

How social contexts affect cognition: mentalizing interferes with sense of agency during voluntary action

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Supplementary Analysis

Assessing the relation between belief ratings and effect of social context on agency ratings

To assess whether belief in the cover story of playing with a human participant could be related to the effects of social context observed on agency ratings, we first looked at correlations between these variables. As only half of participants in Exp 1 were told they were playing with another person, i.e. the “social” group, only these participants were asked to rate their belief, therefore only this group’s data was considered ($N = 24$). In Exp 2, all participants were told they were playing with another person, and gave belief ratings ($N = 43$). The effect of social context on agency ratings was summarised per participant by computing the difference in mean agency ratings obtained when the co-player was absent *minus* when the co-player present, with positive values indicating a diffusion of responsibility effect (higher agency when alone than in presence of other agents). For each experiment, we tested the correlations between the social context effect on agency ratings and the belief ratings. As can be observed in Fig S1, there was no robust correlation between the variables in either experiment (Exp 1, social group: $r = -0.06$, $t_{22} = -0.29$, $p = 0.77$; Exp 2: $r = 0.08$, $t_{41} = 0.48$, $p = 0.63$).

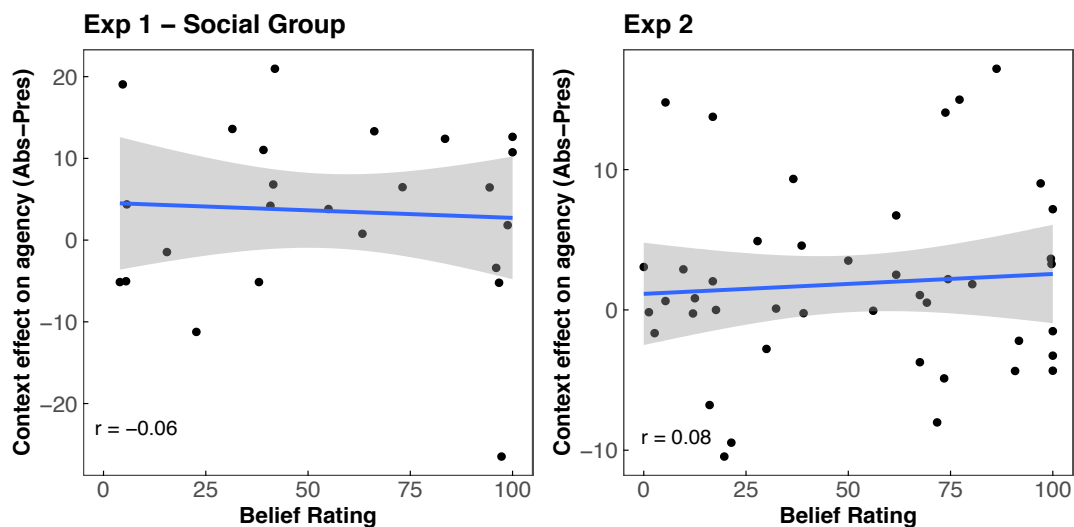


Fig S1. Correlations between belief ratings and the effect of social context on agency ratings (mean agency ratings in co-player absent *minus* present condition).

Since the results discussed in the main article showed an interaction between social context and outcome value, rather than an overall main effect of social context, we further assessed whether there might any correlation when only considering the social

context effect on agency ratings (co-player absent minus present) for only relatively “good” outcomes (i.e. outcome value Z score > 0). This still did not reveal any robust correlations with belief ratings (Exp 1, social group: $r = 0.09$, $t_{22} = 0.40$, $p = 0.69$; Exp 2: $r = 0.07$, $t_{41} = 0.42$, $p = 0.68$).

Exp 1 - Social Group: Revised models of agency ratings

To further assess any potential effect of belief in the social cover story to our effects of interest, we considered the effect of including belief ratings in our multilevel regression model of agency ratings. Since we did not have ratings for the non-social group, and previous analysis all derived from one model, we could not simply add belief ratings to the previous model. To properly compare how parameter estimates for the effects of interest might be affected by including the belief ratings in the model, we first needed to run a simplified regression model only on the data for the social group.

