How to cope with unfairness
Writing helps to regulate negative emotions

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Objective: Humans are tremendously sensitive to unfairness. Unfairness can elicit strong negative emotions which in turn have influence on our decision making (Sanfey et al., 2003; Van't Wout et al., 2006). Therefore, it might be useful to regulate our emotions in these situations. But how can we cope with our negative emotions? Psychological emotion regulation strategies, like reappraisal or suppression were shown to alter rejection rates in the Ultimatum Game and to regulate emotions in the Dictator Game (Grecucci et al., 2012 and 2013). However these strategies have to be learned and are difficult to implement in everyday life. We test a more intuitive response focused emotion regulation strategy; writing a message to the person who treated us unfair.

Methods: We used the Dictator Game to elicit unfair situations. 24 participants played the role of a proposer and 213 female participants played the role of a receiver in a Dictator Game. Receivers had to indicate their emotions at three time points; before receiving an unfair offer, after receiving an unfair offer and after the emotion regulation strategy. Participants were randomly allocated to one of four different emotion regulation conditions; writing a message which is forwarded to the proposer, writing a message which is not forwarded, description of a neutral picture and waiting. All emotion regulation strategies were applied for three minutes. An additional group of participants evaluated the content of the messages written in both message writing conditions via an online questionnaire.

Results: Participants reported less pleasure and dominance and more arousal after receiving an unfair allocation (pleasure 6.22 vs. 4.04; $p < 0.01$, arousal 3.20 vs. 4.39; $p < 0.01$ and dominance 5.05 vs. 3.94; $p < 0.01$). We further compared all emotion regulation conditions in one regression analysis. Writing a message to the proposer increased pleasure ratings (b=.18, t=2.00, p<.05). Writing a message, which is not transferred to the proposer, also increased pleasure ratings (b=.20, t=2.06, p<.05). Writing about a neutral picture in contrast had no effect on pleasure ratings. Arousal and dominance ratings were not altered by any of the emotion regulation strategies. Forwarded and non-forwarded messages did not differ in content.

Conclusions: Writing a message is an effective emotion regulation strategy in a social context. In order to be effective the message does not need to be forwarded. Thus, the mere writing of our opinion seems to be an effective emotion regulation strategy to cope with unfairness.

Neural Correlates of Sensory Integration in a Value-Based Decision-Making Task

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<u>Objective:</u> Previous research has examined how people integrate value-based information along multiple dimensions of an item or set of items (e.g., risk vs. reward, taste vs. health). These decisions have been well described by models of noisy evidence accumulation such as the drift diffusion model. However, whereas noise in standard evidence accumulation paradigms (e.g., perceptual decisions) is in the sensory evidence itself, standard neuroeconomic paradigms use unambiguous stimuli and assume that the primary source of noise is in the neural representation of the associated reward. In order to more directly examine the influence of noisy sensory evidence on multi-attribute value-based decisions, we had participants perform a *value-based* perceptual decision-making task in which sensory evidence varied along two stimulus dimensions.

<u>Methods:</u>
Participants performed a random dot motion task while in the scanner. On each trial, they viewed a dot array that was majority red or blue, a subset of which moved up or down. Color and motion coherence varied from trial to trial. Participants were allowed to respond based on motion direction, color, or both, but gave one response on each trial, which mapped onto one direction and one color (e.g., left for blue or up), so that a response could be correct for zero, one, or two dimensions on a given trial. They were rewarded for each dimension they got correct on that trial. The reward for each dimension was instructed, and the relative reward for the two dimensions varied throughout the session.

<u>Results:</u>
We found that participants' choices were influenced by the coherence of both motion and color – the more evidence there was in favor of a given response, the more likely that response. This effect interacted with reward contingencies, such that participants placed greater weight on evidence from the currently more rewarded dimension. The fMRI data revealed a significant interaction, whereby ventral mPFC tracked the evidence in favor of the high versus low reward attribute, and dorsal cingulate instead tracked the relative evidence in favor of the low versus high reward attribute (or the overall difficulty of the choice).

<u>Conclusions:</u>
Our findings suggest that rewards can be integrated into a perceptual decision-making task in order to generate a low-level analog to common multi-attribute choices (e.g., between foods or products), allowing for greater control over the generation of preferences. Such a task could provide a valuable test bed for exploring complex phenomena related to self control (e.g., prioritizing healthy over tasty food attributes).

