

## The social dominance paradox

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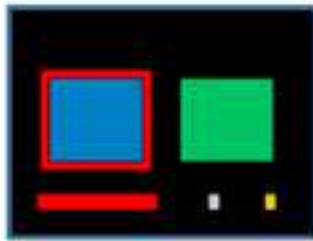
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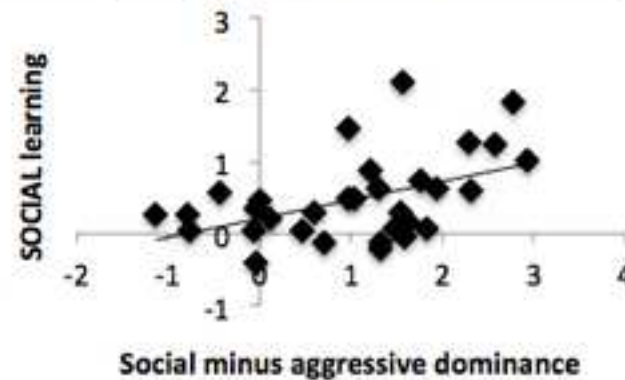
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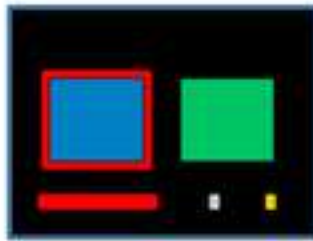
**Experiment 1:** social, but not aggressive, dominance was positively correlated with SOCIAL learning



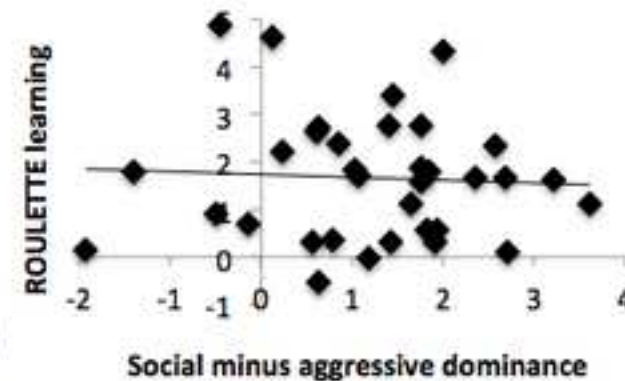
"Pick the box most likely to give you reward... Before you make your choice you will see the most popular choice [red frame] selected by a group of four participants ..."



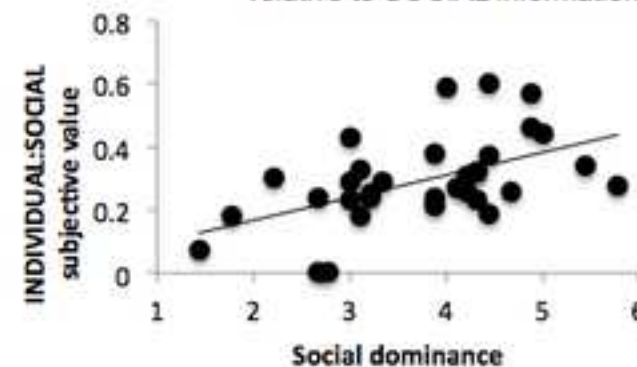
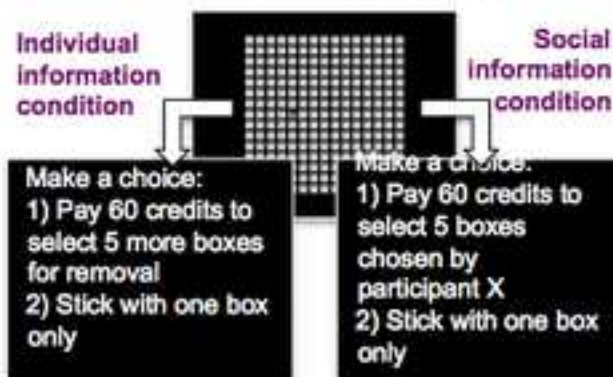
**Experiment 2:** neither social nor aggressive dominance was correlated with learning from ROULETTES



"Pick the box most likely to give you reward... Before you make your choice you will see a suggestion [red frame]. The computer has generated this suggestion using virtual roulette wheels..."



**Experiment 3:** paradoxically social dominance is correlated with the subjective value of INDIVIDUAL relative to SOCIAL information



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## The social dominance paradox

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Running title: Social dominance and learning strategy

18

19 **SUMMARY**

20 Dominant individuals report high levels of self-sufficiency, self-esteem, and  
21 authoritarianism. The lay stereotype suggests that such individuals ignore information from  
22 others preferring to make their own choices. However the non-human animal literature  
23 presents a conflicting view - suggesting that dominant individuals are avid social learners  
24 whereas subordinates focus on learning from private experience. Whether dominant  
25 humans are best characterised by the lay stereotype or the animal view is currently  
26 unknown. Here we present a 'social dominance paradox': using self-report scales and  
27 computerised tasks we demonstrate that socially dominant people explicitly value  
28 independence but, paradoxically, in a complex decision-making task, they show an  
29 enhanced reliance (relative to subordinate individuals) on social learning. More specifically,  
30 socially dominant people employed a strategy of copying other agents when the agents'  
31 responses had a history of being correct. However, in humans two subtypes of dominance  
32 have been identified [1]: aggressive and social. Aggressively dominant individuals - who are  
33 as likely to 'get their own way' as socially dominant individuals but who do so through the  
34 use of aggressive or Machiavellian tactics: did not use social information, even when it was  
35 beneficial to do so. This paper presents the first study of dominance and social learning in  
36 humans and challenges the lay stereotype in which all dominant individuals ignore others'  
37 views [2]. The more subtle perspective we offer could have important implications for  
38 decision-making in both the boardroom and the classroom.

39

## 40 RESULTS AND DISCUSSION

41 In Experiment 1 adult participants (N = 33; Age mean(SEM) = 27.88(1.39); M:F = 19:14;  
42 Supplemental Data 1) completed subjective rating scales of social and aggressive dominance  
43 [1, 3] (Supplementary Experimental Procedures (Supp. Exp. Proc.) 1) and a computerised  
44 decision-making task [4] that enabled separate investigation of individual and social learning  
45 [4] (**Fig 1**). Validation studies [1] have demonstrated that individuals who score high in  
46 either social (SD) or aggressive (AD) dominance – on the scales we employed – have strong  
47 beliefs about the importance of individual accountability and self-report high levels of self-  
48 esteem, authoritarianism and self-sufficiency [1]. In a real-life social interaction, wherein  
49 participants work in groups to select a hypothetical new housemate, high SD and AD  
50 individuals excel in influencing the group's choice according to their personal preferences.  
51 However, analysis of video recordings of such interactions demonstrates significant  
52 differences in the methods employed: whereas SDs tend to rely on reasoning to persuade  
53 others, ADs use aggression and Machiavellian tactics such as threat, deceit and flattery [1].  
54  
55 In the decision-making task, participants scored points by using individually-experienced  
56 (outcome history) and/or social (**Fig 1** red frame) information to make choices between a  
57 blue and a green stimulus. On each trial a red frame surrounded one of the two stimuli.  
58 Participants were instructed that this frame (the social information) represented the most  
59 popular choice made by a group of 4 participants who had completed the task previously.  
60 The actual probability of reward associated with the blue and green boxes, and the  
61 probability that the red frame surrounded the correct box, varied according to uncorrelated  
62 pseudorandom schedules (**Fig 2**, Supp. Exp. Proc. 2). A Bayesian Learner Model algorithm [4,

63 5] was employed to create two models of optimal performance (**Fig 2**): the Individual  
64 Learner Model and the Social Learner Model. The Individual Learner Model comprised the  
65 probability, based on the outcome history, that a blue choice would be rewarded. Thus, for  
66 each trial, its value represented the reward probability associated with a blue choice that a  
67 participant would have derived if they had been learning, in an optimal fashion, exclusively  
68 from private information about reward outcomes (i.e. ignoring the social information). The  
69 Social Learner Model comprised the probability, based on the social information weighted  
70 by the history of correct social information, that the group's choice would be rewarded.  
71 From this model we computed, for each trial, the reward probability of a blue choice that a  
72 participant would have derived if they had been learning, in an optimal fashion, exclusively  
73 from the social information (i.e. ignoring individual experience). Using logistic regression  
74 these two models were regressed against participants' choices. This resulted in individual  
75 and social beta values (regression slopes) that represent the degree to which choices were  
76 explained by the two respective models. A participant whose choices were strongly  
77 influenced by the social information (reflected in the Social Learner Model) would have a  
78 high social beta value; a participant who consistently went against the social information  
79 would have a negative social beta value.

