

Neural basis of increased costly norm enforcement under adversity

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and Δ ($\Delta = \Delta_{\text{obs}} - \Delta_{\text{cal}}$) is the difference between the observed and calculated Δ ($\Delta_{\text{obs}} = 10^{-10} \text{ cm}^2$).

With the above method, we can obtain the Δ values of the A_1 and A_2 bands. As shown in Fig. 1, the Δ values of the A_1 and A_2 bands are 10^{-10} and 10^{-11} cm^2 , respectively. The Δ value of the A_1 band is larger than that of the A_2 band. This indicates that the A_1 band is more sensitive to the variation of the atmospheric water vapor concentration than the A_2 band. The Δ values of the A_1 and A_2 bands are 10^{-10} and 10^{-11} cm^2 , respectively (Wang et al., 2011).

With the Δ values of the A_1 and A_2 bands, we can calculate the Δ values of the A_1 and A_2 bands at different atmospheric water vapor concentrations. The Δ values of the A_1 and A_2 bands at different atmospheric water vapor concentrations are plotted in Fig. 2 (Wang et al., 2010). A comparison of Fig. 2 shows that the Δ values of the A_1 and A_2 bands increase with increasing atmospheric water vapor concentration.

The Δ values of the A_1 and A_2 bands are proportional to the atmospheric water vapor concentration (Aydin et al., 1998; Figs. 1 and 2, 1999). If the atmospheric water vapor concentration is constant, the Δ values of the A_1 and A_2 bands are proportional to the atmospheric water vapor concentration (Balogh et al., 2009; Balogh et al., 2013), i.e., $\Delta_{\text{obs}} = \Delta_{\text{cal}} + \Delta_{\text{err}}$ (Fig. 3) (Cao et al., 2008; Li et al., 2010).

According to Eqs. (1)–(3), the Δ values of the A_1 and A_2 bands are proportional to the atmospheric water vapor concentration. Therefore, the Δ values of the A_1 and A_2 bands are proportional to the atmospheric water vapor concentration.

