two experimental sessions, to avoid having a constant amount of money per offer and to diminish confounding related to the total amount of money in each offer. Average offer size (total of 25.11 ILS) was equivalent to the minimum hourly wage in Israel during the period of data collection. The maximum gain if all offers were accepted was 276 ILS. In accordance with previous studies, each offer was accompanied only by the initials of the supposed proposer, to avoid uncontrolled reactions associated with gender, name and visual appearance of proposers (Halko, Hlushchuk, Hari, & Schürmann, 2009; Kim, Choi, & Jang, 2011; Ma, Hu, Jiang, & Meng, 2015; Marchetti, Castelli, Harlé, & Sanfey, 2011; Solnick & Schweitzer, 1999; Solnick, 2001). We generated two sets of 36 initials from common and real names of men and women, creating a comparable distribution in terms of the alphabet used between the two sets.

Finally, participants were told about the sequence and timing of each offer trial, and practiced on a single equal-split offer (12 ILS per player). In addition, throughout this instructions phase, each participant was required to correctly complete four multiple-choice questions to verify their comprehension of the task. Three questions examined comprehension of the rules of the game and one additional question examined comprehension of how the monetary reward could be actually gained.

Participants' UG and DG offers

At the end of the instructions phase participants provided their own UG offer to be supposedly added to the database of offers. After completing the UG task, participants were asked to provide a hypothetical offer (i.e. not included in the database of offers) in the Dictator Game (DG; Forsythe, Horowitz, Savin, & Sefton, 1994), which is exactly like the UG but the offer cannot be rejected. Thus, in the DG there is no concern for reciprocity and the lower the offer, the more money a proposer allegedly keeps to him- or her- self. Since the DG offer is presented here as hypothetical, the difference between the offer allocated in the initial UG offer and that of the DG offer may further indicate the influence of the UG task on participants' emotional state, whereby a larger decrease might reflect a greater willingness to retaliate and express anger (i.e. equating less money offered with more retaliation).

Validation study of interpersonal messages

Previous UG studies have incorporated messages to accompany UG offers, but not specifically to induce anger (Croson, Boles, & Murnighan, 2003; Kravitz & Gunto, 1992; Xiao & Houser, 2005). A pilot study using an online survey platform (Qualtrics, Provo, UT) was conducted to validate the angering quality of the interpersonal messages. Fifty-eight volunteers (age 18-70 years, $M=34.12\pm12.25$ years; 31 females) were recruited from various social media networks. Participants were asked to imagine a bargaining situation specifically reflecting the UG in which

they needed to decide whether to accept or reject the monetary offer. Without specifying an actual amount of money, they were then asked to rate on a 0 (not at all) to 10 (very much) scale the level of anger evoked by each of 95 randomly-presented interpersonal messages which would accompany such a UG offer. To keep messages succinct, they were limited to a maximum of 35 characters. After completing the rating, they were asked to write down any specifically angering or non-credible sentences they remembered, and also rate on the same 0-10 scale the overall level of anger induced by the sentences (*M=5.60±2.10*). Based on the results of this pilot study, we chose 24 messages per offer type, to be divided into the two sets required for the final UG study. The 24 most angering messages (mean anger rating range of 6.93-8.21) were selected for the unfair offers. The next 24 most angering messages (mean rating range of 6.00-6.90) were selected for the medium offers. The 24 least angering messages (mean rating range of 2.85-4.81) were selected for the fair offers. These messages were then divided into two sets of 36 messages comparable in anger level for each offer type.

The final 72 messages were translated by four of the authors from Hebrew to English, considering cultural differences and slang, and the final version was validated by an additional native English speaker. For future use in English speaking countries, these messages were further submitted to a validation procedure in which native English speakers (n=63) were similarly asked to rate the level of anger evoked by each message in a UG bargaining context (Table S2).