80

81 Multiple regression models applied at the group level showed that social dominance  
82 ( $t(32)=2.08$ ,  $p = 0.048$ , standardised  $\beta$  ( $\text{std}\beta$ )=0.39) was a significant positive predictor of the  
83 social beta values: The higher a participant scored in SD the more they used the social  
84 information, as estimated by the Social Learner Model, to make their choices (**Fig 3; Fig S1;**  
85 see Supp. Exp. Proc. 3 for replication study). In contrast aggressive dominance was a  
86 significant negative predictor of social betas ( $t(32)=-2.74$ ,  $p = 0.01$ ,  $\text{std}\beta=-0.49$ ), the higher a

87 participant scored in AD the less likely they were to use the social information to make their  
88 choices. Notably there was no correlation between SD and AD ( $r = 0.21$ ,  $p = 0.24$ ). Fisher's r-  
89 to-z transformation (Supp. Data 3) confirmed that the relationship between SD and the use  
90 of social information was significantly different from the relationship between AD and the  
91 use of social information ( $z = 3.57$ ,  $p = 0.0002$ ). By regressing dominance scores against  
92 mean number of correct responses we also found that aggressive ( $t(32)=-2.27$ ,  $p = 0.03$ ,  
93  $\text{std}\beta=-0.41$ ), but not social ( $t(32)=-0.11$ ,  $p = 0.91$ ,  $\text{std}\beta=-0.02$ ), dominance was predictive of  
94 poor overall performance. Neither social ( $t(32)=-0.45$ ,  $p = 0.66$ ,  $\text{std}\beta=-0.11$ ) nor aggressive  
95 ( $t(32)=0.71$ ,  $p = 0.49$ ,  $\text{std}\beta=0.16$ ) dominance predicted individual learning betas, and both SD  
96 and AD were significantly better predictors of social than of individual learning (SD: Fisher's  
97 r-to-z = 1.9,  $p = 0.03$ ; AD: Fisher's r-to-z = -2.57,  $p = 0.01$ ). Together these results suggest  
98 that whereas responses from socially dominant individuals followed those of the group,  
99 responses from aggressively dominant individuals did not. This neglect of social information  
100 had a detrimental effect on the AD individuals' overall task performance.

101

102 The link between SD and social learning concurs with findings concerning other social  
103 animals (e.g. bird and primate species) where dominant individuals tend to be social  
104 learners whereas subordinates tend to rely on individual learning [6, 7]. Modelling in  
105 economics and behavioural ecology has shown that whereas individual learning can be slow,  
106 risky, and costly in energetic terms - these pitfalls can be avoided by social learning.  
107 However, if all group members learn only socially, the group's wisdom can diverge from  
108 reality [7, 8]. Thus a division of labour in which highly socially dominant individuals favour  
109 social learning, and subordinate individuals are dedicated individual learners, may serve to  
110 optimise knowledge acquisition at the group-level.



111

112 In the current task there are a number of ways that the social information can be used to  
113 one's advantage: one could identify when the information is predominantly correct and  
114 copy the group's responses (matching); one could identify when the information is  
115 predominantly incorrect and select the non-recommended option (non-matching); or  
116 optimally, use both of these strategies. Notably matching and non-matching are equal in  
117 utility but only non-matching involves actively going against the group's choice. To  
118 investigate which strategy was driving the effect of SD we conducted a further analysis  
119 which separated trials in which the social information was predominantly correct ( $p(\text{red}$   
120  $\text{frame} = \text{correct}) > 0.5^1$ ) from those in which it was predominantly incorrect ( $p(\text{red frame} =$   
121  $\text{correct}) < 0.5$ ). This analysis showed that SD was a significant predictor of the use of  
122 predominantly correct ( $t(32) = 2.86$ ,  $p = 0.01$ ,  $\text{std}\beta = 0.56$ ,  $\text{partial } r = 0.50$ ), but not  
123 predominantly incorrect ( $t(32) = 0.25$ ,  $p = 0.81$ ,  $\text{std}\beta = 0.05$ ,  $\text{partial } r = 0.05$ ), social information  
124 (see Supp. Exp. Proc. 4a for replication study). SD was a better predictor of the use of  
125 predominantly correct than incorrect information (Fisher's  $r\text{-to-}z = 1.93$ ,  $p = 0.05$ ; see Supp.  
126 Exp. Proc. 4b for AD analysis). These results indicate that the superior performance of SD  
127 individuals was based primarily on their tendency to match, rather than to non-match, social  
128 information; to copy other agents when the other agents' responses were correct, rather  
129 than to choose the alternative when the agents' responses were incorrect. Given that  
130 matching and non-matching would have been equally effective in scoring points, and that  
131 copying is known to promote cooperative behaviour [9], this suggests that SDs may use  
132 social learning to serve, not only instrumental and epistemic functions, but also  
133 interpersonal functions such as the promotion of positive social attitudes between

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<sup>1</sup> Probabilities were derived from the Social Learner Model

134 informant and learner.

135

136 In nonhuman primates subordination has been associated with sub-optimal dopamine  
137 system function [10, 11]. Given that dopamine has been linked to general, as opposed to  
138 specifically social, learning processes [12–14] this raises an important question for our  
139 study: does the effect of dominance generalise to learning from any indirect source of  
140 information? To find out, we ran a second experiment in which the procedure and data  
141 analysis were identical, but participants were told that the red frame represented the  
142 ‘choice’ of a computer programme simulating roulette wheels, rather than choices made by  
143 other agents. Participants were informed that the roulette wheels could fluctuate between  
144 selecting predominantly correct and predominantly incorrect ‘choices’ (Supp. Exp. Proc. 2 &  
145 5). In this group (N = 34; Age mean(SEM) = 26.21(0.96); M:F = 19:15; Supp. Data. 1) the  
146 effect of the red frame was unrelated to social ( $t(33)=0.42$ ,  $p = 0.68$ ,  $\text{std}\beta=0.09$ ) or  
147 aggressive ( $t(33)=-0.78$ ,  $p = 0.94$ ,  $\text{std}\beta=-0.01$ ) dominance (see Supp. Exp. Proc. 6 for further  
148 analysis). These data suggest that the effects of indirect information on choice in  
149 Experiment 1 depended on the participants believing that the red frame represented the  
150 behaviour of other agents, i.e. social information.

151

152 The results of Experiments 1 and 2 identify a ‘social dominance paradox’: socially dominant  
153 individuals, who are typically characterised as having strong beliefs about the importance of  
154 individual accountability, and who highly value their own opinions and abilities [1], are  
155 nonetheless more likely than low SD individuals to rely on social information and to copy  
156 others. However, thus far, aside from referring to previous literature, we have provided no  
157 direct evidence that SD individuals explicitly value individual accountability. To investigate

158 whether this is indeed the case we ran a third experiment in which 34 participants (age  
159 mean(SEM) = 23.38(0.81)) completed the SD sub-scale and a novel task. This task estimated  
160 the value that participants assigned to individual (private) and social information by  
161 requiring them to pay for this information (**Fig 4**). The aim of Experiment 3 was to index  
162 spontaneous individual differences in the 'baseline' values attributed to social and private  
163 information thus, in contrast to Experiments 1 and 2, there was no clear optimal strategy  
164 since this might bias social/private information valuation. Social dominance (mean(SEM) =  
165 3.77(0.17)) was positively correlated with the value attributed to individual (Pearson's  $r =$   
166 0.40,  $p = 0.02$  (significant at Bonferroni-corrected  $\alpha$  of 0.025)) but not social ( $r = 0.21$ ,  $p =$   
167 0.25) information (**Graphical abstract: Experiment 3**). Thus, the results of Experiment 3  
168 confirm the existence of a social dominance paradox: when asked to make explicit  
169 judgements, socially dominant individuals assign a high value to private information, but  
170 when they are in the thick of a complex decision-making task, they make extensive use of  
171 social information.