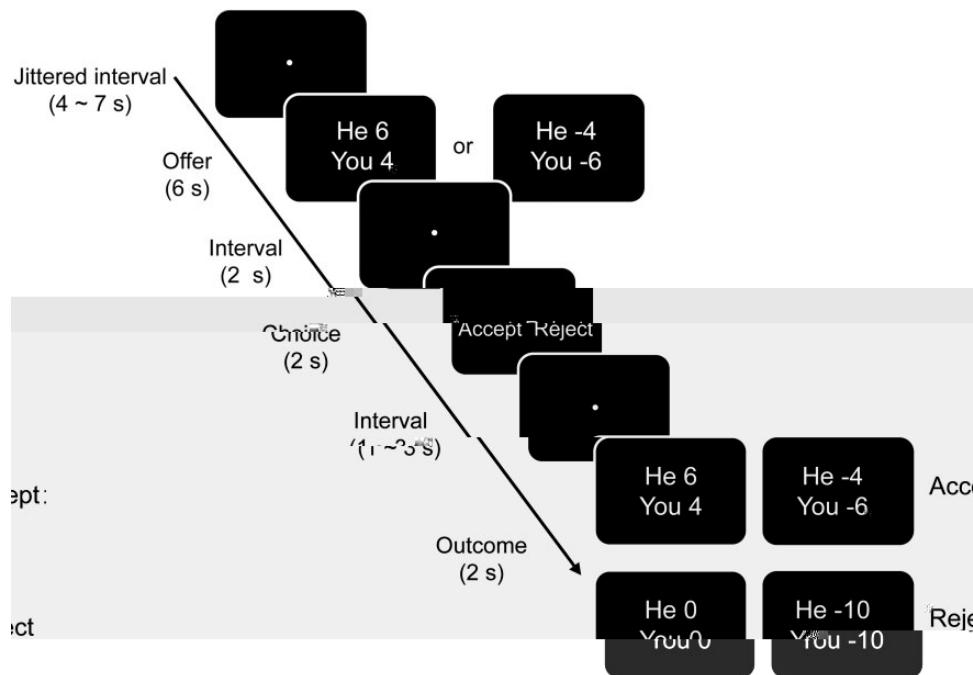


Fig. 1 Sequence of events and timing in a trial. Each trial began by presenting the offer to the participant for 6 s. The participant was told to evaluate the offer but not to press any button at this moment. After a 2 s interval, the participant had to decide whether to accept or to reject the offer by pressing one of two buttons. After another interval, the duration of which varied from 1 to 3 s, the outcome of this trial was presented. Upon acceptance, the amount of gain or loss would be divided according to the proposer's offer. Upon rejection, both the participant and the proposer would get nothing (in the gain domain) or have to pain the full price (in the loss domain).

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A two-factor mixed ANOVA revealed significant main effects of Adversity ($F(1, 18) = 4.71$; $p < .05$) and Condition ($F(1, 18) = 2.87$; $p < .05$), as well as a significant interaction ($F(1, 18) = 8.27$; $p < .01$).

Adversity was associated with a decrease in the amount of money accepted ($M = 6$, $SD = 2.6$, $n = 18$, $t(17) = 2.14$, $p < .05$; $F(1, 18) = 1.31$, $p > .05$). A two-factor mixed ANOVA revealed significant main effects of Adversity ($F(1, 18) = 1.31$, $p > .05$) and Condition ($F(1, 18) = 2.14$, $p < .05$).

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fMRI data acquisition

Functional MRI (fMRI) data were collected using a GE Signa 3.0-T scanner (General Electric, Milwaukee, WI, USA). Participants were positioned in a magnetically shielded room and were instructed to keep their eyes closed during the task. They were instructed to respond to the offer by pressing one of two buttons. One button was labeled 'Accept' and the other 'Reject'. The task was presented in a block design, with 12 blocks of 18 trials each. Each trial lasted approximately 18 s, consisting of an offer presentation (6 s), a choice period (2 s), and an outcome presentation (2 s). The choice period was preceded by a jittered interval (4–7 s) and followed by an interval (1–3 s) before the outcome was presented. The outcome was either 'He 6 You 4' or 'He -4 You -6'. The order of trials was randomised. The fMRI data were analysed using SPM8 (Statistical Parametric Mapping, Wellcome Trust Centre for Neuroimaging, London, UK).

The experimental setup is shown in Fig. 1. A 2-mm-thick rectangular block of polyacrylate gelatin (48% water content, 3% agarose, 1% W; $\rho = 2400 \text{ kg/m}^3$; $E = 25 \text{ GPa}$; $\nu = 0.45$, $\alpha = 90^\circ$; $L_{\text{sample}} = 224 \times 224 \text{ }\mu\text{m}^2$; $L_{\text{sample}} = 3 \times 3.5 \times 3.5 \text{ }\mu\text{m}^3$). The sample is placed on a V-groove substrate (V-groove width: $535 \text{ }\mu\text{m}$; V-groove depth: $100 \text{ }\mu\text{m}$) and is held in place by a thin layer of polyacrylate gelatin.

Behavioral modeling

With the help of a camera (A^2 camera, Casio Inc. , 1968; $\text{F} = 1.4$, $f = 10 \text{ mm}$, $\Delta A = 2\text{-mm}$), the displacement field $u(x)$ is measured at each time step k using the optical flow method.