Higher social rankings, higher cooperation: Effects of Social Comparison Processes on Cooperative Behavior

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Objective: Successfull navigation of our complex social world requires the capability of recognizing and judging the relative status of others. Hence, social comparison processes are of great importance in our interactions with others, informing us of our relative standing and motivating our behavior. However, to date few studies have examined in detail how social comparison processes can impact interpersonal decision-making. An aspect of social decision-making that is of particular importance is cooperative behavior. Identifying methods to increase cooperation and efficiency in public goods provision is of vital interest for human societies, and the present study examines how the use of social comparison processes can influence cooperative behavior in useful ways.

Methods: 39 healthy college students were recruited at Radboud University Nijmegen . Participants first played a simple cognitive reaction time task, following which various forms of feedback on performance were given. These different types of feedback were used to manipulate the social comparison processes via social rankings. Then, participants played a modified Public Goods Game which was used to measure cooperation. Participants also completed a social comparison orientation questionnaire (Gibbons & Buunk, 1999) to measure individual differences in social comparison tendencies.

Results: Interestingly, we found that individuals tend to be more cooperative when they were ranked highest in the preceding cognitive task (upward comparison), as compared to those who were ranked at the bottom rank (downward comparison). This was regardless of whether those the participants were compared to were also other players in the Public Goods Game. Using the median of the social comparison orientation score to separate the participants into high and low orientation groups demonstrated that this effect was stronger in the high social comparison orientation group.

Conclusion: In summary, the present research shows how different social comparison processes (via social rankings) can operate in our daily interaction with others, demonstrating an effect on cooperative behavior. Follow-up work is currently examining the neural mechanisms underlying these social comparison effects.

Envisioning the Improbable: Judgment in Networked Contexts

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Objective: Networked contexts (e.g., branded products or asset markets), due to mechanisms like preferential attachment, are often characterized by heavy-tailed probability distributions whereby low-probability/high–consequence events occur with relative frequency. If these contexts are mistakenly classified as thin-tailed (i.e., rare events are exceedingly unlikely), individuals may undervalue assets or fail to insure against catastrophic loss. I demonstrate, through Monte Carlo simulation, that heavy–tailed phenomena very often exhibit samples that appear thin-tailed, even for large samples or long periods making. Accordingly this paper examines the judgments of individuals regarding possible extreme (low–probability/high-consequence) events in heavy–tailed contexts in the absence of representative experience.

Methods: The task asks individuals to rank order six different sets of thin- and heavy-tailed context pairs (e.g., CEO age and CEO pay) designed to test individual ability to distinguish between contexts. The results are correlated with text analysis of reasoning statements and a new incentive compatible method of elicitation that measures individual perceptions of the magnitude and likelihood of possible *errors* surrounding their expectations ― the willingness to pay for, or avoid, tail uncertainty.

Results: I demonstrate that individuals overwhelmingly fail to distinguish between heavy- and thin–tailed contexts in the absence of experience, biasing their judgments towards thin-tailed distributional assumptions, thereby underweighting low probability events, even in very familiar contexts. However, the ability to classify heavy-tailed sample data as possibly misleading, or unsuitable for inference based on context, significantly moderates the biased judgments found in Study 1. Furthermore, individuals with this ability pay orders of magnitude more to avoid, or profit from, tail uncertainty. Finally, intermediate statistical knowledge does not appear to attenuate the biased judgments.

Conclusion: This work supports the theory that individuals behave as *naïve Gaussian statisticians* ― individuals, until they learn otherwise, assume the world is thin-tailed, samples are representative, and that conventional sample-based statistical tools are adequate for inference in heavy-tailed contexts. Since accurate valuation of strategies depends on correct distributional classification (thin- or heavy-tailed) of opportunities and threats, this work has broad implications for individuals, firms, and policy-makers.

Risk learning signals predict optimal investment choices

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Objective

Previous studies have shown that a network of cortical areas such as the anterior insula, the dorsolateral prefrontal cortex (dlPFC) and the anterior cingulate cortex (ACC) encode risk prediction errors in a gambling task that does not involve trial-by-trial learning *[1, 2]*. In this fMRI study, we ask whether neural risk prediction error signals can predict optimal risk taking behavior in a financial risk learning task.

Methods

We collected functional MR images from 46 healthy male participants (age M 40.08, SD 6.53, range 29-49 years) while they engaged in a financial risk learning task *[3]*. The task requires subjects to update their beliefs about a stock's outcome distribution, captured by the mean and variance (risk) of the stock outcome, on a trial-by-trial basis in order to make optimal investments. Every time a new stock outcome is presented, the risk information is updated and results in a risk prediction error.