172

173 In sum, we found that socially dominant people explicitly value independence (Experiment  
174 3) but show an enhanced reliance, relative to subordinate individuals, on social learning  
175 when in a complex decision-making situation (Experiment 1). In our decision-making task  
176 fruitful strategies for utilising the social information flipped between matching and actively  
177 non-matching the group's choice. SD individuals utilised a matching, but not a non-matching  
178 strategy and employed this strategy only when the red frame represented social, not asocial  
179 (roulette), information arguing against a general tendency to match. In contrast, people who  
180 are aggressively dominant did not show a bias towards social learning.

181

182 Although much is known about the population-level functions of social learning [15], very  
183 few studies have investigated the individual-level psychological mechanisms [16], or  
184 attempted to explain why people vary widely in their susceptibility to social influence [17–  
185 19]. The current series of experiments begins to parse this inter-individual variability using a  
186 personality-psychology approach, and shows, for the first time, that dominance is an  
187 important factor. These data challenge the lay stereotype in which all dominant individuals  
188 ignore the views of others [2]. The more subtle perspective offered by our findings may aid  
189 the development of interventions which maximise learning within organisations, and in the  
190 classroom, by accounting for the learner’s personality characteristics.

## 191 **EXPERIMENTAL PROCEDURES**

### 192 *Materials and procedure*

193 In Experiment 1 participants completed subjective rating scales [1, 3] of social and  
194 aggressive dominance, strength of social support network [20] and socioeconomic status  
195 (SES) [21], enabling us to investigate the relationship between dominance and learning  
196 while controlling for social support and SES.

197 Subsequently participants completed the computerised decision-making task [4]. Correct  
198 choices were rewarded with points represented on a bar spanning the bottom of the screen.  
199 Participants' aim was to obtain a silver (£2) or gold (£4) reward. Before participants made  
200 their choice, a red frame appeared which represented the most popular choice from 2  
201 males and 2 females who had completed the task previously. Participants were informed  
202 that previous attempts had been 'juggled' such that ... "in some phases they won't seem  
203 very useful – for example they could be guesses from the very beginning of the task when  
204 they had little experience. In other phases, however, they will seem quite useful – for  
205 example responses from later in the task when they had had the opportunity to practice a  
206 bit more." In animal studies of dominance and social learning, subjects typically observe and  
207 do not compete with models [6, 7]. Therefore, to maintain consistency between the animal  
208 and human literatures, our cover story avoided the introduction of a one-on-one  
209 competitive context (e.g. Behrens et al [4]).

210 The study was conducted in accordance with the 1964 Declaration of Helsinki (local ethics  
211 committee code: PSYETH(UPTD) 12/13 59).

212

213 *Data analysis*

214 Using a Bayesian Learner Model [5] the Individual Learner Model was computed by  
215 integrating the observed choices and outcomes [5] estimating the underlying trial-by-trial  
216 probability that blue was rewarded. The Social Learner Model was estimated from the  
217 observed veracity of the advice on each trial. Here the model generates estimates of the  
218 underlying probability that the social information was correct which were used to weight  
219 the group's choice. Binomial logistic regression was used to estimate the degree to which  
220 both 'models' explained each participant's choices, resulting in an individual and social  
221 learning beta for each participant.

222 To investigate whether dominance was predictive of learning strategy we used individual  
223 and social betas as dependent variables in two separate regression models. Both models  
224 comprised two predictor variables of interest (SD, AD) and five predictors of no interest  
225 (age, gender, randomisation, social support, SES). See Supp. Exp. Proc. 7 for normality tests.

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277

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283 algorithm, and Max Fage and Sophie Sowden for help with data collection.

284 **FIGURE LEGENDS**

285 **Figure 1.** In the decision task, participants were required to select between a blue and green  
286 box in order to win points. On each trial, participants first saw a cue screen for between 1  
287 and 4 secs. Then either the blue or green box was highlighted with a red frame. Participants  
288 were instructed that this frame represented either the most popular choice made by a  
289 group of 4 participants who had completed the task previously (Experiment 1), or the  
290 'choice' from a computer-simulated roulette wheel (Experiment 2). After 0.5 – 2 secs a  
291 question-mark appeared indicating that the participant could make their response.  
292 Immediately after participants had responded, their selected option was framed in grey. A  
293 further 0.5 to 2 sec interval ensued, after which participants received feedback in the form  
294 of a green or blue box in the middle of the screen. If participants were successful the red  
295 reward bar progressed towards the silver and gold goals. The probability of reward  
296 associated with the blue and green boxes, and the probability that the red frame  
297 surrounded the correct box, varied according to uncorrelated pseudorandom schedules (Fig  
298 2 and Supp. Exp. Proc. 2).

299

300 **Figure 2.** To create the Social (solid red line) and Individual (solid blue line) Learner Models,  
301 trial outcomes and social information were used as inputs to a Bayesian Learner Model  
302 algorithm. The model generated estimates (solid lines) of the underlying probability (dashed  
303 lines) that blue was rewarded (top) and that the social information was useful (bottom). The  
304 above example concerns randomization Group 1 (see Supp. Exp. Proc. 2 for randomisation  
305 details).

306

307 **Figure 3.** Y-axes show social (Experiment 1) or roulette (Experiment 2) learning betas; x-  
308 axes show social dominance or aggressive dominance. Whereas social dominance was  
309 significantly positively associated with social learning betas, aggressive dominance was not.  
310 Neither forms of dominance were predictive of roulette learning betas. See also **Fig S1**.

311

312 **Figure 4.** The aim was to guess whether a hidden picture was a face, house, car or scene.  
313 Each correct guess earned 100 credits. The task comprised two phases: a selection phase  
314 and a guessing phase. In the selection phase participants were presented with a 15x15 grid,  
315 one box of which was missing to reveal part of a hidden picture. Participants then decided  
316 whether to complete the subsequent guessing phase with just one box missing, or to pay  
317 credits to have five additional boxes removed in the guessing phase. In the Individual  
318 Information Condition, the additional boxes were selected by the participants themselves, in  
319 the Social Information Condition they were selected by previous participants. Credit stores  
320 started at 0 and participants were informed that credits spent in the selection phase would  
321 be deducted from profits from the guessing phase. Each condition comprised 6 levels  
322 varying in the cost of additional information (0, 15, 30, 45, 60 or 75 credits). There were 5  
323 trials per pay level and thus 30 trials per condition. In the guessing phase the boxes selected  
324 in the selection phase were removed and participants indicated whether the hidden picture  
325 was a face, house, car or scene.