Figure 2 shows the results of the ANOVA analysis of the effect of the three factors on the total number of AAs. The main effect of the factor $\text{AAs} \times \text{W+}$ was significant ($F_{1,10} = 11.2, P < 0.01$). The main effect of the factor $\text{AAs} \times \text{W-}$ was also significant ($F_{1,10} = 11.2, P < 0.01$). The interaction between $\text{AAs} \times \text{W+} \times \text{W-}$ was significant ($F_{1,10} = 11.2, P < 0.01$). The main effect of the factor W+ was significant ($F_{1,10} = 11.2, P < 0.01$), while the main effect of the factor W- was not significant ($F_{1,10} = 11.2, P > 0.05$). The interaction between $\text{W+} \times \text{W-}$ was significant ($F_{1,10} = 11.2, P < 0.01$). The interaction between $\text{AAs} \times \text{W+}$ was significant ($F_{1,10} = 11.2, P < 0.01$). The interaction between $\text{AAs} \times \text{W-}$ was significant ($F_{1,10} = 11.2, P < 0.01$). The interaction between $\text{W+} \times \text{W-}$ was significant ($F_{1,10} = 11.2, P < 0.01$). A significant interaction between $\text{AAs} \times \text{W+} \times \text{W-}$ was observed ($F_{1,10} = 11.2, P < 0.01$) (Figure 2). The results of the ANOVA analysis are shown in Table 1.

Table 1. Results of the ANOVA analysis of the effect of the three factors on the total number of AAs.

Table 2 Brain activations in the gain *vs* loss contrast

Regions	Hemisphere	Max <i>T</i> -value	Cluster size (voxels)	Cluster level corrected <i>P</i> _{FWE}	MNI coordinates		
					<i>x</i>	<i>y</i>	<i>z</i>
Gain–loss							
VMPFC	R	6.85	155	<0.001	6	47	-11
PCC	R	4.37	60	0.019	9	-10	-11
VTA	L	6.73	167	<0.001	-6	-52	16
Loss–gain							
Putamen	R	5.50	52	0.034	30	5	7
DLPFC	L	7.01	138	<0.001	-36	2	34
Rolandic	R	7.01	112	0.001	45	-10	22
IPL/angular	R	5.32	153	<0.001	27	-61	46
SOG	L	6.54	58	0.022	-21	-67	40
Calcarine	L	8.15	554	<0.001	-18	-73	16

SOG, superior occipital gyrus.

Table 3 Brain activations in parametric contrast (conjunction of gain and loss domains)

Regions	Hemisphere	Max T-value	Cluster size (voxels)	Cluster level corrected P_{FWE}	MNI coordinates		
					x	y	z
Increase with SU							
VMPFC	L/R	4.55	181	0.021	6	53	-17
VS	L/R	3.78	10	0.039 ^a	-3	8	-11
Parahippocampus	R	4.02	151	0.044	18	-28	-10
Fusiform	L	5.65	361	<0.001	-33	-28	-19
Precuneus	L	4.09	178	0.022	-9	-55	13
Decrease with SU							
ACC	L/R	3.99	17	0.025 ^a	-6	32	25
DLPFC	R	5.36	246	0.004	39	26	28
	L	5.90	437	<0.001	-42	20	31
Putamen/insula	R	4.58	149	0.047	30	20	1
PAG	R	5.12	278	0.002	3	-22	-14
IPL	R	6.13	1342	<0.001	24	-55	34
	L	5.66			-24	-51	40
IOG	L	4.60	674	<0.001	-42	-76	-8

PAG, periaqueductal gray; IOG, inferior occipital gyrus. ^aSVC based on independently defined ROI (see Methods).

