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Graphical Abstract

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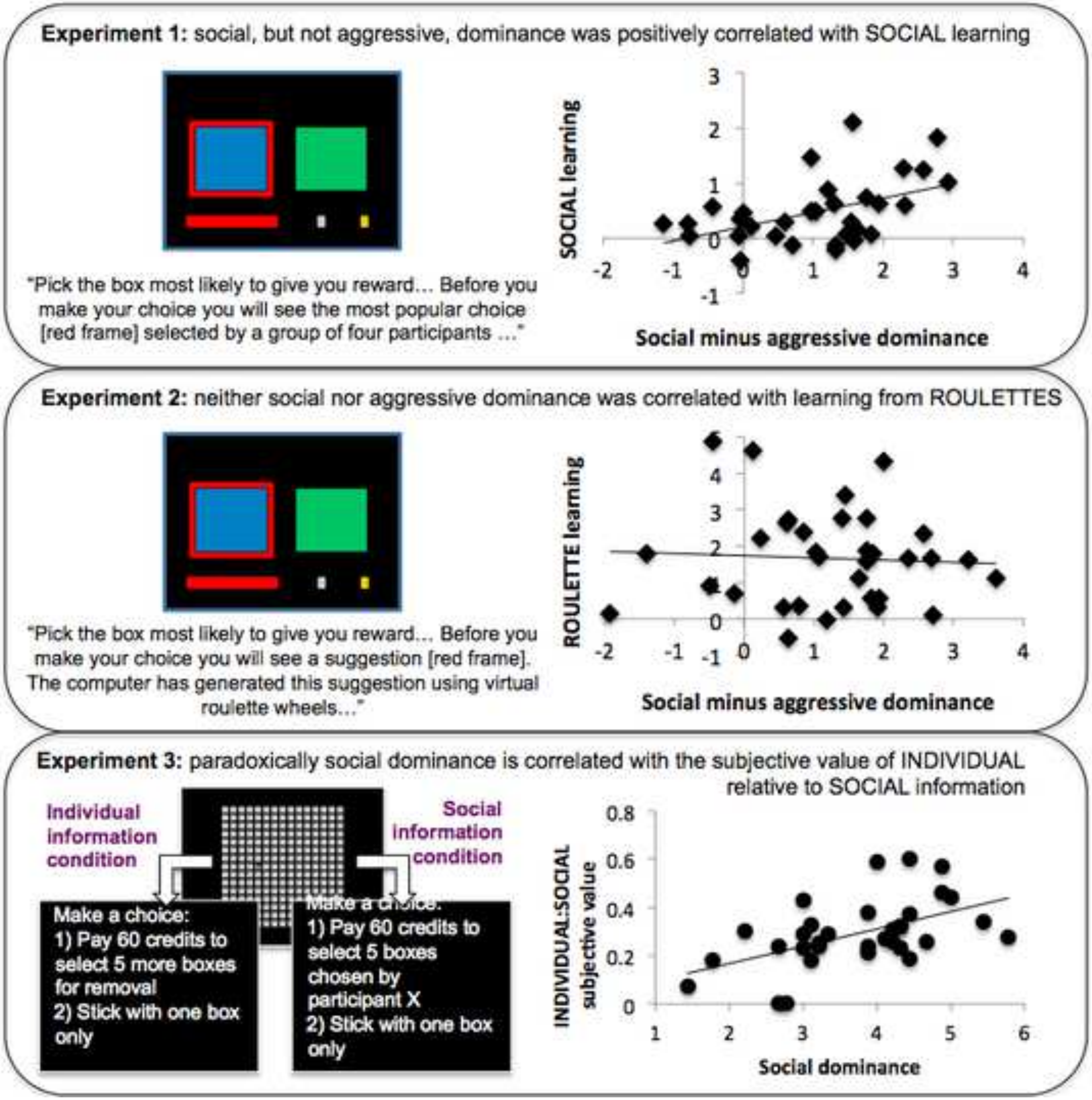

The social dominance paradox

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Running title: Social dominance and learning strategy