Figure 1  
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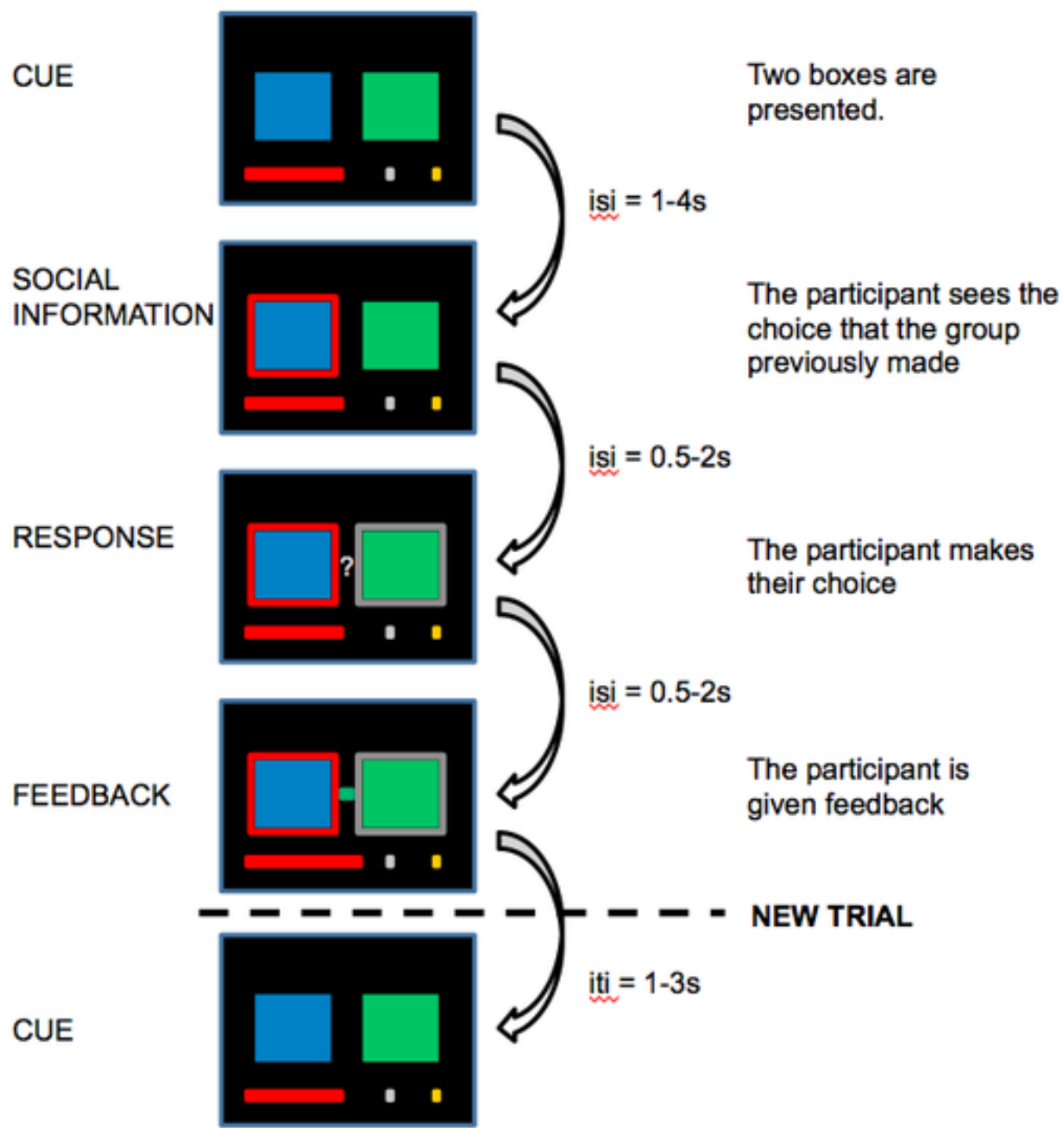


Figure 2

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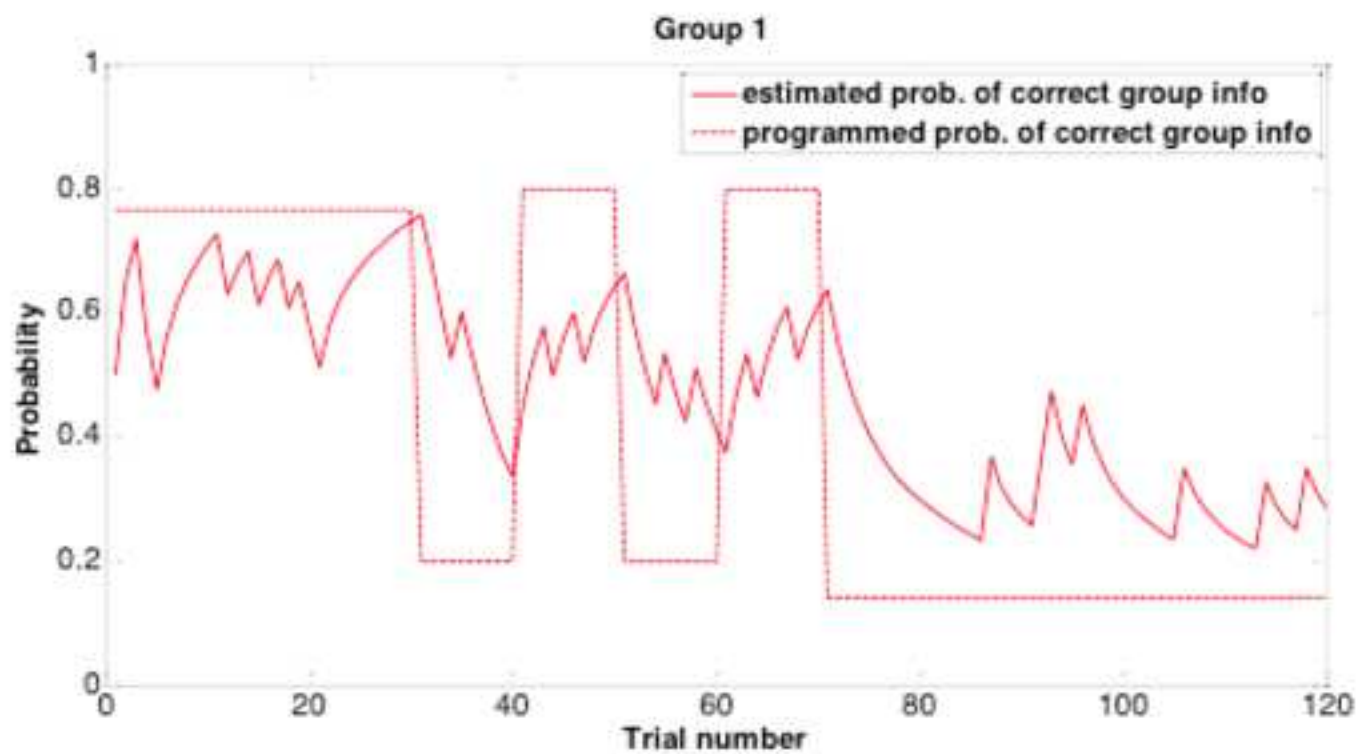
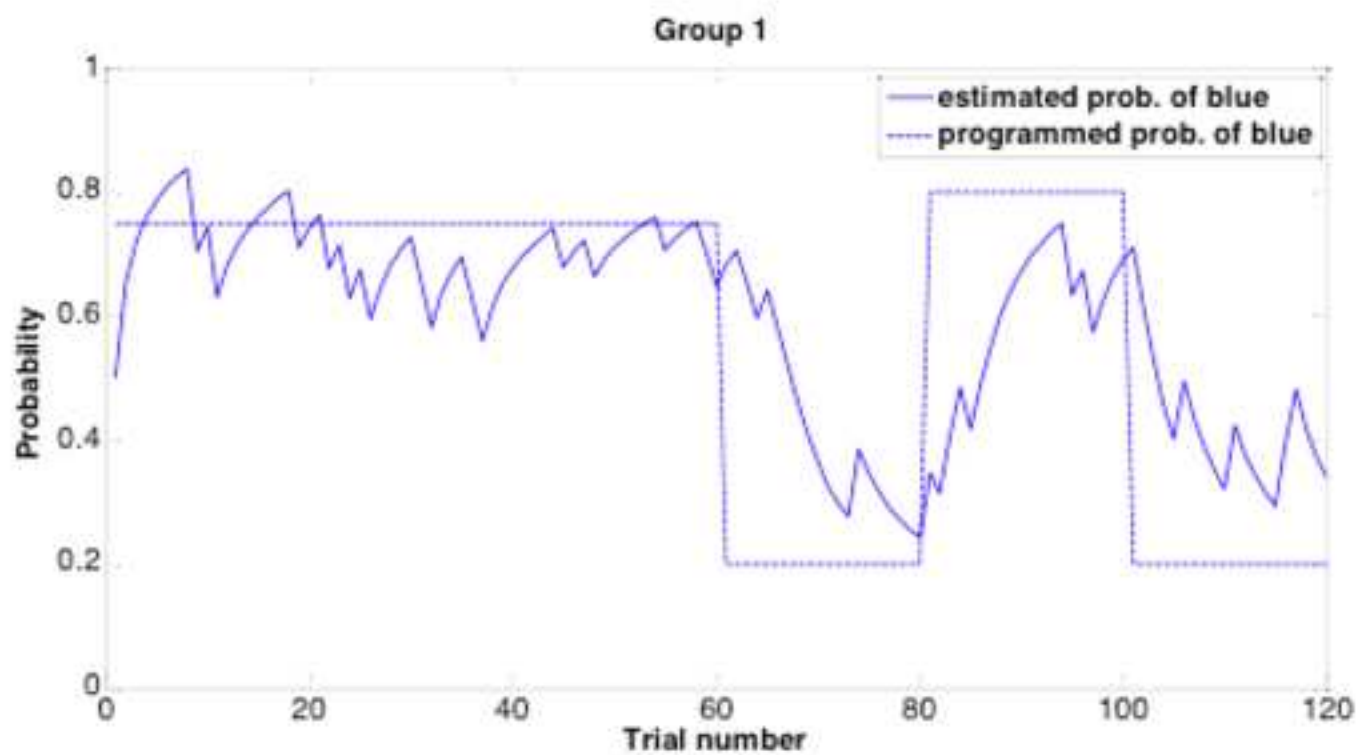