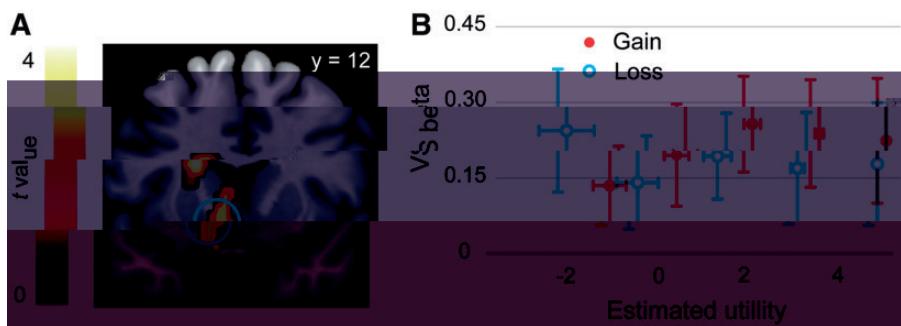


Fig. 3 Positive effect of SU modulated by frame. **(A)** Whole-brain exploratory analysis of the contrast 'Gain₊ [masked (excl.) by Loss₊]'. **(B)** Beta values corresponding to 10 types of offers (based on GLM 3) extracted from the VS peak. Error bars represent s.e.m.

Table 4 Brain activations in parametric contrast (domain-specific activations)

Regions	Hemisphere	Max T-value	Cluster size (voxels)	Cluster level corrected P_{FWE}	MNI coordinates		
					x	y	z
Positive association with SU only in gain domain							
VMPFC	L	5.02	378	<0.001	-6	62	1
Caudate	L	4.62	673	<0.001	-18	14	19
MTG	R	4.23	154	0.041	51	-22	-11
Fusiform	L	5.10	232	0.006	-60	-43	-8
Angular	R	5.16	182	0.020	60	-52	25
Negative association with SU only in loss domain							
LOFC	L	4.93	170	0.027	-48	47	1