Simple regression model

The same methods were used as for fitting the full model of Exp 1, except that only data for the Social Group was included, and therefore the “group” predictor and its interactions were removed. That is, our model predicted agency ratings from the social context (co-player absent vs. present), outcome value (Z score), and a context \times outcome interaction. The results are summarised in Table S1. This reveals parameter estimates that are very similar to those obtained from the full model (Table 1). In our full model, reported in the main text, we set weak [Normal(0, 5)] priors on all parameters, including on the effects of group. These encode a weak belief that the two groups are likely to be somewhat similar. Consequently, some information is shared across the two groups, so that removing the data from Non-social group from the model increases our posterior uncertainty about parameters estimated for the Social group. As a result, the estimated context \times outcome effect for the Social group is slightly less precise here ($b = 4.30$, 95% CI = [-0.52, 8.80], $BF_{10} = 2.81$) than in the full model ($b = 4.20$, 95% CI = [0.21, 8.32], $BF_{10} = 2.97$).

Table S1. Exp 1 - Social Group – simple model. Estimated parameters at the population-level from the Bayesian multilevel model. Estimate is the posterior mean and SE is the posterior standard deviation, with the lower and upper bounds of 95% Credible Intervals, and Bayes Factors in favour of the null (BF_{01}) and alternative (BF_{10}) hypotheses. Context: presence vs. absence of the alternative agent (i.e. co-player present/absent).

Parameter	Estimate	SE	2.5%	97.5%	BF_{01}	BF_{10}
Intercept	59.09	4.14	50.69	67.08	NA	NA
Context	2.71	2.04	-1.30	6.78	0.93	1.07
Outcome	8.75	2.49	3.54	13.36	0.02	65.72
Context \times Outcome	4.30	2.37	-0.52	8.80	0.36	2.81

Model with belief ratings

We could now compare those results, to one with belief ratings added as a predictor at participant level. Belief ratings were converted to 0-1 (to align the scale of effects with other predictors), and were mean centred across sample (so that a value of 0 corresponds to a belief rating of 54.8%, the average). In addition to the model described above, we added belief ratings as a general predictor of agency ratings, as well as potentially interacting with context, and with the context \times outcome interactions. The results can be observed in Fig S2, and details are summarised in Table S2. This reveals no evidence for belief ratings having any overall effect on agency ratings, nor any interactions with context or a three-way interaction. Importantly, the context \times outcome interaction differs only slightly when controlling for belief ratings ($b = 4.22$, 95% CI = [-0.62, 8.75], $BF_{10} = 2.36$) relatively to that found in the analogous model above that does not control for these ratings ($b = 4.30$, 95% CI = [-0.52, 8.80], $BF_{10} = 2.81$).