Results

First, we demonstrate that when the stock's outcome variance decreases (negative risk prediction error) subjects are more likely to choose the optimal investment in the next trial. Second, we confirm in a whole-brain analysis that activation in dlPFC, ACC, anterior insula and inferior parietal lobule (IPL) correlates positively with risk prediction error at the presentation of the stock outcome. Third, using ROIs from the literature *[1]*, we show that activation in the same regions that encode the risk prediction error predicts optimal investment choices in the next trial. This effect is enhanced for negative compared to positive risk prediction errors.

Conclusions

Our results suggest that an efficient risk prediction error encoding supports optimal financial risk taking. Other studies have investigated trial-by-trial effects of risky decisions without actual learning *[4]* or for learning under ambiguity *[5]*. This study complements previous research by demonstrating the relevance of neural risk prediction error signals for risk taking behavior in an unambiguous risk learning task.

Acknowledgements

References

[1] Rudorf et al. (2012). *J Neurosci*
[2] Preuschoff et al. (2008). *J Neurosci*
[3] Kuhnen (in press). *J Finance*

[4] Xue et al. (2010). *NeuroImage*
[5] d'Acremont et al. (2009). *NeuroImage*

Advancing developmental decision neuroscience of valuation

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Objective: Health behavior decisions, such as eating, exercise, and drugs, are of great importance, and can impact physical, emotional, and economic life outcomes. What we value significantly influences our decisions. We possess an understanding of neurofunctional mechanisms of valuation in adults, but less work has been done with youth. The objectives of this project are to determine the computational and neural mechanisms underlying valuation and food decision-making in children using a human fMRI task.

Methods: Twenty healthy children between the ages of 8-14 (10 females) underwent a series of behavioral choice tasks and self-report measures. Participants were then scanned using an event-related fMRI paradigm, using 60 single food images. Choices were either the child's own preference to eat, or their perceived mom's preference for them to eat. fMRI data were analyzed using the AFNI software.

Results: Preliminary results (n=18) showed distinct behavioral and neural patterns between the two choice conditions. Child participants used primarily taste values when they made their own choices, which was accompanied by ventromedial prefrontal cortex (vmPFC) activations. Interestingly, when projecting what foods they believed their mother would choose for them, child participants used both taste and health values, which was accompanied by dorsolateral prefrontal cortex (dlPFC) activations.

Conclusions: Understanding developmental mechanisms of value-based choices in children will have critical importance for improving health behavior choices in early development. Ultimately, the goal is to use neuroscience findings to help improve youth decision-making, and design behavioral intervention programs and prevention programs accordingly.

Elimination of a Market Anomaly in Auctions is only Apparent due to Incorrect Estimations

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Objective: Individual-level anomalies such as the base-rate fallacy are theorized to disappear through learning in auctions. However, we tested the hypothesis that because of uncertainty, the base-rate fallacy only superficially disappears through auction-based learning, and actually leads to systematic biases in market values.

Methods: Twenty-four university students participated in the study. First, participants were given a task (Task 1) to estimate their individual biases. This task was equivalent to the taxicab problem (Kahneman and Tversky, 1972), and included a set percentage of real coins (prior probability) and an appraiser who judged the coins with a set accuracy (likelihood). Participants were asked to give the probability that a coin appraised as real was actually real (posterior probability). Then, in Task 2, participants estimated the accuracy of an appraiser after observing a series of his appraisals and the outcomes. Task 3 was an auction in which coins judged as real by the appraiser in Task 2 were sold to one of six participants. The accuracy of the appraiser was queried at the end of the auction. While participants thought they were bidding against each other, they were actually biddings against computer-generated agents. The contract price always converged on the optimal price because we used a second-price auction in which the agents' bid prices converged on the optimal price. After 40 auctions, Task 1 was repeated to determine whether participant bias was altered through auction-based learning. This procedure was repeated with four groups of six participants. We used a logit model of Bayes' theorem to analyze the data, and generated importance-bias values for the prior probability (α) and the likelihood (β).

Results: We found that before the auction the mean distributions of α and β significantly deviated from the optimal value in Task 1 (t-test, Ps < 0.001), indicating importance-biases of prior probability and likelihood. As predicted, while subjects' bids converged on the optimal price after the auctions in Task 3, biases did not disappear. Additionally, while many participants correctly estimated appraiser accuracy in Task 2, the averaged estimation of appraiser accuracy was significantly different from the correct value after the auctions.