SUMMARY

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

RESULTS AND DISCUSSION

In Experiment 1 adult participants (N = 33; Age mean(SEM) = 27.88(1.39); M:F = 19:14; Supplemental Data 1) completed subjective rating scales of social and aggressive dominance [1, 3] (Supplementary Experimental Procedures (Supp. Exp. Proc.) 1) and a computerised decision-making task [4] that enabled separate investigation of individual and social learning [4] (**Fig 1**). Validation studies [1] have demonstrated that individuals who score high in either social (SD) or aggressive (AD) dominance – on the scales we employed – have strong beliefs about the importance of individual accountability and self-report high levels of self-esteem, authoritarianism and self-sufficiency [1]. In a real-life social interaction, wherein participants work in groups to select a hypothetical new housemate, high SD and AD individuals excel in influencing the group's choice according to their personal preferences. However, analysis of video recordings of such interactions demonstrates significant differences in the methods employed: whereas SDs tend to rely on reasoning to persuade others, ADs use aggression and Machiavellian tactics such as threat, deceit and flattery [1].

In the decision-making task, participants scored points by using individually-experienced (outcome history) and/or social (**Fig 1** red frame) information to make choices between a blue and a green stimulus. On each trial a red frame surrounded one of the two stimuli. Participants were instructed that this frame (the social information) represented the most popular choice made by a group of 4 participants who had completed the task previously. The actual probability of reward associated with the blue and green boxes, and the probability that the red frame surrounded the correct box, varied according to uncorrelated pseudorandom schedules (**Fig 2**, Supp. Exp. Proc. 2). A Bayesian Learner Model algorithm [4, 5] was employed to create two models of optimal performance (**Fig 2**): the Individual Learner Model and the Social Learner Model. The Individual Learner Model comprised the probability, based on the outcome history, that a blue choice would be rewarded. Thus, for each trial, its value represented the reward probability associated with a blue choice that a participant would have derived if they had been learning, in an optimal fashion, exclusively from private information about reward outcomes (i.e. ignoring the social information). The Social Learner Model comprised the probability, based on the social information weighted by the history of correct social information, that the group's choice would be rewarded. From this model we computed, for each trial, the reward probability of a blue choice that a participant would have derived if they had been learning, in an optimal fashion, exclusively from the social information (i.e. ignoring individual experience). Using logistic regression these two models were regressed against participants' choices. This resulted in individual and social beta values (regression slopes) that represent the degree to which choices were explained by the two respective models. A participant whose choices were strongly influenced by the social information (reflected in the Social Learner Model) would have a high social beta value; a participant who consistently went against the social information would have a negative social beta value.

Multiple regression models applied at the group level showed that social dominance ($t(32)=2.08$, $p = 0.048$, standardised β (stdβ)=0.39) was a significant positive predictor of the social beta values: The higher a participant scored in SD the more they used the social information, as estimated by the Social Learner Model, to make their choices (**Fig 3; Fig S1;** see Supp. Exp. Proc. 3 for replication study). In contrast aggressive dominance was a significant negative predictor of social betas ($t(32)=-2.74$, $p = 0.01$, stdβ=-0.49), the higher a participant scored in AD the less likely they were to use the social information to make their choices. Notably there was no correlation between SD and AD ($r = 0.21$, $p = 0.24$). Fisher's r-to-z transformation (Supp. Data 3) confirmed that the relationship between SD and the use of social information was significantly different from the relationship between AD and the use of social information ($z = 3.57$, $p = 0.0002$). By regressing dominance scores against mean number of correct responses we also found that aggressive ($t(32)=-2.27$, $p = 0.03$, std$\beta=-0.41$), but not social ($t(32)=-0.11$, $p = 0.91$, std$\beta=-0.02$), dominance was predictive of poor overall performance. Neither social ($t(32)=-0.45$, $p = 0.66$, std$\beta=-0.11$) nor aggressive ($t(32)=0.71$, $p = 0.49$, std$\beta=0.16$) dominance predicted individual learning betas, and both SD and AD were significantly better predictors of social than of individual learning (SD: Fisher's r-to-z = 1.9, $p = 0.03$; AD: Fisher's r-to-z = -2.57, $p = 0.01$). Together these results suggest that whereas responses from socially dominant individuals followed those of the group, responses from aggressively dominant individuals did not. This neglect of social information had a detrimental effect on the AD individuals' overall task performance.

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

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

[1] Probabilities were derived from the Social Learner Model

informant and learner.