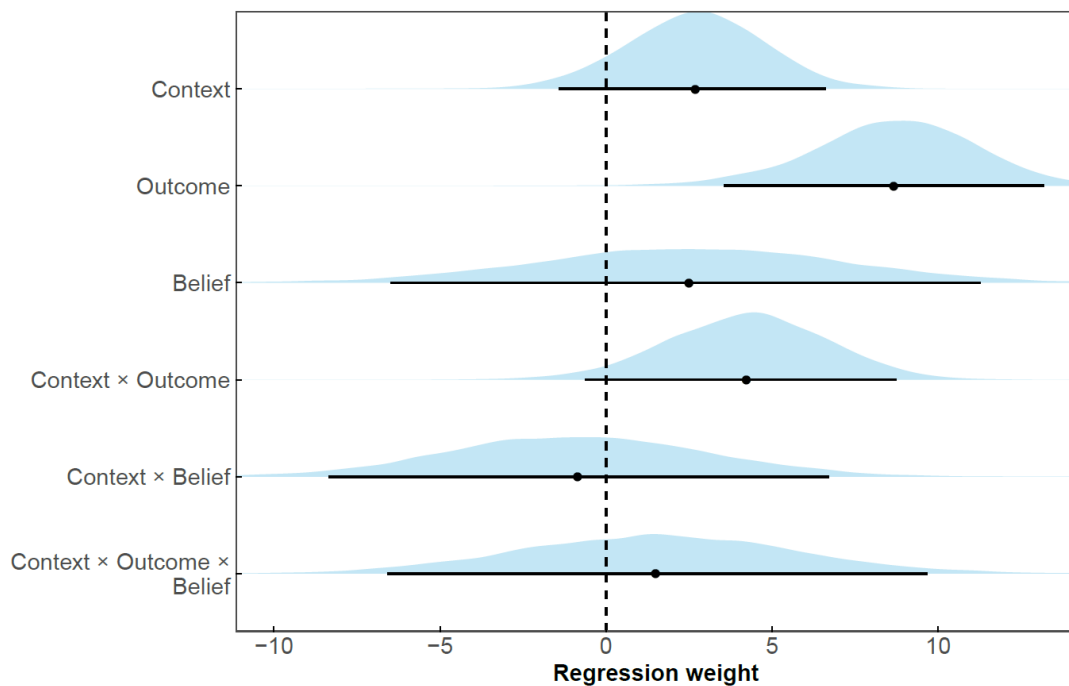


Fig S2. Exp 1 - Social Group – model with belief ratings. Density plots of the posterior fixed effects estimates from the Bayesian multilevel model. Points show posterior means, and horizontal lines are 95% Credible Intervals. Context: presence or absence of the alternative agent (i.e. co-player present/absent).

Table S2. Exp 1 - Social Group – model with belief ratings. Estimated parameters at the population-level from the Bayesian multilevel model. Estimate is the posterior mean and SE is the posterior standard deviation, with the lower and upper bounds of 95% Credible Intervals, and Bayes Factors in favour of the null (BF₀₁) and alternative (BF₁₀) hypotheses. Context: presence vs. absence of the alternative agent (i.e. co-player present/absent).

Parameter	Estimate	SE	2.5%	97.5%	BF ₀₁	BF ₁₀
Intercept	58.87	4.04	50.93	66.79	NA	NA
Context	2.68	2.05	-1.42	6.60	1.02	0.98
Outcome	8.66	2.44	3.55	13.18	0.01	83.47
Belief	2.50	4.56	-6.49	11.27	0.96	1.04
Context × Outcome	4.22	2.40	-0.62	8.75	0.42	2.36
Context × Belief	-0.86	3.89	-8.36	6.71	1.24	0.81
Context × Outcome × Belief	1.49	4.13	-6.58	9.67	1.09	0.92

Exp 2: Revised model of agency ratings

Next, we turned to assessing the effect of belief ratings in Exp 2, where all participants were exposed to the social cover story, and hence belief ratings were obtained from all participants. Belief ratings were analysed as above. We adapted the model reported in main article by adding belief ratings an overall predictor of agency ratings, and testing potential interactions with context, and the context x outcome interaction. Similarly to Exp 1, this revealed no evidence that belief ratings are relevant predictors or moderators of the effects of interest on agency ratings, nor that including them in the model changed the effects of interest.