Conclusions: These results suggest that deviation from optimal price was eliminated, but it caused formation of the systematic biased estimations. Thus, learning through auctions is not a magic bullet for eliminating market anomalies. Further, these results seems to occur when subjects are confronted with complex problems that do not have simple, single solutions (i.e. ill-posed problems).

Preferences under pressure: limited processing time increases risk aversion during monetary decision making

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Objective: It takes time for the brain to process, interpret, and act on incoming sensory information. As a result, trade–offs between speed and accuracy are a ubiquitous feature of both perception and action. In decision making, the relationship between processing duration and behavioral/neurophysiological stochasticity has been addressed from a number of different perspectives, most notably with the drift diffusion model. But how processing duration might impact preferences has received less attention. Here, we assess the impact of processing duration on risk–taking during a monetary decision–making task.

Methods: 12 adults (18–32 y.o., 8 F) participated in this study. On each trial, participants saw 2 options: a certain gain of $5 and a lottery whose magnitude ($8, $20, $50, $125) and probability of payout (.25, .5, .75) was systematically manipulated. Options were simultaneously presented on each side of a central fixation dot, and participants viewed the display for one of four durations (1 second (s), 2 s, 4 s, 8 s). After the display duration ended, the options disappeared, and participants had 1 s to enter their choice using the keypad. Critically, responses were only allowed during this window. Visual feedback of the choice was presented for 2 s, followed by a 1 s inter–trial–interval.

12 unique trial types (4 values x 3 probabilities) were presented 4 times each, at each of the 4 display durations (192 trials). To assess violations of first order stochastic dominance (FOSD), an additional trial type ($5 gain with .5 probability) was presented 5 times, at each of the 4 display durations. All trials were randomly intermingled and presented in 4 blocks of 53 trials each. At the end of the experiment, 1 of the trials was randomly selected and the outcome of that trial was realized.

Results: Processing duration impacted choice behavior. Participants chose the certain gain significantly more often than the lottery in the short (1 s), relative to the long (8 s) display conditions ($p<0.01$, paired non–parametric randomization test, n=11). Participants were also less consistent in their responses to repeated presentations of the same choice options in the short, relative to the long display conditions ($p<0.05$, paired non–parametric randomization test, n=11). One participant was excluded for choosing the dominated option on more than 10% of the FOSD trials.

Conclusions: These preliminary results suggest that the temporal context in which a decision is made can modulate not only the consistency of choice behavior, as has been previously noted, but also, the willingness to choose a risky over a certain option - a measure of risk aversion - when processing time is limited.

Motivational Blindness in Financial Decision-Making

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People often learn about the opinion of others before making a decision, but do not always go along with these opinions. What determines if an option will be considered or discarded? One of the most salient features of an opinion is valence – whether the other person's belief indicates good or bad outcomes for oneself. Here, using fMRI and a financial decision making task, we tested how people incorporate opinions of other people into decisions. We find that participants are more likely to alter investment decisions in response to information they want to hear and ignore information they do not want to hear, even in the face of potential loss. Specifically, when the partner's opinion indicated potential gains, participants strongly increased their financial investments. Yet, when the partner's opinion indicated potential loses, people barely changed their financial investments. This difference was most pronounced when the partner expressed high confidence in their opinion. While favourable opinions delivered with high confidence led to strong changes in financial investments, unfavourable opinions delivered with high confidence showed no effect at all. The fMRI results suggest that the differences in the processing of favourable and unfavourable opinions can be explained by differences in the activation of reward-related areas of the brain. Our results indicate that people selectively incorporate favourable opinions into their decision making, while turning a blind eye towards unfavourable ones.

Decision-making under uncertainty in Post-Traumatic Stress Disorder

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Objective: Post-traumatic stress disorder (PTSD) affects a significant proportion of the population, yet currently there exists no available means to identify individuals at heightened risk for the disorder. One aspect of most traumas that is widely ignored in the context of PTSD is the often extraordinary levels of uncertainty surrounding highly adverse circumstances. We hypothesized that individual differences in attitudes towards uncertainty may explain part of the variation in the likelihood of developing PTSD symptoms. Here we tested this hypothesis by assessing risk and ambiguity attitudes in the gain and loss domain in a group of combat veterans with and without PTSD.