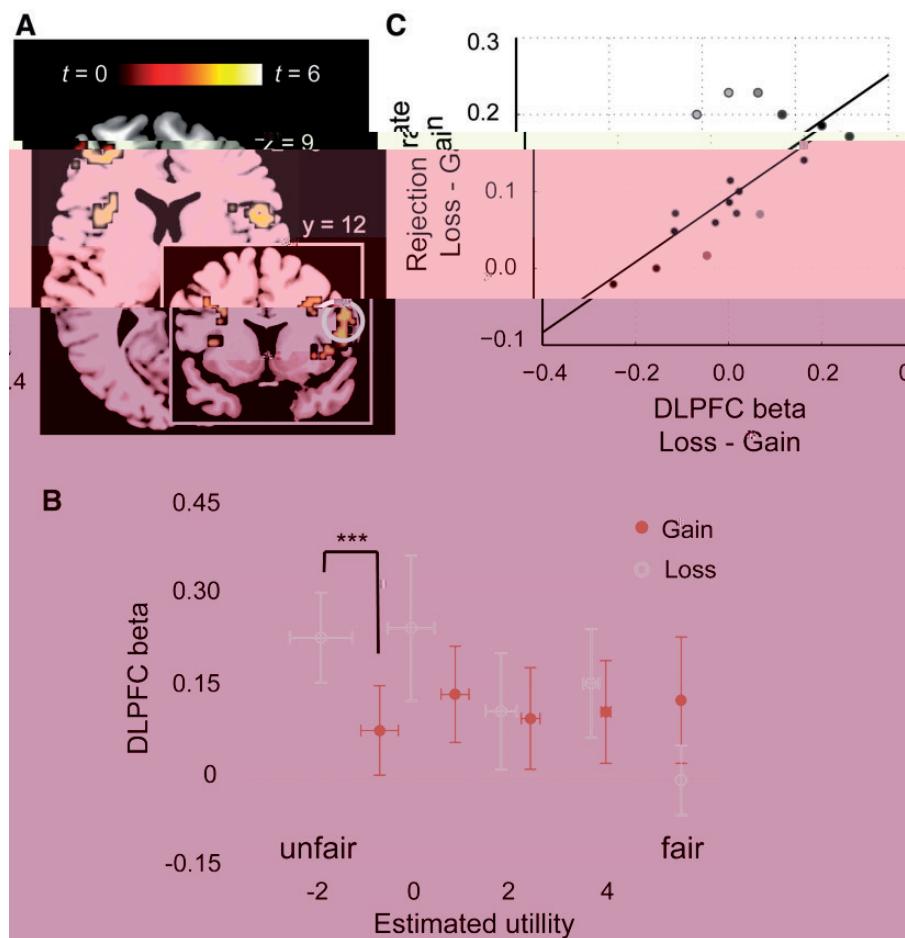


Fig. 4 Negative effect of SU modulated by frame. (A) Whole-brain level exploratory analysis of the contrast ‘Loss_ [masked (excl.) by Gain_]’. (B) Beta values corresponding to 10 types of offers (based on GLM 3) extracted from the DLPFC peak. (C) The difference in the mean beta values in the gain and loss domain predicted the differences in rejection rates between the loss and gain domain ($r = 0.80$, $P < 0.001$). *** $P < 0.001$ (two-tailed). Error bars represent s.e.m.

Gain-loss domain and third-party punishment

Third-party punishment was also modulated by the gain-loss domain. In the gain domain, the third-party punishment effect was significantly reduced compared to the loss domain ($F_{(1,30)} = 1.30$, $P = 0.264$; $F_{(4,120)} = 1.03$, $P = 0.395$).

Finally, we examined the interaction between the gain-loss domain and the third-party punishment effect (Fig. 6). As shown in Fig. 6, the third-party punishment effect was significantly reduced in the gain domain compared to the loss domain ($F_{(1,30)} = 1.30$, $P = 0.264$; $F_{(4,120)} = 1.03$, $P = 0.395$).