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

The results of Experiments 1 and 2 identify a 'social dominance paradox': socially dominant individuals, who are typically characterised as having strong beliefs about the importance of individual accountability, and who highly value their own opinions and abilities [1], are nonetheless more likely than low SD individuals to rely on social information and to copy others. However, thus far, aside from referring to previous literature, we have provided no direct evidence that SD individuals explicitly value individual accountability. To investigate whether this is indeed the case we ran a third experiment in which 34 participants (age mean(SEM) = 23.38(0.81)) completed the SD sub-scale and a novel task. This task estimated the value that participants assigned to individual (private) and social information by requiring them to pay for this information (**Fig 4**). The aim of Experiment 3 was to index spontaneous individual differences in the 'baseline' values attributed to social and private information thus, in contrast to Experiments 1 and 2, there was no clear optimal strategy since this might bias social/private information valuation. Social dominance (mean(SEM) = 3.77(0.17)) was positively correlated with the value attributed to individual (Pearson's $r = 0.40$, $p = 0.02$ (significant at Bonferroni-corrected α of 0.025)) but not social ($r = 0.21$, $p = 0.25$) information (**Graphical abstract: Experiment 3**). Thus, the results of Experiment 3 confirm the existence of a social dominance paradox: when asked to make explicit judgements, socially dominant individuals assign a high value to private information, but when they are in the thick of a complex decision-making task, they make extensive use of social information.

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

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

EXPERIMENTAL PROCEDURES

Materials and procedure

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

Subsequently participants completed the computerised decision-making task [4]. Correct choices were rewarded with points represented on a bar spanning the bottom of the screen. Participants' aim was to obtain a silver (£2) or gold (£4) reward. Before participants made their choice, a red frame appeared which represented the most popular choice from 2 males and 2 females who had completed the task previously. Participants were informed that previous attempts had been 'juggled' such that … "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." In animal studies of dominance and social learning, subjects typically observe and do not compete with models [6, 7]. Therefore, to maintain consistency between the animal and human literatures, our cover story avoided the introduction of a one-on-one competitive context (e.g. Behrens et al [4]).

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

Data analysis

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

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

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FIGURE LEGENDS

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

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

Figure 3. Y-axes show social (Experiment 1) or roulette (Experiment 2) learning betas; x-axes show social dominance or aggressive dominance. 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. See also **Fig S1**.

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

Figure 1
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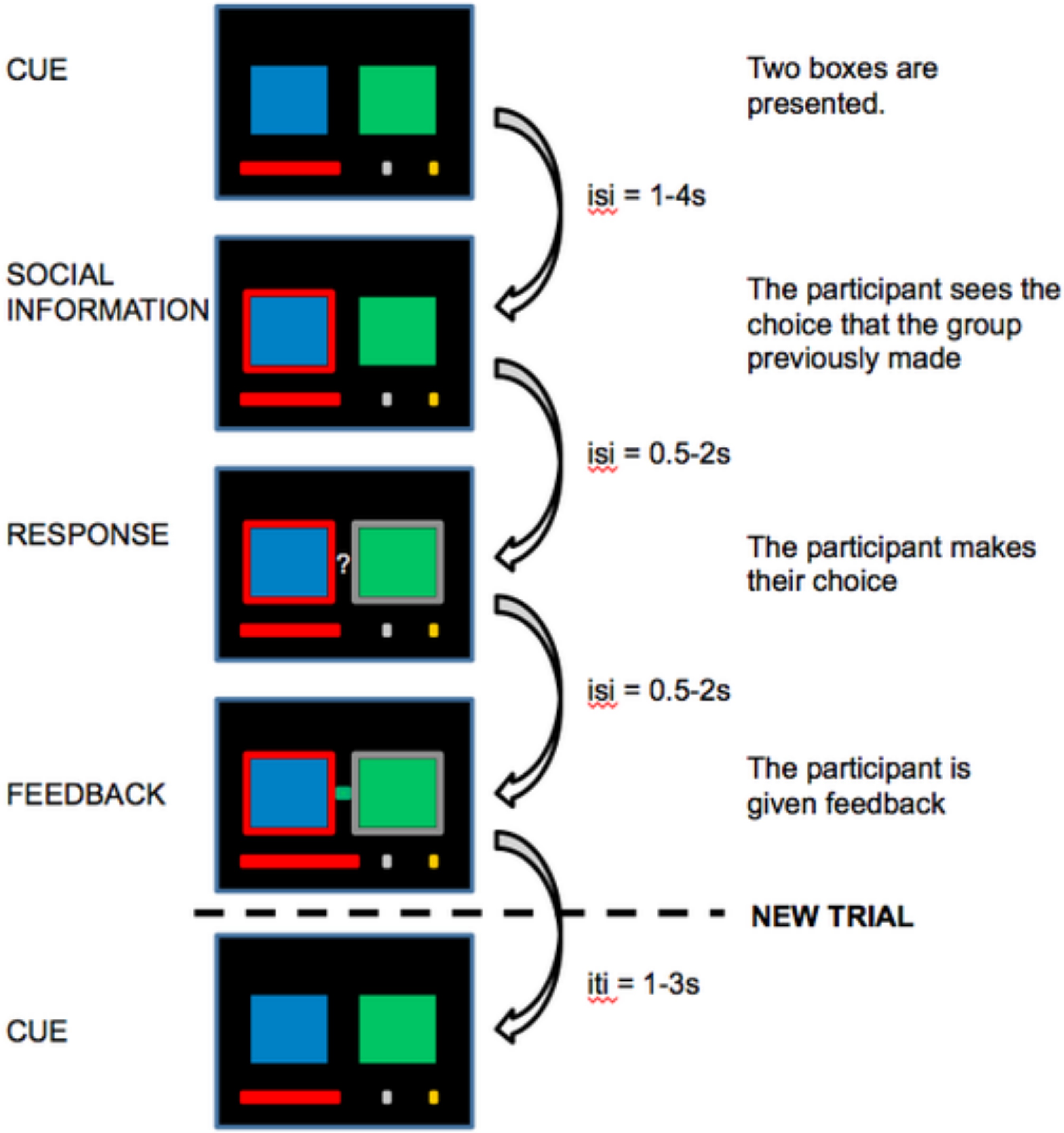

