Supplementary materials: Neural segregation of objective and contextual aspects of fairness

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Supplementary results

Supplementary behavioural results

The proposals our subjects made were consistent with those seen in previous studies (Camerer, 2003). The mean proportion offered was 0.44 (s.d. 0.09) over all 32 subjects, and there was no significant difference (two-tailed ttest, $p>0.1$) between the group of 16 scanned subjects (mean 0.46; s.d. 0.10) and the 16 subjects who solely underwent behavioural testing (0.42; 0.07). There was also only small variation within each subject's offers and no significant effect of trial number on the mean offer.

Mach IV questionnaire scores (Christie and Geis, 1970) were typical of normal populations (mean 95.4; stdev 11.9; n=32); with no difference between scanning group and behavioural groups (97.8 (11.4) vs. 93.1 (12.3), two-tailed ttest, $p>0.1$). Using the Van Lange social value orientation questionnaire more subjects were classified as prosocial in the scanning than in the behavioural group (Van Lange et al., 1997). In the scanning group 8 were classified as prosocial, 5 as individualist, 2 as competitive and 1 was not classifiable, whilst in the behavioural group 4 were prosocial, 4 individualist, 4 competitive and 4 not classifiable. During the learning session subjects learnt the reputations of the three opponent groups (L, M and H), with only 6 of the 32 subjects (2 in the scanning group) incorrectly ranking the L, M and H groups on a visual analogue scale from "most unfair" to "most fair".

In subjects who solely underwent behavioural testing a proportion accepted all, or almost all, offers and therefore although the effects of context were in the same direction they were not significant ($p>0.1$; Supplementary Fig. 1).

Supplementary neuroimaging results

We observed a main effect of choice in increased activation for accepting, relative to rejecting, offers in bilateral supplementary motor area (SMA) and pre-SMA in both our factorial (Table 1) and parametric (positive correlation with offer amount; Table 2) analyses. The pre-SMA and SMA have distinct anatomical connections and in imaging studies the vertical commissure anterior (VCA) line is often used to distinguish the precise source of activation (Nachev et al., 2008). Interestingly in light

of our previous findings, the peak voxel of this cluster was anterior to the VCA in pre-SMA, a region with strong connections to DLPFC (Nachev et al., 2008). No activation survived cluster level correction for the reverse contrast (reject>accept) or for the main effects of context (M-in-H > M-in-L or M-in-L > M-in-H).

Further supplementary information

A group format was used for Proposers so subjects treated each trial individually, and also avoided the need for a less plausible scenario that many subjects previously attended the experiment. However, in reality the three Proposer groups comprised three sets of 25 offer proportions. Each set spanned a full range from around 0.10 to 0.50 of the endowment (this varied between trials) with the intention that subjects consider each individual offer and not deterministically accept or reject offers from a group. The behavioural regularity from experimental economics is that offers below 0.25 are rejected about half the time (Camerer, 2003). The “M set” offers were concentrated around this point to maximise our sensitivity to contextual changes in acceptance rates, with half of trials between 0.2 and 0.31 where correlation of offer amount and inequality is shown by r=-0.6. The “L set” had a mean offer proportion of 0.21; the “M set” had a mean offer proportion of 0.30; and the “H set” had a mean offer proportion of 0.40 (see below for the full L, M and H sets). The means of the “L set” and “H set” were chosen to induce the context effects on the “M set”. The full sets of offers are as follows: L = {0.08, 0.08, 0.09, 0.09, 0.1, 0.1, 0.1, 0.15, 0.15, 0.15, 0.16, 0.16, 0.17, 0.17, 0.2, 0.21, 0.22, 0.26, 0.27, 0.3, 0.31, 0.37, 0.4, 0.5, 0.5}; M = {0.08, 0.1, 0.16, 0.2, 0.21, 0.22, 0.23, 0.24, 0.25, 0.26, 0.26, 0.27, 0.28, 0.29, 0.3, 0.31, 0.32, 0.36, 0.37, 0.4, 0.46, 0.5, 0.5, 0.5, 0.5}; and H = {0.1, 0.15, 0.21, 0.27, 0.3, 0.35, 0.36, 0.36, 0.37, 0.4, 0.4, 0.41, 0.42, 0.42, 0.45, 0.46, 0.47, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5}.