Taylor Aggression Paradigm (TAP) procedure

Before the TAP started, participants read instructions and competition rules on the computer screen. To familiarize them with the range of noise intensities, they were then played intensities of levels 4, 7, and 10. Subsequently, to further convince participants of the interactive nature of the manipulation, a message on-screen stated ‘please wait until both players are ready’, and was followed by a 5-second countdown. The task then started.

Each round of the task was divided into four phases. First, participants chose the intensity level of white noise they would inflict on their opponent if they won the round, on an intensity scale of 0 (no sound) to 10 (loud aversive white noise at 110dB). Only after participants entered their selected noise intensity, could they press the on-screen button ‘ready’ that initiated the competition, whereby a target at the center of the screen turned green. In the next phase, the target changed to yellow as soon as the putative competitor also pressed their 'ready' button. The yellow color served as a warning sign to note that the competition was about to begin. In the third phase, once the target color changed from yellow to red, the participants had to press the mouse button as quickly as possible. Throughout the 10 rounds of the task, the sequential change of target color from green to yellow randomly varied between 0-5000ms (in 500ms steps); the change from yellow to red randomly varied in range of 500-3000ms (in 500ms steps). In the final phase, the winner was declared allegedly based on the shortest reaction-time. At the same time, the level of noise intensity chosen by the putative opponent was revealed, and if the participant lost the round, they heard (through headphones) the noise blast at the intensity chosen by their opponent, for two seconds. Importantly, even if they won, participants were still privy to what noise intensity their opponent chose to administer to them.

The noise intensities were in fact predefined throughout the game and two sequences of noise intensities were generated for the two experimental sessions. The order of noise levels for the first set was 5, 2, 4, 3, 6, 5, 6, 9, 7, 8, and for the second 5, 3, 2, 4, 6, 6, 5, 8, 9, 7 (randomly counterbalanced between participants across the two experimental sessions). The average level of noise, as well as the gradual increase in noise intensities, which aimed to further provoke and induce anger and aggression as the task evolved, was comparable in both sequences. To induce and measure interpersonal anger and aggression, participants always lost the first and last rounds, while they randomly won 50% of the remaining rounds. However, for credibility, participants had to click the mouse button faster than 700ms to potentially win their designated winning rounds. The average winning percentage for all participants was M=54.57±7.82 with no difference between time-points

or UG versions (*ps*>0.14) indicating that participants responded quickly and won about half of the rounds.

Table S1: Two sets of offers for the UG

		Set A				Set B			
Offer	**#**	**proposer**	**responder**	**%**	**difference**	**proposer**	**responder**	**%**	**difference**
Fair	1	11	11	0.500	0	10	10	0.500	0
	2	13	13	0.500	0	12	12	0.500	0
	3	14	14	0.500	0	15	15	0.500	0
	4	14	13	0.481	1	13	12	0.480	1
	5	11	10	0.476	1	12	11	0.478	1
	6	16	14	0.467	2	15	13	0.464	2
	7	13	11	0.458	2	14	12	0.462	2
	8	11	9	0.450	2	12	10	0.455	2
	9	16	13	0.448	3	15	12	0.444	3
	10	13	10	0.435	3	14	11	0.440	3
	11	16	12	0.429	4	17	13	0.433	4
	12	15	11	0.423	4	14	10	0.417	4
Medium	1	14	7	0.333	7	15	8	0.348	7
	2	17	9	0.346	8	16	8	0.333	8
	3	15	7	0.318	8	14	6	0.300	8
	4	18	9	0.333	9	17	8	0.320	9
	5	15	6	0.286	9	16	7	0.304	9
	6	19	9	0.321	10	20	10	0.333	10
	7	18	8	0.308	10	17	7	0.292	10
	8	15	5	0.250	10	16	6	0.273	10
	9	20	9	0.310	11	19	8	0.296	11
	10	17	6	0.261	11	18	7	0.280	11
	11	20	8	0.286	12	21	9	0.300	12
	12	19	7	0.269	12	18	6	0.250	12
Unfair	1	18	4	0.182	14	17	3	0.150	14
	2	19	4	0.174	15	20	5	0.200	15
	3	20	4	0.167	16	21	5	0.192	16
	4	19	3	0.136	16	18	2	0.100	16
	5	21	4	0.160	17	22	5	0.185	17
	6	19	2	0.095	17	20	3	0.130	17
	7	24	6	0.200	18	23	5	0.179	18
	8	22	4	0.154	18	21	3	0.125	18
	9	22	3	0.120	19	23	4	0.148	19
	10	24	4	0.143	20	23	3	0.115	20
	11	24	3	0.111	21	25	4	0.138	21
	12	26	4	0.133	22	25	3	0.107	22