Figure 2
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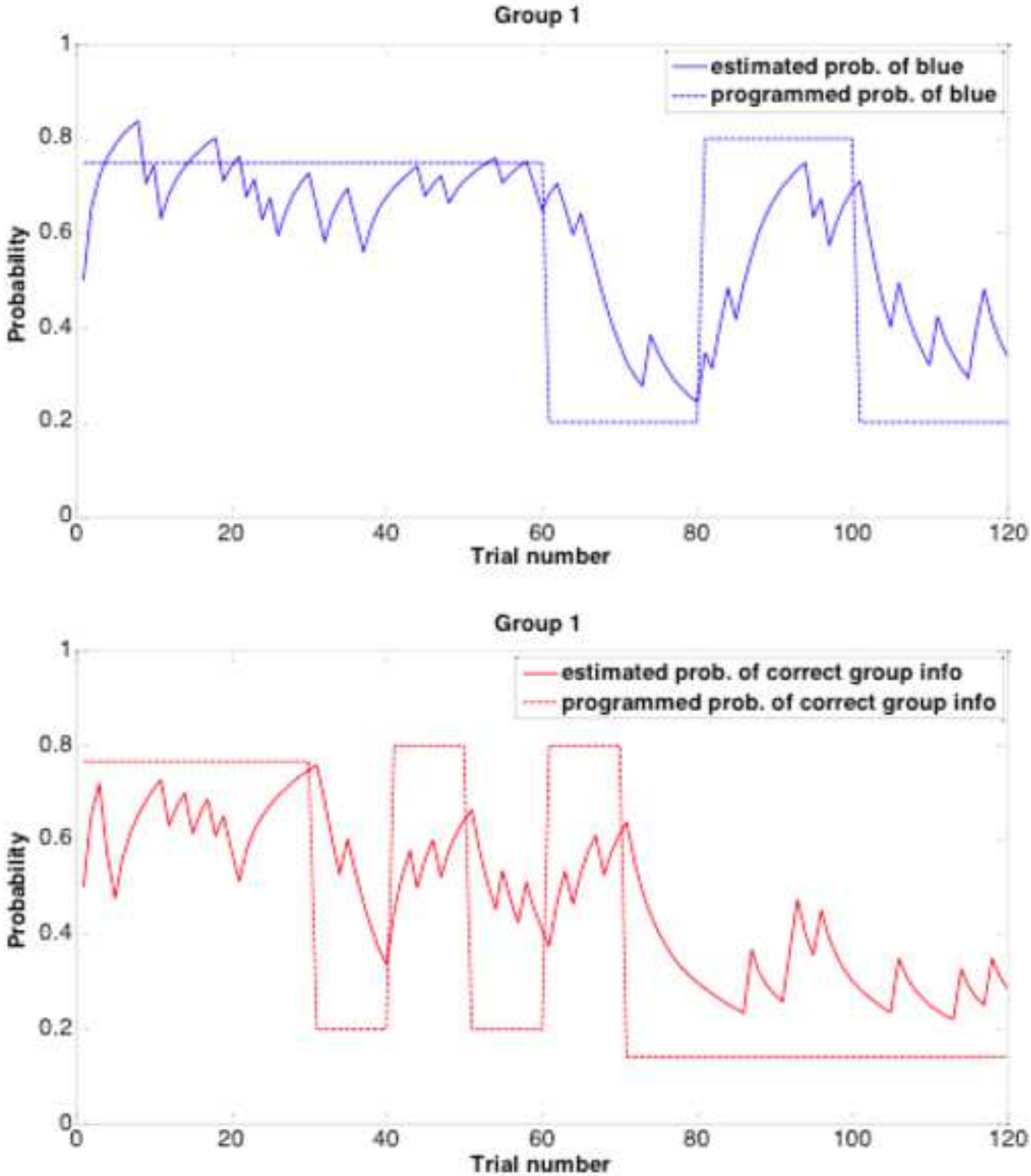