Figure 3  
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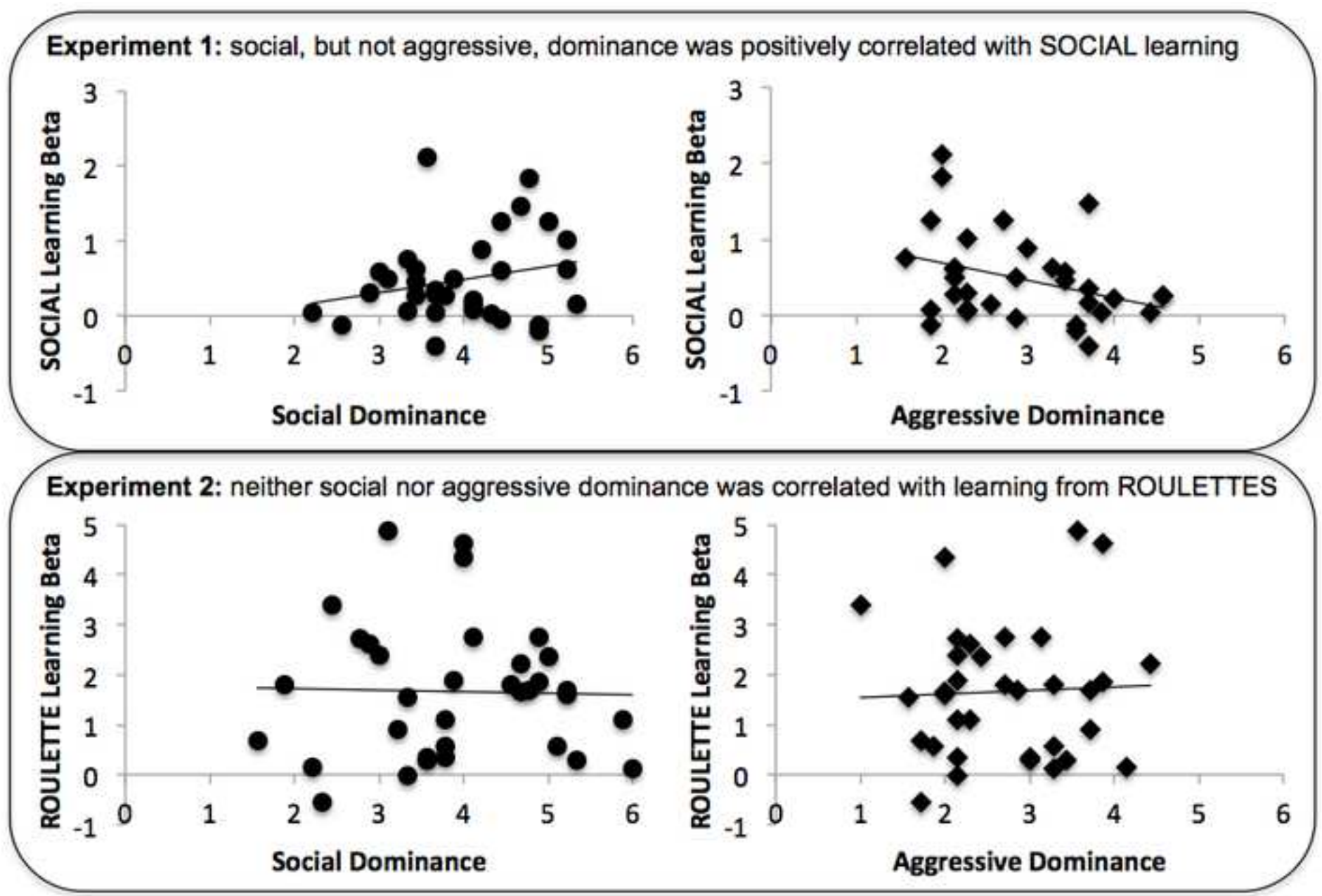
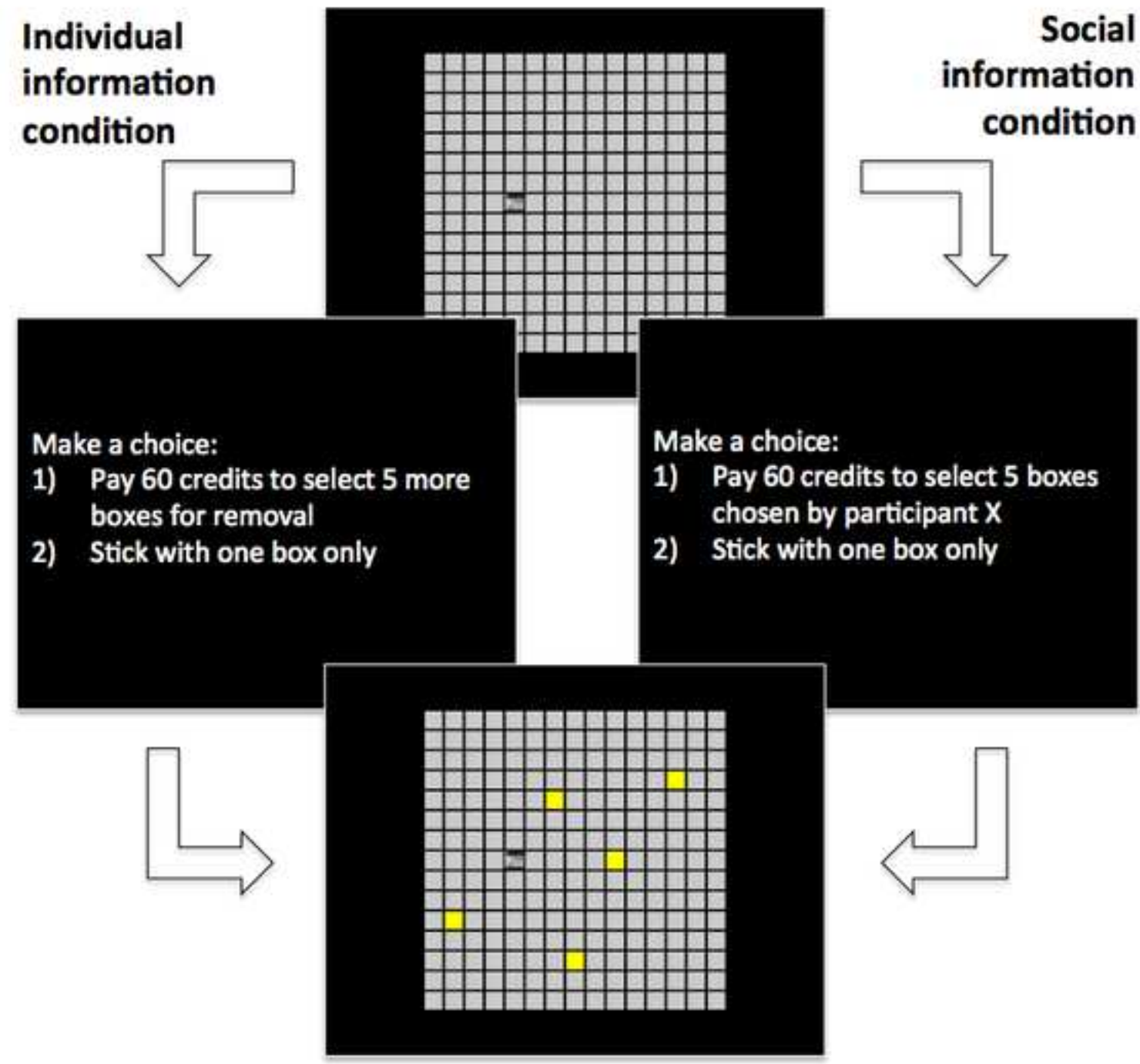