Table S1: The two sets of 36 offers each were balanced in terms of sum of money that could be gained in each offer type (Fair=141ILS; Medium=90ILS; Unfair=45ILS, for a total of 276 ILS).

Table S2: Two sets of interpersonal messages for the anger-infused UG

		Set A			Set B		
Offer Type	**#**	**message**	**length**	**anger**	**message**	**length**	**anger**
Fair	1	You know what to do	19	2.81±2.66	Hope you'll take it	19	1.44±1.80
	2	Let's split it equally	22	0.49±1.19	The bonus awaits us	19	1.14±2.20
	3	Don't hesitate	14	2.62±2.53	Giving you a great offer	24	1.78±2.10
	4	Roll with me…	13	2.22±2.21	I wish everyone was fair like me	32	2.98±2.38
	5	If you take it, we both win	27	1.89±2.51	Take it and we'll both win	26	2.17±2.40
	6	Let's do this already	21	3.35±2.67	I give as much as I take	24	2.33±2.46
	7	The offer speaks for itself :)	30	2.29±2.48	Heart to heart, dollar to dollar	32	2.03±2.21
	8	Hope I can count on you	23	1.27±2.02	Much respect, let's make it	34	1.37±2.23
	9	Equality for all!	17	1.05±2.16	Let's do this together, bro	27	0.65±1.61
	10	I know you'll make the right	35	1.81±2.23	We're all happy, right?	23	2.08±2.48
	11	I'm being fair, you should too	30	2.63±2.33	I really need the money…	24	2.46±2.38
	12	Let's make a deal	17	1.13±1.84	I split the pie equally	23	0.78±1.55
Medium	1	Dog eat dog, bitch!	19	8.59±2.41	So I took a little more. So	34	6.33±2.74
	2	Some people are just worth more	31	6.54±3.13	Not everything's fair in life	29	5.65±2.86
	3	Don't be a jerk!	16	6.59±2.90	You need me more than I need you	32	6.13±2.65
	4	Don't be stupid	15	6.83±2.63	I don't owe you anything!	25	6.40±2.86
	5	No hard feelings honey!	23	4.90±3.12	Trust me, I'm generous	22	3.11±2.59
	6	Gotta be a psycho not to take this	34	6.14±2.95	Not open for discussion. Take it.	33	6.51±2.92
	7	All or nothing baby	19	5.10±3.38	Honey, special offer just for	34	3.81±3.28
	8	Shame on you if you reject this	31	5.92±2.73	This isn't econ 101.Just take it.	34	5.81±2.95
	9	Maybe next time you'll get more	31	5.05±2.72	This is it. All or nothing!	27	5.19±3.30
	10	This game is not for the weak	29	4.49±2.79	Survival of the strongest	25	4.97±2.85
	11	That's the offer, deal with it	30	6.30±2.75	Don't be a sucker	17	6.06±2.74
	12	Honestly, I'm being generous here	33	4.10±2.85	I'm not stupid! Watch it!	25	6.35±3.09
Unfair	1	Come on, loser!!!	17	8.41±1.91	Don't be a dirty pig!	21	7.68±2.80
	2	Be happy you got anything at all	32	7.05±2.81	Take it or I'll come get you!	29	7.81±2.72
	3	Who the hell are you?	22	6.84±2.90	Come on dummy, take it!	23	7.87±2.33
	4	You must be an A-hole if you	35	8.27±2.10	Don't start cryin like a girl :(	32	7.97±2.51
	5	C'mon accept this, don't be a loser	35	6.89±2.40	I'm in control now so just take it	34	7.35±2.67
	6	Kiddo, let me teach you about life	34	6.38±2.88	You don't deserve any more	26	6.98±2.90
	7	Be a good kid and take it	25	5.71±2.83	I bet you gave a dumb offer	27	7.40±2.41
	8	Don't be a dumbass rookie	25	8.22±2.31	You're a dipshit if you reject this	35	8.79±1.78
	9	Take it! I have no time for this	32	6.08±3.11	Cutie, you don't have a choice	35	7.13±3.07
	10	Take it like a little bitch	27	9.19±1.57	Going for the win. Screw you	28	8.40±2.43
	11	more for me, less for you, all good	35	7.16±2.96	Hope I didn't end up with an	34	7.38±2.64
	12	This is it hon	14	4.71±3.06	Sorry honey, it is what it is	29	6.40±2.88