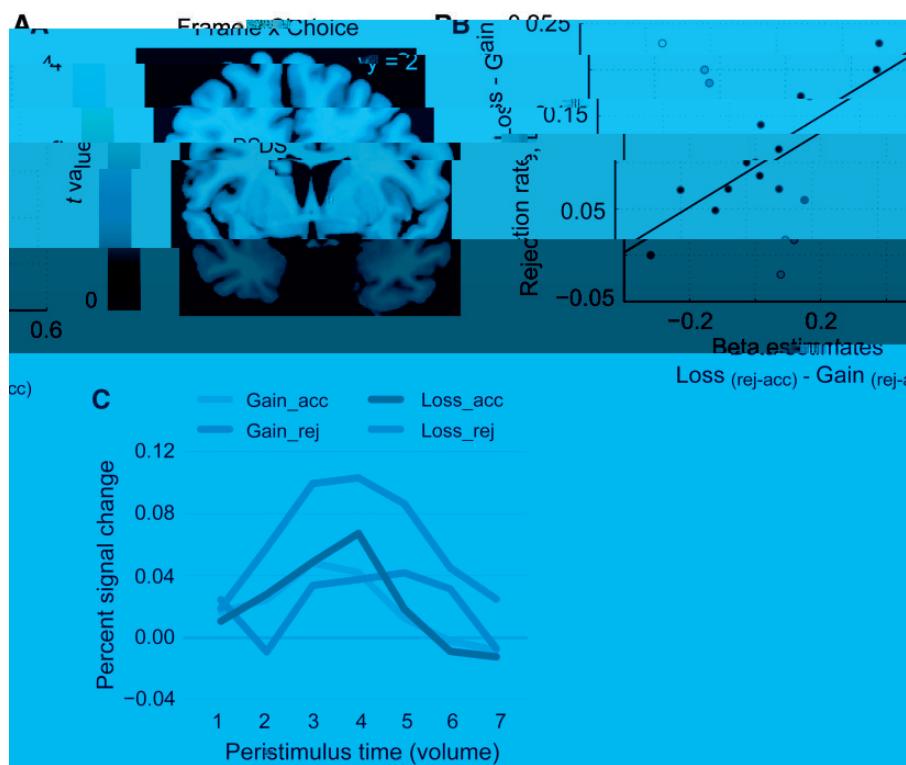


Fig. 5 Neural effects of interaction between choice and frame. (A) ROI-based analysis of the contrast 'Loss (rej-acc) – Gain (rej-acc)'. SVC revealed an activation cluster in the left DS, whose rejection-induced activation was higher in the loss compared with gain domain. (B) Activation timecourse extracted from a 6 mm sphere around the maximum coordinates indicates that this interaction effect was driven by the amplified activation difference in the loss relative to the gain domain. (C) The differences in beta estimates extracted from the activation maximum (Loss – Gain) predicted the increases in rejection rate in the loss relative to the gain domain ($r = 0.67, P < 0.05$). Note, the white and grey dots are outliers identified by robust regression and they are down-weighted in computing the correlation coefficients (Wager et al., 2005).

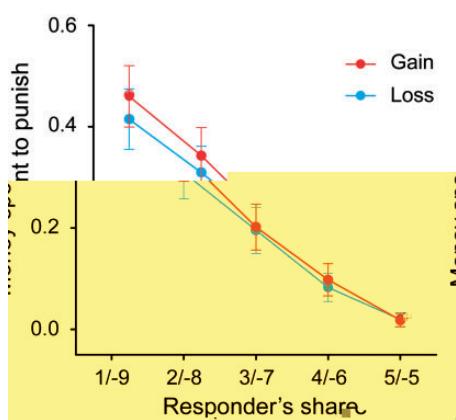


Fig. 6 Effect of fairness and domain on third-party punishment behavior. The amount spent on punishment increased as the offer fairness decreased. Gain–loss domain did not modulate third-party punishment. Error bars represent s.e.m.

DISCUSSION

This study examined the neural mechanism underlying the interaction between choice and frame in decision making. We found that the interaction effect was driven by the amplified activation difference in the loss relative to the gain domain. This finding is consistent with previous studies showing that the loss domain is more sensitive than the gain domain to the interaction between choice and frame (Wang et al., 2013; Wager et al., 2011). In addition, we found that the subjective value of the choice was negatively correlated with the activation in the left DLPFC, which is consistent with previous studies (Wager et al., 2004; Wager et al., 2007; Botvinick et al., 2008, 2012; Wager et al., 2011; Caggiano et al., 2013). In addition, the amount spent on punishment increased as the offer fairness decreased. Gain–loss domain did not modulate third-party punishment.

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Thus, we have $\lambda \in \Lambda^{\text{max}} \cap \Lambda^{\text{min}} = \Lambda^{\text{max}} \cap \Lambda^{\text{min}} = \Lambda^{\text{max}} \cap \Lambda^{\text{min}} = \Lambda^{\text{max}} \cap \Lambda^{\text{min}}$.

REFERENCES

- A., (1998). *The Nicomachean Ethics*. E., (2007). A., B., C., D., E., F., G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. (2007). Journal of Neuroscience, 27(31), 8161–5.

B., C., D., E., F., G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. (2013). B., D., E., F., G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. Neuroimage, 76, 412–27.

B., C., D., E., F., G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. (2012). B., C., D., E., F., G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. Human Brain Mapping, 33(6), 1452–69.

B., C., D., E., F., G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. (2008). B., C., D., E., F., G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. Neuron, 58(4), 639–50.

B., C., D., E., F., G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. (2011). D., E., F., G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. Nature Neuroscience, 14(11), 1468–74.

B., C., D., E., F., G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. (1999). B., C., D., E., F., G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. Psychopharmacology, 142, 24–30.

B., C., D., E., F., G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. (2009). B., C., D., E., F., G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. Neuroeconomics: Decision Making and the Brain. B., C., D., E., F., G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. 353–65.

B., C., D., E., F., G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. (2003). B., C., D., E., F., G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. Proceedings of the National Academy of Sciences of the United States of America, 100(6), 3531–5.

B., C., D., E., F., G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. (2005). B., C., D., E., F., G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. Advances in Applied Microeconomics, 13, 1–23.

B., C., D., E., F., G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. (1987). B., C., D., E., F., G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. The American Economic Review, 77(3), 243–50.