Supplementary figures

Supplementary Figure 1 Bias of acceptance by contextual manipulation. All of the illustrated offers represent the “M” set of offers presented in three different contexts (illustrated in grey scale) as a manipulation of subjective fairness: M-in-L (interleaved with lower offers); M-alone (presented alone); and M-in-H (interleaved with higher offers). The mean percentage of acceptances during the main session is shown for the scanned group (n=16), the group who underwent solely behavioural testing (n=16) and the combined data from the two groups (n=32). In the scanned and combined groups: significantly more offers were accepted in the M-in-L condition

than in the M-in-H condition; significantly more offers were accepted in the M-alone condition than the M-in-H condition; but there was no significant difference between M-in-L and M-alone. No contextual biases reached statistical significance in the behavioural group, with a proportion of subjects accepting all or nearly all of the offers. Subjects attended the laboratory in pairs of whom the subject with more acceptances in the learning session underwent behavioural testing during the main session whilst the other was scanned (see Methods), resulting in a higher acceptance rate in the main session for the behavioural (n=16; mean 0.58; st.dev. 0.22) than for the scanned group (n=16; mean 0.41; st.dev. 0.12).

Supplementary Figure 2 Probability of acceptance as a function of offer proportion and its biasing by context. Group data from the scanned subjects (n=16) during the main session is shown. Data is shown for the "M" offers in the three contexts: M-alone (green; "neutral"); M-in-L (blue; "more fair"); and M-in-H (red; "less fair"). In the upper part of the figure, the probability of acceptance is shown both as a series of data points and by a logistic curve fitted to those points. It can also be seen that the point of indifference (or point of subjective equality) defined as an acceptance probability of 0.5 corresponds to the peak reaction times plotted below.

Supplementary Figure 3 Illustration of neuroimaging regressors. This figure is created from the M-alone condition for subject 1 in run 1 of the main session, convolved with the canonical hemodynamic response function in SPM, and illustrating the half the offer amounts around one quarter of the endowment known behaviourally to be a typical point of indifference between accepting and rejecting (Camerer, 2003). To aid interpretation offer amount is shown monotonically increasing (blue line). Inequality is shown orthogonalised with respect to offer amount (red line) and before orthogonialisation (green line).