Methods: 54 participants (27 veterans with PTSD and 27 non-PTSD veteran controls) were endowed with $125 of real money and then asked to choose 320 times between a certain positive or negative dollar amount (±$5) and a positive or negative lottery, respectively. The lottery varied in the amount of money that can be won or lost (between $5 and $125) as well as the outcome probability or the level of ambiguity. Ambiguity level was systematically varied by limiting the information participants had regarding outcome probabilities presented for a given lottery. At the end of the experiment one randomly chosen trial was played for real money, so that subjects had to treat each trial as if they would be paid according to their choice.

Results: While the two groups exhibited comparable behavior when making choices under risk (known probabilities) they differed in their behavior under ambiguity (unknown probabilities). In particular, individuals with PTSD were more susceptible to ambiguity under losses.

Conclusions: PTSD symptomatology may be associated with increased ambiguity aversion in the loss domain. Although our research cannot point to a causal direction it demonstrates the potential of using neuroeconomic techniques in studying mental disorders. Our results provide grounds for further research and may help to direct novel methods of diagnosis and treatment evaluation.

Individual Differences in the Asymmetric Dominance Effect

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Objective: The asymmetric dominance effect (ADE, the increase in the choice share of a dominating option when an asymmetrically dominated decoy is added to the choice set) has been replicated across different domains and even organisms. Few, if any, of the numerous studies of the ADE have investigated individual differences. This study analyzes the distribution of the effect sizes of this behavioral phenomenon and uses process data to determine what characterizes those choosers most susceptible to the ADE.

Methods: 86 adults participated in 1 of 4 similar experiments, which examined the ADE within-subjects. In all experiments, subjects made at least 150 choices between a smaller, immediate amount of money and one or more larger, delayed amounts. A subset of these choices showed the same pair of rewards either in isolation or with an asymmetrically dominated decoy, stochastically dominated by the delayed reward. The two-option choices were tailored to each subject so that they would be close to indifference between the immediate option and the delayed option, given their estimated discount rate. 38 subjects participated in a behavioral version of the experiment and 47 subjects participated in an eye-tracking version.

Results: The addition of the decoy led to an increase in the percentage of patient choices (decoy = 52.7% ±3.2%; two-option= 48.1% ±3.1%; $t(82) = 5.24$, $p < 0.001$). However, this analysis hides a non-uniform distribution of effect sizes. A Gaussian Mixture model of the effect sizes reveals two distinct groups, one that showed the effect (N = 26; mean = 14.2% ±5.7%) and one that did not (N = 57; mean = 0.2% ±4.2%). When comparing the two groups, we found that subjects who exhibited the ADE were closer to indifference (i.e., 50% patient choices) in the two-option trials and had longer reaction times for all choices. These subjects also had a higher percentage of alternative-based eye movement transitions (i.e., comparing attributes within an option) and a lower percentage of attribute-based eye movement transitions (i.e., comparing the same attribute in different options).

Conclusions: We demonstrate that the ADE has a bimodal distribution across subjects, with only a minority of subjects exhibiting the effect. Our data contradict hypotheses that this effect results from heuristic decision strategies, as those that exhibit the effect take longer to decide and scan options in an alternative-based manner. We find no evidence for a shift in how different attributes are weighted; instead, our results better support that the existence of a dominance relation per se provides a boost to the value of the dominating option.

Neural and behavioral correlates of matching outcomes and expectations in altruistic and reciprocal behaviors.

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Objective: Economic games, such as the classical "Investment game" (Berg et al, 1995), have shown that humans show altruistics and reciprocal behaviors, unlike those expected of a "*Homo economicus*", who only acts in self-interest. Nevertheless, in such games it is unclear how much of a trustee's behavior responds to altruism vs. reciprocity. In addition, the influence of the trustees' expectations on the trustee's behavior, and its neuroelectrical correlates, remains unexplored.

Methods: Twenty adult Italian and thirty adult Chilean subjects participated as trustees in the study, which used a modified version of the Investment game (Cox, 2000). In our version of the game, trustees randomly faced trials in which either (simulated) trustors decided how much money to invest or, alternatively, a computer split the total amount between trustors and trustees. In both cases, trustees were asked to report how much money they expected to receive and to send any amount back. Trustees' neuroelectrical activity was recorded by electroencephalogram during the temporal window when they received the feedback about the amount send by the trustors or the computer. Event-related potentials were computed.

Results: Our results show that (i) subjects do not behave as the self-interest hypothesis predicts, (ii) the trustees display altruism (or inequity-aversion) and reciprocity, (iii) matching outcomes with expectations predicts changes in expectations and allocations and (v) feedback-related negativity seems to be associated with the process of matching outcomes with expectations.