Figure 4  
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## SUPPLEMENTAL INFORMATION INVENTORY

**Supp. Data 1:** *Participant information table. Related to Experiments 1 & 2 experimental procedures*

**Supp. Data 2:** *Standardised residual betas from regression analysis plotted against social and aggressive dominance. Related to Fig. 3*

**Supp. Data 3:** *Partial correlations table. Related to Experiments 1 & 2 experimental procedures*

**Supp. Exp. Proc. 1:** *Dominance rating scale*

**Supp. Exp. Proc. 2:** *Randomisation schedules*

**Supp. Exp. Proc. 3:** *Experiment 1 - replication study*

**Supp. Exp. Proc.4a:** *Experiment 1 - replication of the correlation between social dominance and the use of a matching strategy*

**Supp. Exp. Proc. 4b:** *Experiment 1 - further analysis*

**Supp. Exp. Proc. 5:** *Participant instruction scripts*

**Supp. Exp. Proc. 6:** *Experiment 2 - further analysis*

**Supp. Exp. Proc. 7:** *Normality test details*



## SUPPLEMENTAL DATA

## Supp. Data 1

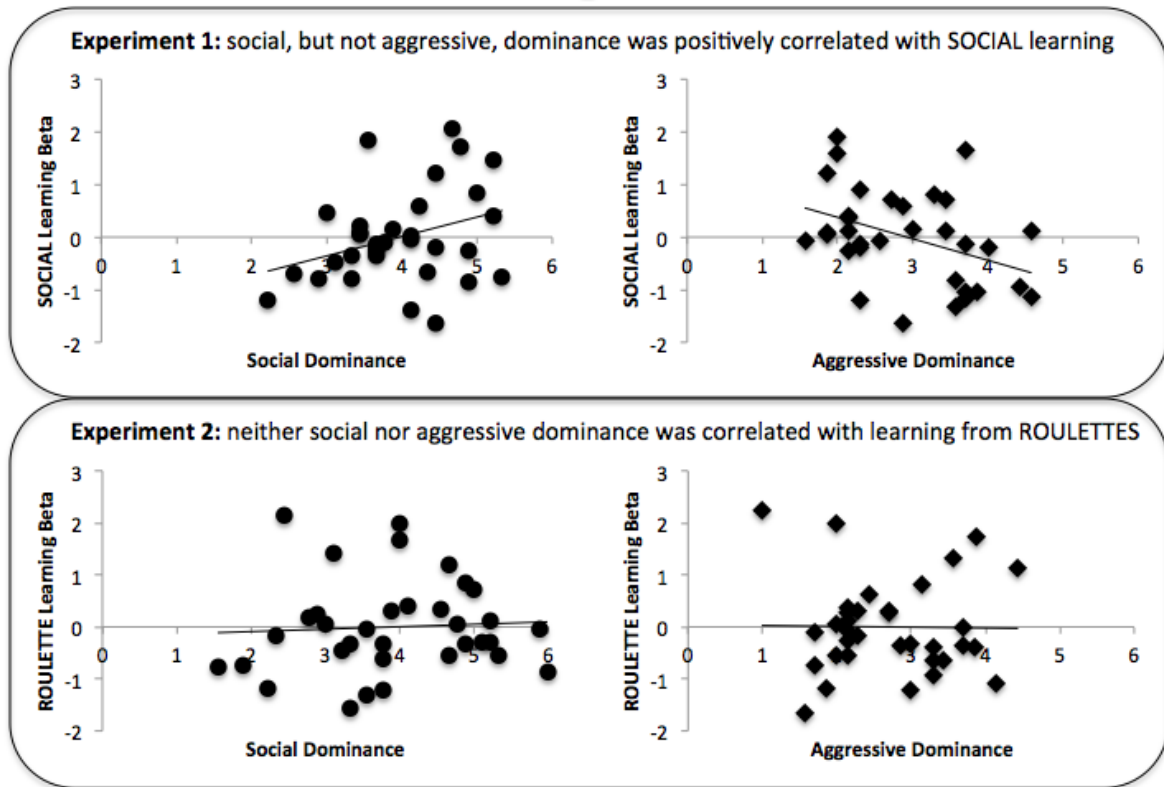
*Participant information table. Related to Experiments 1 & 2 experimental procedures*

	Experiment 1	Experiment 2	Statistics
<b>N</b>	33	34	
<b>Gender M:F</b>	19:14	19:15	
<b>Age mean(SEM)</b>	27.88(1.39)	26.21(0.96)	t(65)=0.99, p > 0.05
<b>SES mean(SEM)</b>	49.03(2.09)	42.56(2.55)	t(65)=1.96, p > 0.05
<b>Social support mean(SEM)</b>	4.54(0.28)	4.98(0.24)	t(65)=1.21, p > 0.05
<b>Social dominance mean (SEM)</b>	3.97(0.14)	3.91(0.20)	t(65)=0.25, p > 0.05
<b>Aggressive Dominance mean (SEM)</b>	2.92(0.15)	2.70(0.14)	t(65)=1.07, p > 0.05

**Table S1: Participant information.** Participants in Experiment 2 were not significantly different from Experiment 1's participants in terms of age, gender, socioeconomic status (SES), social support, social dominance or aggressive dominance. All participants had normal / corrected-to-normal vision; were screened for neurological / psychiatric conditions; gave informed consent; were reimbursed for their participation; and were fully debriefed upon task completion.

## Supp. Data 2

Standardised residual betas from regression analysis plotted against social and aggressive dominance. Related to Fig. 3



**Figure S1.** Y-axes show social (Experiment 1) or roulette (Experiment 2) learning betas controlling for age, gender, randomisation, social support, socioeconomic status, and social dominance (where aggressive dominance is represented on the x-axis) or AD (where SD is on the x-axis). Whereas social dominance was significantly positively associated with social learning betas, aggressive dominance was not. Neither forms of dominance were predictive of roulette learning betas.

### Supp. Data 3

*Partial correlations table. Related to Experiments 1 & 2 experimental procedures*

Expt	Predictor	Dependent variable	Controlling for ...	P value	Pearson's r
1	AD	Social learning betas	Age, gender, randomisation, SES, social support, social dominance	0.01	-0.48
1	AD	Individual learning betas	Age, gender, randomisation, SES, social support, social dominance	0.49	0.14
1	SD	Social learning betas	Age, gender, randomisation, SES, social support, aggressive dominance	0.048	0.38
1	SD	Individual learning betas	Age, gender, randomisation, SES, social support, aggressive dominance	0.66	-0.09
2	AD	Roulette learning betas	Age, gender, randomisation, SES, social support, social dominance	0.94	-0.02
2	AD	Individual learning betas	Age, gender, randomisation, SES, social support, social dominance	0.99	0.003
2	SD	Roulette learning betas	Age, gender, randomisation, SES, social support, aggressive dominance	0.68	0.08
2	SD	Individual learning betas	Age, gender, randomisation, SES, social support, aggressive dominance	0.20	-0.25

**Table S2:** To investigate whether regression coefficients for the relationships between social/aggressive dominance and social and individual learning betas were significantly different we used Fisher's r-to-z-transformation. To do so we computed partial correlations resulting in Pearson's r statistics which were used as inputs in the r-to-z transformation. The above table shows partial correlations between social (SD)/aggressive (AD) dominance and social /roulette/individual learning indices controlling for age, gender, randomisation schedule, socioeconomic status (SES) and social support.