Figure 3

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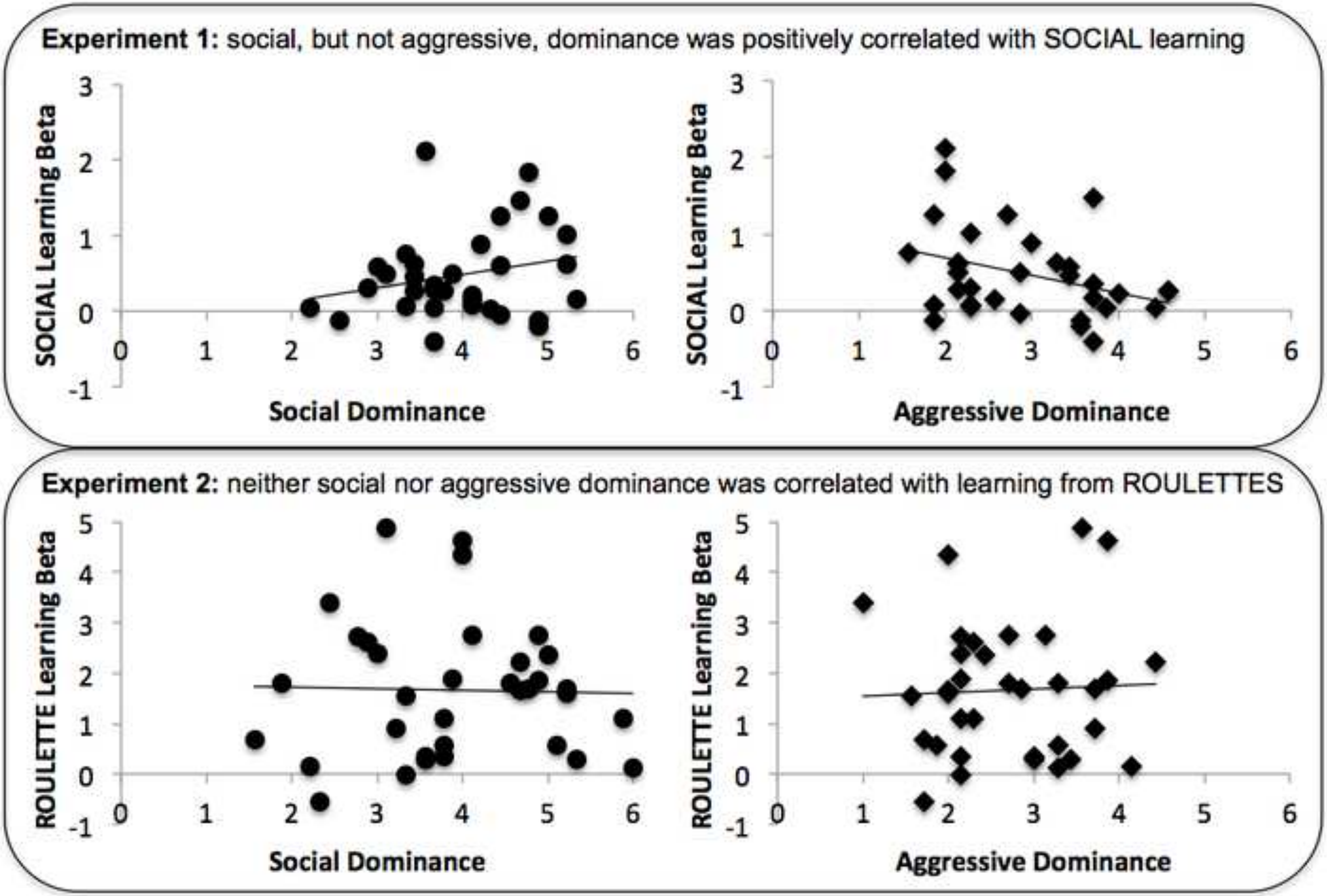