Conclusions: These results suggest that reciprocal behavior is more than "pure" altruism, and that matching outcomes with expectations influences trustee decisions in human exchanges.

The neural link of prosocial behavior and happiness

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Objective: Despite recent efforts to investigate the neurobiology of prosocial behavior, surprisingly little is known about 1) whether and how generous behavior can be enhanced, 2) how this relates to happiness and 3) whether there is a neural link connecting generous behavior and happiness. Here, we study these questions with the help of human neuroimaging.

Methods: Participants were told that they would receive money sent home in the following four weeks. Half of the participants made a commitment to spend this money for other people (Other group), while the remaining participants made a commitment to spend the money for themselves (Self group). Subsequently, subjects underwent an independent decision-making task while blood-oxygen-level-dependent (BOLD) responses were measured using functional magnetic resonance imaging. Here, subjects could accept or reject options that involved varying monetary costs for themselves and varying monetary benefits for another person. To track the changes in happiness, we assessed happiness upon arrival of the subjects and at the very end of the procedure.

Results: Analysis of the behavioral data revealed that the subjects in the Other group showed significantly more generous behavior than subjects in the Self group. Furthermore, the subjects in the Other group reported a greater increase in happiness compared to the Self group. On the neural level, modulation in functional connectivity between temporo-parietal junction (TPJ) and striatum predicted commitment-induced generous behavior. Strikingly, the BOLD response in the very same striatal region showed group-dependent modulation as a function of happiness change.

Conclusion: Our data demonstrate that simple commitment to be prosocial can promote generosity, which in turn increases happiness. Importantly, we show that this effect is underpinned by a neural link, which is the TPJ and the striatum.

Neural Correlates of Third-Party Help and Punishment: An fMRI Investigation

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Objective: Social norms are a cornerstone of human society. In order to maintain this norm system two enforcement mechanisms are possible: we can either help the victim or punish the violator when social norms are violated (e.g. fairness norm). A recent behavioral study found that third-party help and punishment decisions can be modulated by empathy. However, the neural underpinnings of third-party help and punishment and how trait empathy is involved in these processes still remain unclear. In the present study we used fMRI to address these questions.

Methods: Eighty-four participants were in the role of the first and second parties in a dictator game and thirty-six participants were tested as third parties in the scanner. While lying in the scanner participants saw transgression from the first party (i.e. unfair allocations in the Dictator Game) and could decide to either punish the violator (i.e. the first party) or help the victim (i.e. the second party). In a control condition these decisions were made by the computer. Empathy was measured using the Interpersonal Reactivity Index (IRI) scale after scanning. fMRI data were analyzed via a general linear model to investigate brain regions activated by helping and punishing. Additionally, psycho-physiological interaction (PPI) analyses were used to test whether different networks are involved in helping and punishing.

Results: Both helping the victim and punishing the violator elicited similar activity in reward-related brain regions (i.e. bilateral ventral striatum). The contrast between help and punish yielded no significant activation. Moreover, IRI scores positively correlated with activation in the lateral prefrontal cortex (LPFC) as well as in the anterior cingulate cortex (ACC) for the contrast between help and punish. The PPI analysis further showed that empathy scores positively correlated with the functional connectivity between bilateral striatum and right LPFC when people decided to help (vs. control).

Conclusions: These results suggest that the mechanism underlying third-party help and punishment are similar, both accompanied by activity in reward related areas and that high empathic people recruit different brain areas compared to low empathic people in order to help or punish. These results provide evidence for understanding the neural basis of social norm enforcement and its between-subject variability.

Budget constraints affect rats' preferences for differently priced liquid reinforcers in a two alternative forced choice decision making task

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Objective: 1) To determine if changing budget size systematically affects choice patterns in rat consumers, independently of price changes. 2) to evaluate the stability of preferences as a function of choices made.

Methods: Eight adult male Long-Evans rats were tested in daily choice sessions conducted in an operant box. The rats made a series of choices between chocolate- and vanilla-flavored soymilk by spending a budget of nosepokes as work effort to obtain these rewards. Each rat went through four experimental phases (each lasting 10 sessions) with prices adjusted up or down for chocolate and vanilla, respectively, once under uncompensated budgets and once in a phase were the budgets were adjusted so that the bundle chosen under the immediately preceding baseline phase could have been reselected under the new price regime. Demand elasticity was calculated for both commodities separately for compensated and original budget conditions. To test whether budget size affected the rats' choice distributions, we compared the time-resolved evolution of preferences for both commodities across conditions with similar prices, but different budgets.