## SUPPLEMENTAL EXPERIMENTAL PROCEDURES

### Supp. Exp. Proc. 1

#### *Dominance rating scale*

The dominance rating scale [1] required participants to rate themselves on a scale from 1 to 6 with respect to the following statements:

#### **Social dominance subscale**

I have no problems talking in front of a group  
At school I found it easy to talk in front of the class  
No doubt I'll make a good leader  
I like taking responsibility  
I certainly have self-confidence  
For me it is not difficult to start a conversation in a group  
I am not shy with strangers  
People turn to me for decisions  
I generally put people into contact with each other

*Social dominance score = average score*

#### **Aggressive dominance subscale**

When a person is annoying, I put him in his place  
If I need something I borrow it from a friend without his approval.  
I find it important to get my way, even if this causes a row  
I like it when other persons serve me  
I quickly feel aggressive with people  
I find it important to get my way  
I think that achieving my goals is more important than respecting others

*Aggressive dominance score = average score*

For Experiment 1 the rating scale was administered before the social learning task was introduced. For the replication studies (Supp. Exp. Proc. 3 and 4) task and rating scale order was reversed thus removing any potential priming effects associated with the rating scales. Experiment 3 was conducted as part of a larger task battery; rating scale and task completion was separated by a 20-minute filler task.

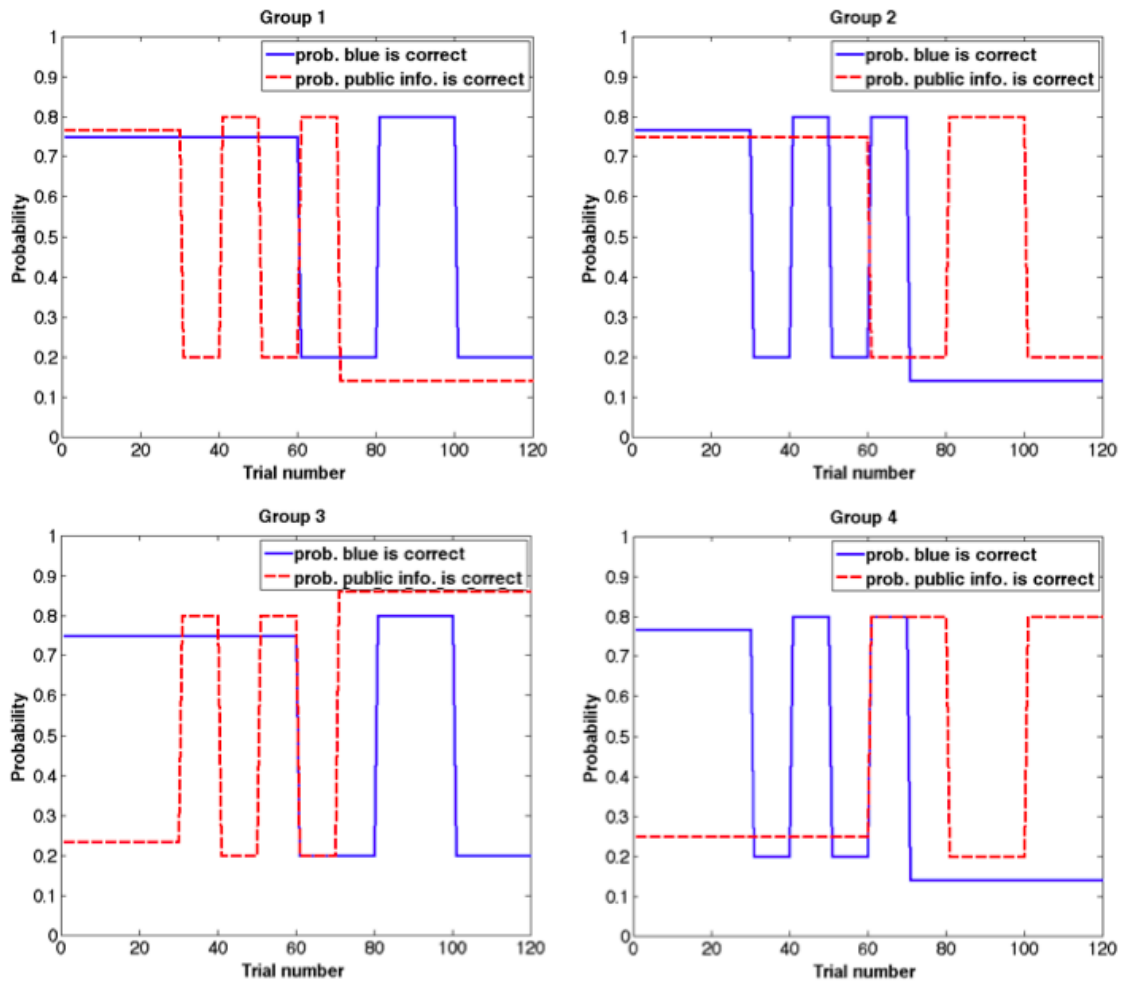
## Supp. Exp. Proc. 2

### *Randomisation schedules*

Outcomes (blue/green) and the veracity of social advice (correct/incorrect), in both Experiment 1 and Experiment 2, were governed by four different pseudo-randomisation schedules. These were based on the schedules used by Behrens et al [4]. However, the schedules were counterbalanced between participants to ensure that a preference for social over individually-experienced information could not be explained in terms of a preference for increased, or early occurring, volatility.

The randomisation schedule for group 1 (Fig S2) was the same as that employed by Behrens et al. During the first 60 trials, the reward history was stable, with a 75% probability of blue being correct. During the next 60 trials, the reward history was volatile, switching between 80% green correct and 80% blue correct every 20 trials. Meanwhile, during the first 30 trials, the social information was stable, with 75% of choices being correct. During the next 40 trials, the social information was volatile, switching between 80% incorrect and 80% correct every 10 trials. During the final 50 trials, the social information was stable again, with 85% of choices being incorrect. Schedules for groups 2, 3, and 4 were inverted and counterbalanced versions of schedule 1.

For both Experiment 1 and Experiment 2 a univariate ANOVA demonstrated that there was no effect of randomisation schedule on either individual (Experiment 1:  $F(32) = 0.887$ ,  $p = 0.459$ ; Experiment 2:  $F(33) = 1.412$ ,  $p = 0.259$ ) or social learning betas (Experiment 1:  $F(32) = 1.782$ ,  $p = 0.173$ ; Experiment 2:  $F(33) = 1.829$ ,  $p = 0.163$ ). Thus the weight attributed to an individual or social learning strategy did not vary systematically as a function of the randomisation schedule received. As a precautionary measure randomisation schedule was included as a regressor of no interest in our multiple regression models, but this did not influence the patterns of significance.



**Fig S2:** Randomisation schedules. Solid blue lines show the probability of blue being the correct choice, dashed red lines show the probability of the social information being correct.

### **Supp. Exp. Proc. 3**

#### *Experiment 1 - replication*

Experiment 1 was repeated in an independent sample of participants ( $N = 22$ ; age (mean(SEM)) = 23.23(2.47); M:F = 9:13) as part of a larger test battery. A repeated-measures ANOVA with within-subject factor learning type (social or individual) and social and aggressive dominance as covariates demonstrated a significant interaction between SD and learning type ( $F(1,17) = 4.59$ ,  $p = 0.047$ ) but no significant relationship between AD and learning type ( $F(1,17) = 2.03$ ,  $p = 0.17$ ). Post-hoc Pearson's correlations demonstrated that SD was significantly positively correlated with social ( $r = 0.46$ ,  $p = 0.04$ ) but not individual learning betas ( $r = -0.33$ ,  $p = 0.15$ ). Such results provide further support for a significant positive relationship between social, but not aggressive, dominance and social learning.