B., C., D., E., F., G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. (2008). B., C., D., E., F., G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. Neuron, 60(5), 930–40.

C., D., E., F., G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. (2003). C., D., E., F., G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. Trends in Cognitive Sciences, 7(5), 225–31.

C., D., E., F., G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. (2013). C., D., E., F., G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. Social Cognitive and Affective Neuroscience, 8(3), 277–84.

C., D., E., F., G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. (2013). C., D., E., F., G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. Journal of Neuroscience, 33(17), 7109–21.

C., D., E., F., G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. (2013). C., D., E., F., G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. Journal of Neuroscience, 33(8), 3505–13.

C., D., E., F., G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. (2008). C., D., E., F., G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. Science, 320, 1739.

C., D., E., F., G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. (2004). C., D., E., F., G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. Science, 305(5688), 1254–8.

D., E., F., G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. (2004). D., E., F., G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. Games and Economic Behavior, 47(2), 268–98.

E., F., G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. (2012). E., F., G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. Proceedings of the Royal Society of London. Series B, Biological Sciences, 279(1749), 4923–8.

F., E., F., G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. (2004). F., E., F., G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. Trends in Cognitive Sciences, 8(4), 185–90.

F., E., F., G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. (2002). F., E., F., G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. Nature, 415(6868), 137–40.

F., E., F., G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. (1999). F., E., F., G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. Quarterly Journal of Economics, 114(3), 817–68.

G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. (2013). G., H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. Neuroimage, 77, 246–53.

H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. (2010). H., I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. Social Cognitive and Affective Neuroscience, 5(4), 414–23.

I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. (1982). I., J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. Journal of Economic Behavior & Organization, 3(4), 367–88.

J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. (2010). J., K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. Neuropsychopharmacology, 35, 4–26.

K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. (2006). K., L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. Science, 312(5781), 1767–70.

L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. (2011). L., M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. PLoS One, 6(10), e25304.

M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. (2008). M., N., O., P., Q., R., S., T., U., V., W., X., Y., Z. Science, 320, 1092–5.