Results: All rats preferred chocolate- over vanilla-flavored soymilk. Increasing the price of chocolate reduced this preference, more so in uncompensated as compared to compensated budget conditions. We found that demand for chocolate soymilk was generally inelastic ($0 > e > -1$) and significantly less elastic than demand for vanilla. Crucially, demand for chocolate was less elastic under compensated than under uncompensated budgets. When we compared time-resolved preference estimates between budget conditions, using equal-length sets of trials, we found significantly higher preferences for chocolate in the budget-compensated condition. Importantly, this difference emerged before the budget would have run out.

Conclusions: Our results indicate that compensating budgets reduces rats' sensitivity to price changes as indexed by a reduction in demand elasticity. Furthermore, we show that rats' preferences are dynamically sensitive to budget conditions. The results were approximated well by choice models in demand theory, but contradict predictions generated from Matching Law that presume equal choice distributions for conditions with equal prices.

Abstract

Lie in a spontaneous way-An fMRI study

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Objective: Most previous fMRI studies about deception suffer from the problem of "instructed lies", which makes their relation to actual lying behavior questionable. The current study investigates 1) the neural substrates of spontaneous lying and truth-telling, and 2) differences between instructed and spontaneous lying behavior.

Method: Forty-two male subjects were recruited. During fMRI scanning, they were asked to play a gambling game in which they first guessed a dice number and then indicated whether their guess was correct after they saw the real result. In the spontaneous session, subjects were allowed to make their decisions all by themselves and were able to win more money by lying. In the instructed session, subjects were asked to report their betting results correctly or incorrectly according to the respective instructions in the trial.
Based on their behavior in the spontaneous session, subjects were divided into honest, partially dishonest and dishonest groups.

Results: In the partially dishonest group, the ventral anterior cingulate cortex showed stronger activation in the spontaneous lie condition compared to the truth conditions. The opposite contrast revealed stronger activity in the right dorso- and ventrolateral prefrontal cortex and the inferior parietal lobule in trials where subject were tempted to lie. When comparing instructed and spontaneous lying, higher activity in the left middle frontal gyrus was observed in the instructed lying condition, which showed no difference among the spontaneous conditions.

Conclusion: Our results show differences in the cognitive processes of spontaneous lying compared to truth-telling. These suggest that while the former may be more related to emotion regulation, the latter may more strongly involve cognitive control. Furthermore we show differential mechanism underlying spontaneous vs. instructed lying. These results provide insights for further studies on deception.

Neuroeconomics and revealed-preference theory as synergistic cornerstones in economics: Linking neural and choice data may enable a novel self-regulatory policy for preventing asset-price bubbles

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Asset-price bubbles challenge the explanatory and predictive power of standard economic theory, so neuroeconomic measures should be assessed for a capacity to improve the predictive power of the standard approach. This assessment <u>objective</u> is achieved by <u>reviewing results</u> from functional magnetic resonance imaging (fMRI) studies of lab asset-price bubbles and herding behavior (i.e., following others' decisions). In subjects exposed to replayed visual displays of lab-market bubbles, activations were found in the medial prefrontal cortex (mPFC), an area implicated in theory-of-mind mechanisms, possibly reflecting subjects' attempts to sense peers' intentions (De Martino et al., 2013). Another study showed displays based on historical records of Lehman Brothers stock prices (Ogawa et al., 2014). Exposure to the Lehman Brothers bubble activated subjects' inferior parietal lobule (IPL) and increased functional connectivity between dorsolateral PFC and IPL, possibly suggesting a future-oriented mental focus during the bubble. These lab market studies may have limited external validity: fast-growing lab bubbles differ temporally from long-lasting real-world bubbles (e.g., the housing- and stock-market bubbles that rose and crashed during 2000-2008). Herding may be hypothesized to occur during these prolonged real-world bubbles, in which case fMRI evidence for the involvement of evolutionarily ancient brain areas (e.g., nucleus accumbens, amygdala, hippocampus) in various forms of herding, including that related to financial decision-making (Burke et al., 2010; Edelson et al., 2011; Zaki et al., 2011), could be informative for predicting bubbles. Crucially, the same choice (e.g., buying a stock) could be generated by herding-related neurocircuitry during bubbles, or by deliberative neocortical circuitry during non-bubble periods. Using functional near-infrared spectroscopy headband technology (Hofmann et al., 2014), it may be possible to identify herding behavior and thus predict bubbles. We propose a field-experimental research program to test this hypothesis, as well as non-intrusive interventions to prevent or mitigate bubbles that could be implemented without government involvement. For example, traders could monitor an open-access aggregated data stream of processed brain activity, collected from consenting traders, for real-time signs of over-heated markets, enabling them to exit these markets and thereby prevent major bubbles voluntarily. In <u>conclusion</u>, a synergism between neuroeconomics and the standard economic approach may be useful for distinguishing bubble and non-bubble periods and intervening in bubbles.