Figure 4
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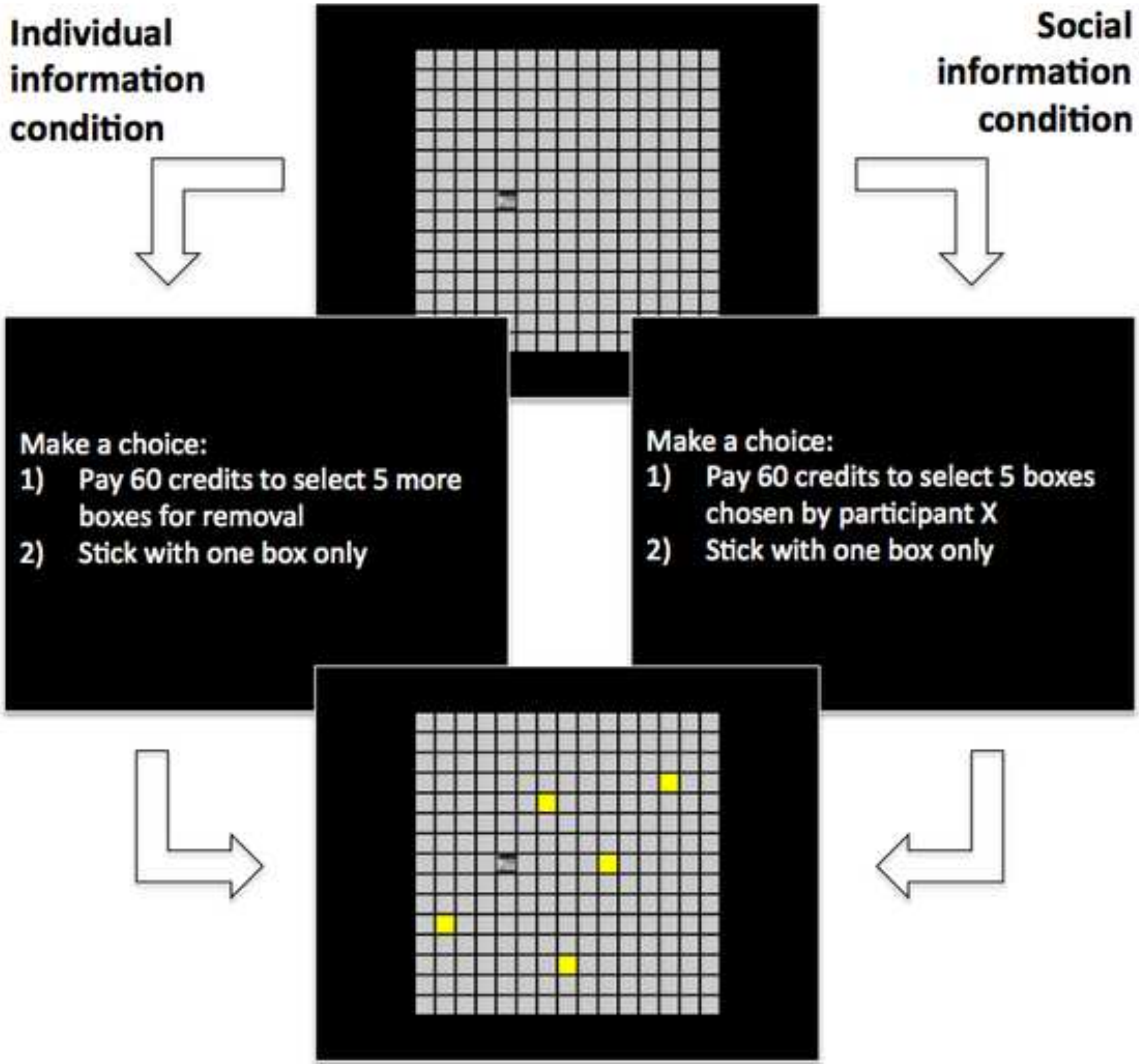