Table S2: The two sets of 36 messages translated to English and divided to the fair, medium and unfair conditions. They were further validated in a survey using MTurk in which 63 (age 21-64 years, M=*36.24±10.66* years; 30 females) native English speakers were instructed to rate the level of anger induced by the messages following the same instructions as in the original validation study. Mean±SD for each message are presented in the anger column.

Supplementary Results

UG Reaction times

Decision reaction times (RT) were measured in milliseconds from the onset of decision period and were log-transformed to normalize the data. These values were submitted to a repeated-measures ANOVA with Offer Type (Fair, Medium, Unfair) as a within-subject factor, and Version (Standard, Anger-Infused) as a between-subjects factor. This analysis revealed a significant main effect of Offer Type, $F(2,234)=10.81$, $p<0.001$, $\eta_p^2=0.08$, with follow-up analyses indicating slower RTs for medium offers compared to both fair and unfair offers (Fair: $M=994.74\pm384.09$ms, Medium: $M=1085.50\pm410.13$ms, Unfair: $M=979.68\pm342.45$ms), ps<0.001. In addition we noted a trend-level main effect of Version, $F(1,117)=3.61$, $p=0.06$, $\eta_p^2=0.03$, with slower RTs for the anger-infused relative to the standard UG version. This may indicate that medium offers in both UG versions as well as the anger-infused version in general required more deliberation time necessary to make a decision regarding whether to accept or reject the offers. No interaction was found ($p>0.17$).

Participants' UG and DG offers

The UG offer allocated by participants at the end of the instructions phase and the DG offer made after the task were submitted to a repeated-measures ANOVA with Offer (UG/DG) as a within-subject factor, and Version (Standard, Anger-Infused) as a between-subjects factor. This analysis revealed a significant main effect of Offer, $F(1,117)=25.37$, $p<0.001$, $\eta_p^2=0.18$, indicating a decrease in offer size between the UG ($M=48.63\pm14.03\%$) and DG ($M=38.44\pm24.90\%$). No main or interaction effects of Version emerged (ps>0.91) indicating no differences between UG versions.

The observed decrease may reflect the inherent difference between the UG and DG (Forsythe et al., 1994). In other words, in the DG there is no concern for fairness norms as the offer cannot be rejected and thus keeping more money to oneself may reflect the self-interest to gain money. However, since the current DG was hypothetical and participants could not actually gain money, we assumed such a decrease indicates the expression of anger following the UG task.

Notwithstanding, DG offers still amounted to almost 40%, thereby indicating a more complex picture in which the emotional state is not necessarily the entire explanation for the observed decrease (Fehr & Schmidt, 2006). Future studies may wish to further investigate this issue.