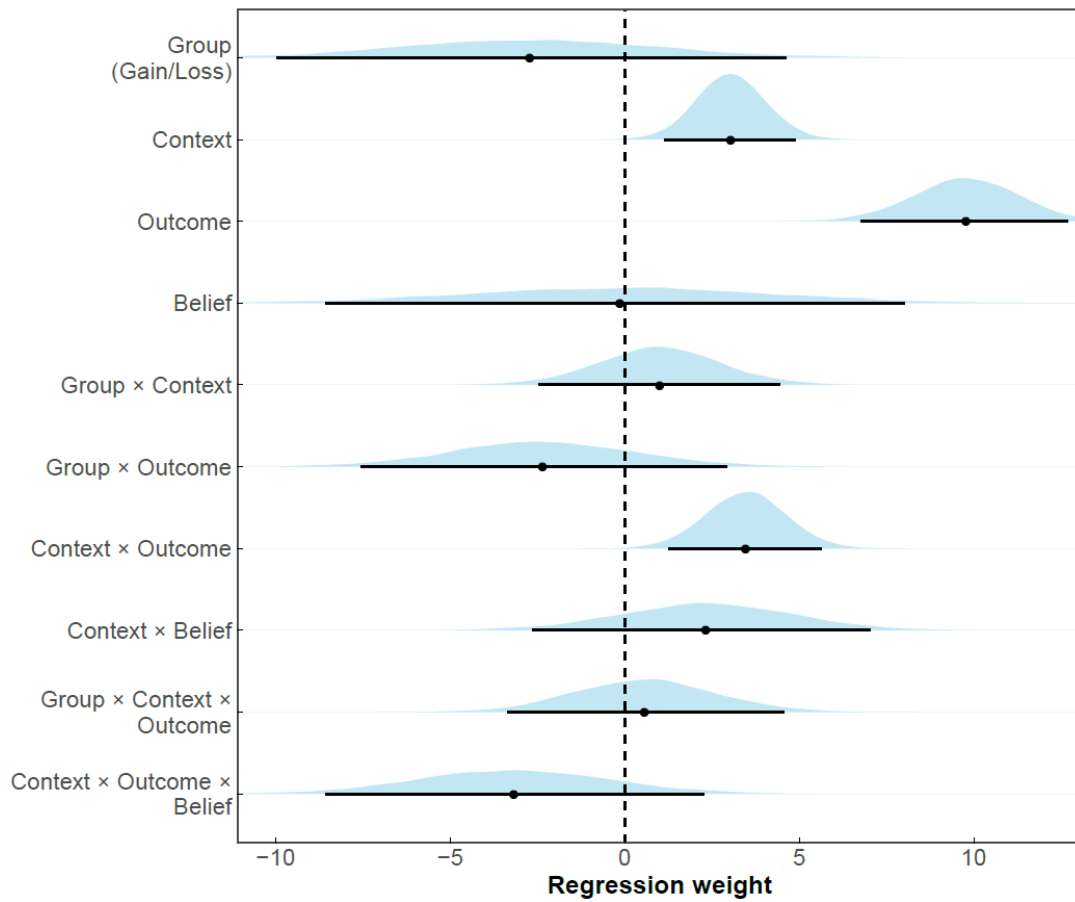


Fig S3. Exp 2 – model with belief ratings. Density plots of the posterior fixed effects estimates from the Bayesian multilevel model. Points show posterior means, and horizontal lines are 95% Credible Intervals. Group: gain vs. loss frame, Context: presence or absence of the alternative agent (i.e. co-player present/absent).

Table S3. Exp 2 – model with belief ratings. Estimated parameters at the population-level from the Bayesian multilevel model. Estimate is the posterior mean and SE is the posterior standard deviation, with the lower and upper bounds of 95% Credible Intervals, and Bayes Factors in favour of the null (BF_{01}) and alternative (BF_{10}) hypotheses. Group: Gain vs. Loss, Context: presence vs. absence of the alternative agent (i.e. co-player present/absent).

Parameter	Estimate	SE	2.5%	97.5%	BF_{01}	BF_{10}
Intercept	58.25	2.60	53.32	63.41	NA	NA
Group	-2.73	3.70	-9.96	4.61	1.01	0.99
Context	3.03	0.95	1.13	4.91	0.05	18.4
Outcome	9.77	1.50	6.77	12.69	0.00	$> 4 \times 10^4$
Belief	-0.14	4.27	-8.57	8.03	1.14	0.88
Group \times Context	0.99	1.74	-2.47	4.44	2.35	0.43
Group \times Outcome	-2.36	2.66	-7.57	2.93	1.25	0.80
Context \times Outcome	3.46	1.11	1.25	5.63	0.03	34.2
Context \times Belief	2.32	2.45	-2.66	7.04	1.26	0.79
Group \times Context \times Outcome	0.56	2.01	-3.37	4.57	2.34	0.43
Context \times Outcome \times Belief	-3.19	2.76	-8.56	2.26	0.94	1.06