- ., D., ., A., ., ., . (1986). Fairness and Economic Behavior. *The American Economic Review*, 76, 728–41.
- ., D., ., ., . (2011). The Neural Basis of Fairness: A Review of Neuroimaging Studies. *Frontiers in Neuroscience*, 5, 49.
- ., D., ., ., B., B., ., ., . (2012). Fairness and Justice: A Neuroeconomics Approach. *Neuroscience and Biobehavioral Reviews*, 36, 786–98.
- ., D., I., ., A., F., ., E., ., C., ., A., F., E. (2008). Fairness and Justice in the Brain: A Neuroeconomics Approach. *Cerebral Cortex*, 18(9), 1987–90.
- ., D., A., ., A., ., ., F., E. (2006). Does Fairness Make a Difference? An fMRI Study. *Science*, 314(5800), 829–32.
- ., D., ., ., C., ., F. (2007). Fairness and Justice in the Brain. *NeuroImage*, 38(1), 203–11.
- ., D., ., ., B., ., F., B., C. (2009). C. Nature Neuroscience, 12, 535–40.
- ., C., B., ., D., E., ., A.E. (2009). Fairness and Justice in the Brain: A Neuroeconomics Approach. *Journal of Experimental Social Psychology*, 45(3), 505–14.
- ., D., C., ., A. (2009). Fairness and Justice in the Brain: A Neuroeconomics Approach. *Social Cognitive and Affective Neuroscience*, 4, 423–8.
- ., D., C., C., C. (1968). The Psychology of Fairness. *Journal of Experimental Social Psychology*, 4(1), 1–25.
- ., D., ., ., . (2007). Fairness and Justice in the Brain: A Neuroeconomics Approach. *Neuron*, 56(1), 14–8.
- ., F., B., ., W. (2011). Nature Neuroscience, 14, 1105–7.
- D., ., A., ., . (2007). Fairness and Justice in the Brain: A Neuroeconomics Approach. *Annals of the New York Academy of Sciences*, 1104, 35–53.
- , B., ., F., ., . (2002). Fairness and Justice in the Brain: A Neuroeconomics Approach. *Proceedings of the National Academy of Sciences of the United States of America*, 99(8), 5669–74.
- , A. (2006). C. *Trends in Cognitive Sciences*, 10(2), 59–63.
- , A. (2011). Fairness and Justice in the Brain: A Neuroeconomics Approach. *Neuron*, 72, 692–7.
- , D., ., A., ., F.B., B., F. (2013). C. *Proceedings of the National Academy of Sciences of the United States of America*, 110(6), 2070–5.
- , F., ., ., ., . (2009). Fairness and Justice in the Brain: A Neuroeconomics Approach. *Proceedings of the National Academy of Sciences of the United States of America*, 106(1), 340–5.
- , . (1958). Fairness and Justice. *The Philosophical Review*, 67(2), 164–94.
- , . (1971). *A Theory of Justice*. Cambridge, MA: Harvard University Press.
- , D.A., ., B., B., C.D. (2002). A. *Neuron*, 35(2), 395–405.
- , .D. (2011). Fairness and Justice in the Brain: A Neuroeconomics Approach. *Neuropsychopharmacology Reviews*, 36, 114–32.
- , C., ., F., W. (2011). Fairness and Justice in the Brain: A Neuroeconomics Approach. *Journal of Neuroscience*, 31(19), 7168–73.
- , . (1754/2011). *The Basic Political Writings*. Cambridge, MA: Harvard University Press.
- , A., ., A., A., I., E., C., D. (2003). Fairness and Justice in the Brain: A Neuroeconomics Approach. *Science*, 300(5626), 1755–8.
- , .D., A., A., A., ., D., A., . (2002). C. Fairness and Justice in the Brain: A Neuroeconomics Approach. *Science*, 29, 2043–6.
- , B., ., D., . (2007). Fairness and Justice in the Brain. *Nature Reviews Neuroscience*, 8(4), 300–11.
- , E., ., D., . (1999). *Unto Others: The Evolution and Psychology of Unselfish Behavior*. Cambridge, MA: Harvard University Press.
- , A., ., A., . (2011). B. *NeuroImage*, 54(1), 671–80.
- , A.B., ., ., D. (2008). Fairness and Justice in the Brain: A Neuroeconomics Approach. *Psychological Science*, 19(4), 339–47.
- , A. (1835/2010). *Democracy in America*. Cambridge, MA: Harvard University Press.
- , F., C., C., A. (2007). Fairness and Justice in the Brain: A Neuroeconomics Approach. *Science*, 315(5811), 515–8.
- , E., A., C., C.F., D., . (2010). Fairness and Justice in the Brain: A Neuroeconomics Approach. *Nature*, 463(7284), 1089–91.
- , A., ., D. (1981). Fairness and Justice in the Brain: A Neuroeconomics Approach. *Science*, 211(30), 453–8.
- , A., ., D. (1991). Fairness and Justice in the Brain: A Neuroeconomics Approach. *The Quarterly Journal of Economics*, 106(4), 1039–61.
- , D., ., C., ., C., . (2005). Fairness and Justice in the Brain: A Neuroeconomics Approach. *NeuroImage*, 26, 99–113.
- , F., B., ., B., . (2011). Fairness and Justice in the Brain: A Neuroeconomics Approach. *Human Brain Mapping*.
- , I.D., ., F., ., D., . (2011). Fairness and Justice in the Brain: A Neuroeconomics Approach. *Journal of Neuroscience*, 31(14), 5244–52.
- , . (2011). Fairness and Justice in the Brain: A Neuroeconomics Approach. *Journal of Experimental Social Psychology*, 47(3), 582–8.