Supplementary References

Campanha, C., Minati, L., Fregni, F., & Boggio, P. S. (2011). Responding to unfair offers made by a friend: neuroelectrical activity changes in the anterior medial prefrontal cortex. *Journal of Neuroscience*, *31*(43), 15569–15574.

Crockett, M. J., Clark, L., Tabibnia, G., Lieberman, M. D., & Robbins, T. W. (2008). Serotonin Modulates Behavioral Reactions to Unfairness. *Science*, *320*(5884), 1739–1739. https://doi.org/10.1126/science.1155577

Croson, R., Boles, T., & Murnighan, J. K. (2003). Cheap talk in bargaining experiments: lying and threats in ultimatum games. *Journal of Economic Behavior & Organization*, *51*(2), 143–159. https://doi.org/10.1016/S0167-2681(02)00092-6

Fehr, E., & Schmidt, K. M. (2006). The economics of fairness, reciprocity and altruism–experimental evidence and new theories. *Handbook of the Economics of Giving, Altruism and Reciprocity*, *1*, 615–691.

Forsythe, R., Horowitz, J. L., Savin, N. E., & Sefton, M. (1994). Fairness in Simple Bargaining Experiments. *Games and Economic Behavior*, *6*(3), 347–369. https://doi.org/10.1006/game.1994.1021

Gilam, G., Lin, T., Raz, G., Azrielant, S., Fruchter, E., Ariely, D., & Hendler, T. (2015). Neural substrates underlying the tendency to accept anger-infused ultimatum offers during dynamic social interactions. *NeuroImage*, *120*, 400–411. https://doi.org/10.1016/j.neuroimage.2015.07.003

Halko, M.-L., Hlushchuk, Y., Hari, R., & Schürmann, M. (2009). Competing with peers: Mentalizing-related brain activity reflects what is at stake. *NeuroImage*, *46*(2), 542–548. https://doi.org/10.1016/j.neuroimage.2009.01.063

Kim, H., Choi, M.-J., & Jang, I.-J. (2011). Lateral OFC Activity Predicts Decision Bias due to First Impressions during Ultimatum Games. *Journal of Cognitive Neuroscience*, *24*(2), 428–439. https://doi.org/10.1162/jocn_a_00136

Kravitz, D. A., & Gunto, S. (1992). Decisions and perceptions of recipients in ultimatum bargaining games. *Journal of Socio-Economics*, *21*(1), 65–84. https://doi.org/10.1016/1053-5357(92)90026-4

Ma, Q., Hu, Y., Jiang, S., & Meng, L. (2015). The undermining effect of facial attractiveness on brain responses to fairness in the Ultimatum Game: an ERP study. *Frontiers in Neuroscience*, *9*, 77.

Marchetti, A., Castelli, I., Harlé, K. M., & Sanfey, A. G. (2011). Expectations and outcome: The role of Proposer features in the Ultimatum Game. *Journal of Economic Psychology*, *32*(3), 446–449. https://doi.org/10.1016/j.joep.2011.03.009

Solnick, S. J., & Schweitzer, M. E. (1999). The Influence of Physical Attractiveness and Gender on Ultimatum Game Decisions. *Organizational Behavior and Human Decision Processes*, *79*(3), 199–215. https://doi.org/10.1006/obhd.1999.2843

Solnick, S. J. (2001). Gender differences in the ultimatum game. *Economic Inquiry*, *39*(2), 189.

Veen, F. M. V. der, & Sahibdin, P. P. (2011). Dissociation between medial frontal negativity and cardiac responses in the ultimatum game: Effects of offer size and fairness. *Cognitive, Affective, & Behavioral Neuroscience*, *11*(4), 516–525. https://doi.org/10.3758/s13415-011-0050-1

Xiao, E., & Houser, D. (2005). Emotion expression in human punishment behavior. *Proceedings of the National Academy of Sciences of the United States of America*, *102*(20), 7398–7401. https://doi.org/10.1073/pnas.0502399102