Reference List

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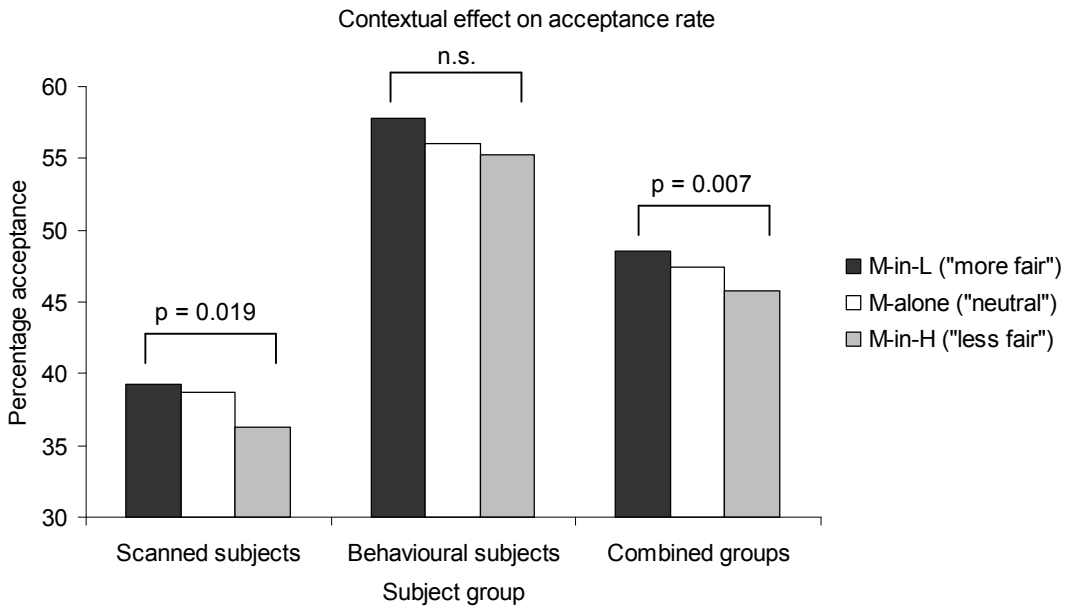
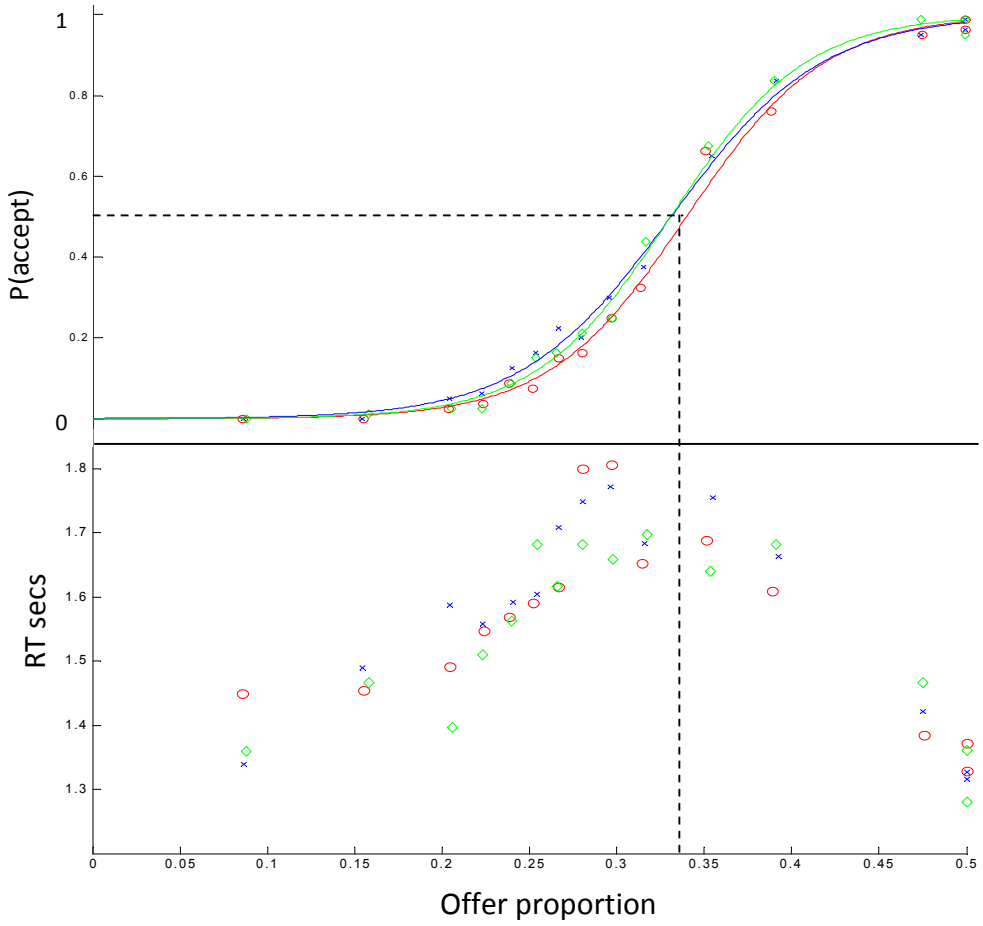
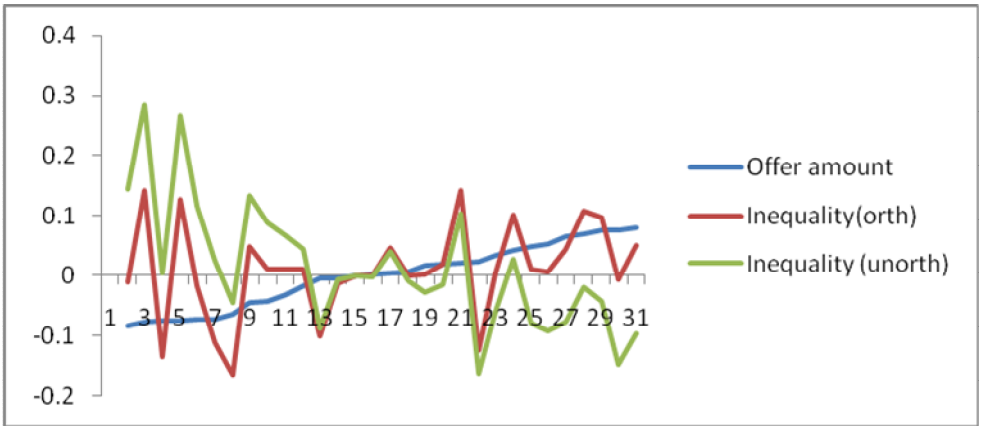
Van Lange PA, Otten W, De Bruin EM, Joireman JA (1997) Development of prosocial, individualistic, and competitive orientations: theory and preliminary evidence. J Pers Soc Psychol 73:733-746.



Supplementary Fig. 1



Supplementary Fig. 2



Supplementary Fig. 3