## **Supp. Exp. Proc.4a**

### *Experiment 1 - replication of the correlation between social dominance and the use of a matching strategy*

It could be argued that the lack of a relationship between SD and the use of a non-matching strategy is due to a general absence of the non-matching strategy in our sample (i.e. negative betas correspond to a non-matching strategy and, on average, betas for predominantly incorrect trials were not significantly less than zero (mean(SEM) = 0.29(0.15),  $t(32) = 1.91$ ,  $p = 0.07$ )). To test this hypothesis we acquired a larger dataset via online testing and specifically selected participants who used both a matching strategy when the social information was predominantly correct **and** a non-matching strategy when information was predominantly incorrect. To do so we used the same procedure employed for Experiment 1 to calculate a beta value, for each participant, which represents their use of information from trials in which the social information was predominantly correct ( $p(\text{red frame} = \text{correct}) > 0.5$ ) and those in which it was predominantly incorrect ( $p(\text{red frame} = \text{correct}) < 0.5$ ). We then selected only those participants who were in the top 1/3<sup>rd</sup> of predominantly correct beta values and in the top 1/3<sup>rd</sup> of absolute beta values for predominantly incorrect trials (where a greater absolute value indicates greater use of a non-matching strategy). This selection resulted in a sample of 69 participants who were matching the social information when it was predominantly correct (mean beta(SEM) = 0.32(0.02);  $t(68) = 16.10$ ,  $p < 0.0001$  (one sample t-test)) and using a non-matching strategy when the social information was predominantly incorrect (mean absolute beta(SEM) = 0.44(0.02);  $t(68) = 19.30$ ,  $p < 0.0001$  (one sample t-test)).

Replicating our results from Experiment 1, we found that SD was significantly positively correlated with the use of predominantly correct ( $r = 0.27$ ,  $p = 0.04$ ), but not predominantly incorrect ( $r = -0.16$ ,  $p = 0.23$ ), social information. Furthermore we used Fisher's r-to-z transformation to test whether the correlation between SD and the beta value for predominantly correct trials was significantly different from the correlation between SD and the absolute value of predominantly incorrect betas. Indeed we found that there was a significantly stronger correlation between SD and the extent to which a matching strategy was employed, compared to SD and the extent to which a non-matching strategy was employed ( $z = 2.35$ ,  $p = 0.02$ ). Thus we fail to find a relationship between social dominance and the degree to which a non-matching strategy is employed even when we can be confident that our participants are using a non-matching strategy.

## **Supp. Exp. Proc. 4b**

### *Experiment 1 - further analysis*

There was no significant relationship between aggressive dominance and the use of predominantly correct ( $t(32) = -1.49$ ,  $p = 0.15$ ,  $\text{std}\beta = -0.27$ , partial  $r = -0.34$ ) or incorrect ( $t(32) = -1.80$ ,  $p = 0.08$ ,  $\text{std}\beta = -0.35$ , partial  $r = -0.29$ ) social information - although the p-value for the latter approached significance - and no difference in the relationship between AD and predominantly correct versus incorrect information (Fisher's r-to-z = -0.22,  $p = 0.83$ ).



## Supp. Exp. Proc. 5

### *Participant instruction scripts*

**Experiment 1:** “On each trial, in the following experiment, you will see a blue and a green box. Your task is to pick the box most likely to give you reward. Things go in phases in this task so sometimes you may be in a blue phase where the blue box will lead to reward, whereas other times you may be in a green phase.

Before you make your choice you will see the most popular choice selected by a group of four participants (2 males and 2 females) who previously played the same task. The only catch is that their responses have been juggled. So in some phases they won’t seem very useful – for example they could be guesses from the very beginning of the task when they had little experience. In other phases, however, they will seem quite useful – for example responses from later in the task when they had had the opportunity to practice a bit more.”

**Experiment 2:** “On each trial, in the following experiment, you will see a blue and a green box. Your task is to pick the box most likely to give you reward. Things go in phases in this task so sometimes you may be in a blue phase where the blue box will lead to reward, whereas other times you may be in a green phase.

Before you make your choice you will see a computer-generated suggestion. The computer has generated this suggestion using virtual roulette wheels.

On each trial the computer spins the roulette, if the ball lands on black the computer will put a frame around the correct answer, if the ball lands on red the computer will frame the incorrect answer.

The only catch is that there are different types of roulette wheel.

Some roulette wheels are half red and half black. This type of roulette is equally likely to give you correct and incorrect suggestions. However, others are biased. This type of roulette will give you either mostly correct or mostly incorrect suggestions.

Once the computer has selected a roulette wheel it will stick with that wheel for a while. However, it will switch between the various different roulette wheels throughout the course of the experiment.”

## Supp. Exp. Proc. 6

### *Experiment 2 - Further analysis*

Roulette learning betas (Experiment 2) were significantly greater than social learning betas (Experiment 1) (social mean (SEM) = 0.48(0.10); roulette = 1.66(0.23);  $t(65) = 4.66$ ,  $p = 0.001$ ) demonstrating that participants could successfully utilise the information represented by the red frame when it was believed to be from a series of roulette wheels. Despite this, for participants who completed the roulette version of the decision task ( $N = 34$ , Supp. data 1) the effect of the red frame was unrelated to social ( $t(33)=0.42$ ,  $p = 0.68$ ,  $\text{std}\beta=0.09$ ) or aggressive ( $t(33)=-0.78$ ,  $p = 0.94$ ,  $\text{std}\beta=-0.01$ ) dominance. As in Experiment 1, individual learning was also unrelated to social ( $t(33)=-1.32$ ,  $p = 0.20$ ,  $\text{std}\beta=-0.32$ ) or aggressive ( $t(33)=0.01$ ,  $p = 0.99$ ,  $\text{std}\beta=0.003$ ) dominance. Neither social, nor aggressive, dominance were significantly better predictors of the use of the roulette information compared with private information (AD Fisher's  $r$ -to- $z = -0.07$ ,  $p = 0.94$ ; SD  $r$ -to- $z = 0.69$ ,  $p = 0.49$ ). In addition, there was no significant relationship between the mean number of correct responses and social ( $t(33) = 1.078$ ,  $p = 0.291$ ,  $\text{std}\beta = 0.227$ ) or aggressive ( $t(33) = -0.525$ ,  $p = 0.604$ ,  $\text{std}\beta = -0.084$ ) dominance. There was also no relationship between SD or AD and predominantly correct ( $p(\text{red frame} = \text{correct}) > 0.5$ ) trials (SD:  $t(33) = -0.76$ ,  $p = 0.46$ ,  $\text{std}\beta = -0.18$ ); AD:  $t(33) = 0.03$ ,  $p = 0.976$ ,  $\text{std}\beta = 0.01$ ) or predominantly incorrect ( $p(\text{red frame} = \text{correct}) < 0.5$ ) trials (SD:  $t(33) = -0.44$ ,  $p = 0.66$ ,  $\text{std}\beta = -0.10$ ); AD:  $t(33) = -0.08$ ,  $p = 0.93$ ,  $\text{std}\beta = -0.01$ ). There was no significant correlation between SD and AD ( $r = 0.27$ ,  $p = 0.12$ ).

### **Supp. Exp. Proc. 7**

For all analyses Kolmogrov-Smirnov statistics were used to examine whether data violated assumptions of normality. Where they did univariate (first quartile – 3 x interquartile range (IQR) or last quartile + 3IQR) and multivariate outliers (Mahalanobis distance > 3.84 ( $p_{\text{chance}} > 0.05$ )) were removed and/or data were log transformed such that the assumption of normality was no longer violated.