SUPPLEMENTAL INFORMATION INVENTORY

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

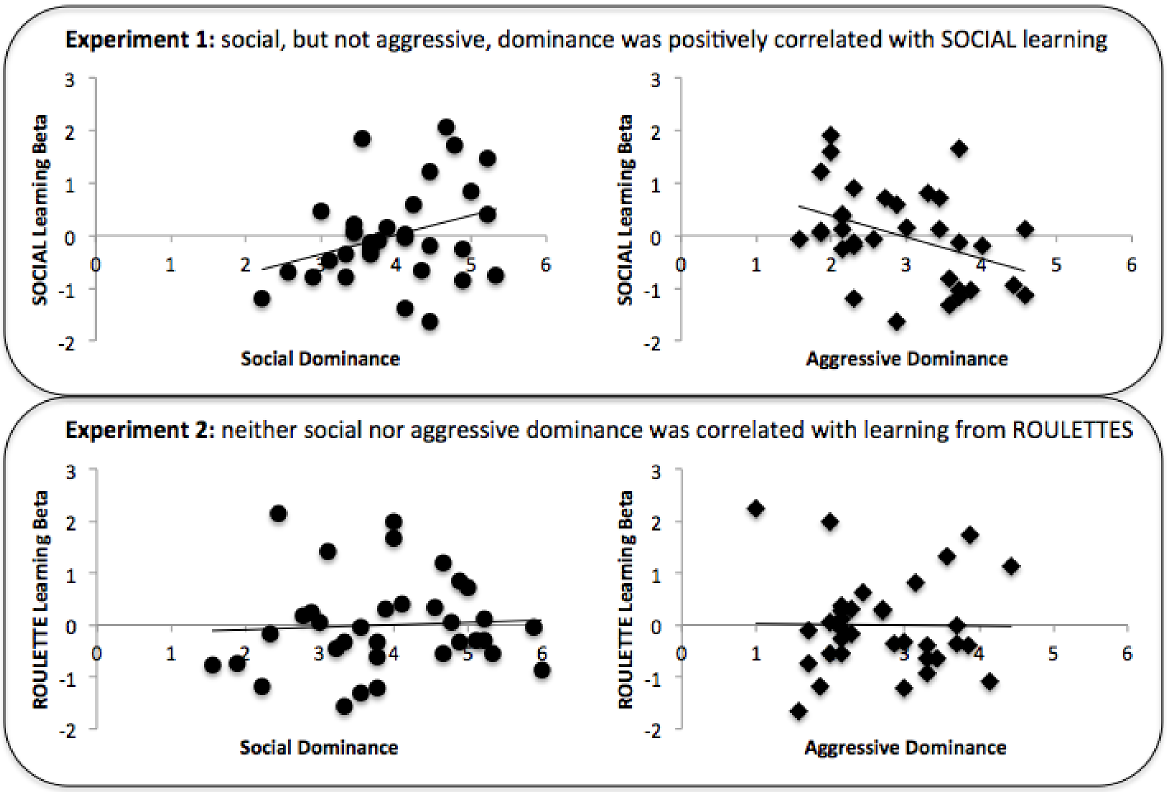

Figure S1. Y-axes show social (Experiment 1) or roulette (Experiment 2) learning betas controlling for age, gender, randomisation, social support, socioeconomic status, and social dominance (where aggressive dominance is represented on the x-axis) or AD (where SD is on the x-axis). Whereas social dominance 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.

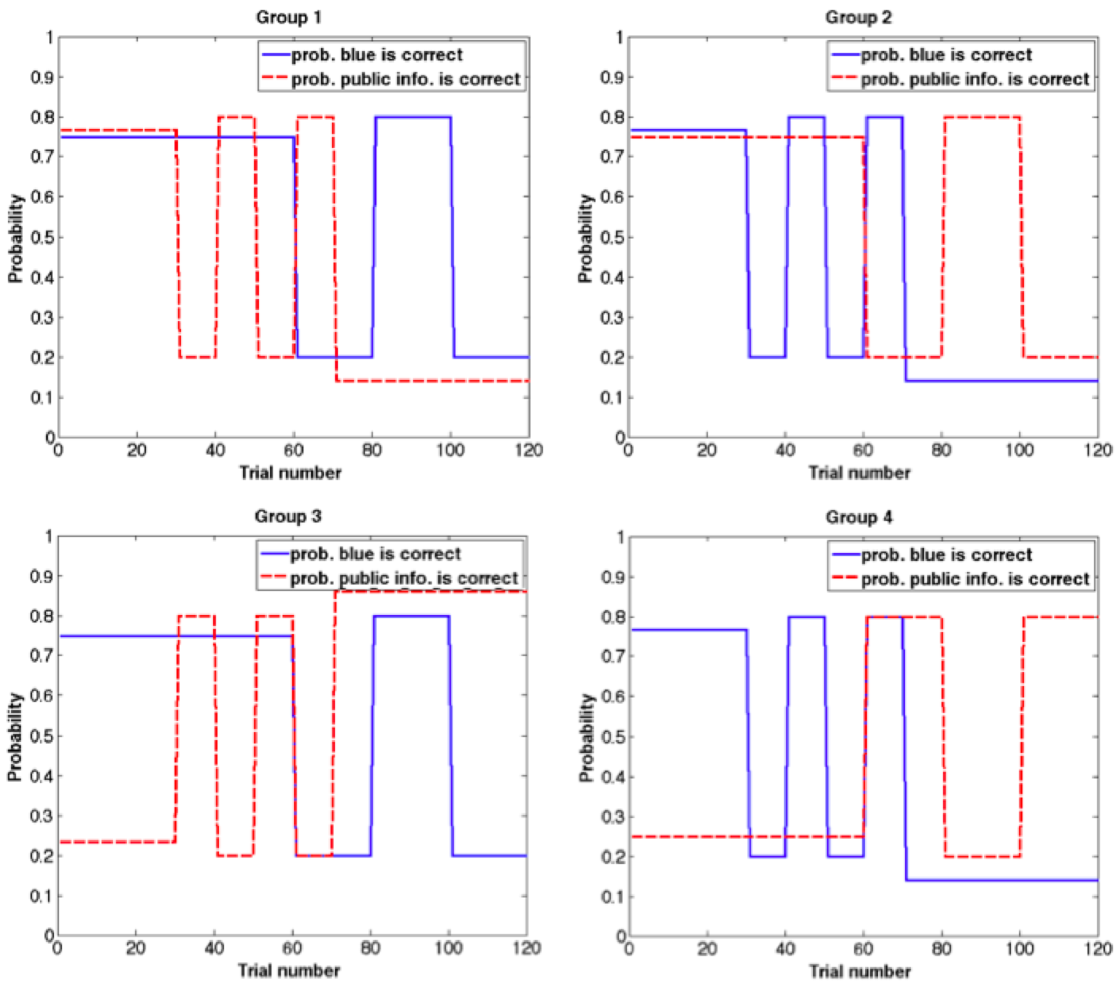

Fig S2: Randomisation schedules. Solid blue lines show the probability of blue being the correct choice, dashed red lines show the probability of the social information being correct.

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(red frame = correct)>0.5) and those in which it was predominantly incorrect (p(red frame=correct)<0.5). We then selected only those participants who were in the top 1/3rd of predominantly correct beta values and in the top 1/3rd 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 ($t(32)=-1.49$, $p = 0.15$, stdβ=-0.27, partial $r = -0.34$) or incorrect ($t(32)=-1.80$, $p = 0.08$, stdβ=-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, $p = 0.83$).

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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."

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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 ($t(33)=0.42$, $p = 0.68$, stdβ=0.09) or aggressive ($t(33)=-0.78$, $p = 0.94$, stdβ=-0.01) dominance. As in Experiment 1, individual learning was also unrelated to social ($t(33)=-1.32$, $p = 0.20$, stdβ=-0.32) or aggressive ($t(33)=0.01$, $p = 0.99$, stdβ=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 ($t(33) = 1.078$, $p = 0.291$, stdβ = 0.227) or aggressive ($t(33) = -0.525$, $p = 0.604$, stdβ = -0.084) dominance. There was also no relationship between SD or AD and predominantly correct (p(red frame = correct) >0.5) trials (SD: $t(33) = -0.76$, $p = 0.46$, stdβ = -0.18); AD: $t(33) = 0.03$, $p = 0.976$, stdβ = 0.01) or predominantly incorrect (p(red frame=correct)<0.5) trials (SD: $t(33) = -0.44$, $p = 0.66$, stdβ = -0.10); AD: $t(33) = -0.08$, $p = 0.93$, stdβ = -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 ($p_{chance} > 0.05$)) were removed and/or data were log transformed such that the assumption of normality was no longer violated.