Investigation of the behavioural and neural correlates of the gambler's fallacy

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Objective: Gambling is associated with cognitive distortions in sequential decision-making, including the gambler's fallacy (the belief that an outcome is more likely after a run the other outcome), and the hot hand belief (the belief that a run of successes will continue). We investigated distortions in both outcome runs (red/black) and feedback streaks (win/loss) within the same task using a simplified roulette game and functional magnetic resonance imaging (fMRI).

Methods: We present the data from 36 adults (12 male, mean age = 25.75 years) who took part in our behavioural study, and 17 adults (7 male, mean age = 27.65 years) who took part in our fMRI study. On each trial, participants predicted the colour of a red/black roulette spin, and placed a large or small bet as an index of confidence. We used logistic regression to analyse the behavioural data, allowing the simultaneous inclusion of both colour run length and feedback streak length predictors. We constructed models to predict colour choice (same as or different from previous outcome) and bet size. The fMRI data were analyzed with a general linear model of 2 (preceding choice) by 2 (current feedback) by 2 (next choice) to investigate the same predictors.

Results: In the behavioural study, participants were less likely to choose the same colour as the last outcome as run length increases (β (SE) = *-0.23 (0.03), p < .001*) in line with the gambler's fallacy. They were less likely to choose the same after a loss (β (SE) = *-0.54 (0.10), p < .001*), and the gambler's fallacy was steeper after losses (Run Length x Previous Feedback interaction: β (SE) = *-0.29 (0.05), p < .001*). In the neuroimaging study, outcome-related activity was modulated by current feedback (win>loss activity in the bilateral ventral striatum and medial prefrontal cortex) and next choice (choice same>different activity in the medial prefrontal cortex and posterior cingulate cortex). In the striatum, a current feedback by next choice interaction was driven by a relative decrease in activity during a loss as participants prepared to commit the gambler's fallacy.

Conclusions: Here we have characterised multiple sequential influences on choice behaviour, using a simple binary choice task with random outcomes. Our initial fMRI results show that activity at outcome during such a binary task is modulated by the preceding context, and that this activity is also modulated by the choice that the participant will make on the next trial. The regions involved include pre-frontal and limbic structures often implicated in decision-making and reward processes.

2300 not spaces

The neural underpinnings of information cascade

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Objective: Herding effect refers to the phenomenon that individuals are more likely to follow the public decisions and ignore their private information when they are under an uncertain situation. According to economic theories, this type of information cascade is affected by the individuals' beliefs via a Bayesian approach. However, there is no neural evidence for these theories. In the current study, we constructed Bayesian and reinforcement learning models to simulate different belief updating strategies. We aim to answer the question of how individuals update their beliefs when they observe other people's decisions in sequence, and how this belief can be implemented neutrally to guide their own decisions.

Methods: Fifteen healthy, adult participants were recruited in this experiment. We adopted a simple "ball-and-urn" game design where there are two urns, one is "red" urn (two red balls and one blue) and the other is "blue" (two blue balls and one red). At the beginning of each trial, one of the two urns will be randomly selected to present to the participants. Subjects were asked to draw a sample from the urn in combination with the observation of other people's decisions on the same urn. Each participant made decisions about the urn color as 1st player, 2nd player or 3rd player. We manipulated other people's decisions (observation) and the color of the ball (private information) such that observations and subject's private information can be congruent or incongruent and this allows us to test how subjects weigh and integrate information from different sources.

Results: Consistent with previous studies, we found that the percentage of trials where participants' decisions did not follow their private information is significant lager in incongruent condition than in congruent condition (as 2nd and 3rd player), as well as the baseline condition (1st player) where participant's only information is his/her own ball color. In addition, model fitting to the behavioral data suggests that Bayesian model is superior to account for subjects' decisions.

Conclusions: These behavioral results tend to suggest that individuals' decisions are guided by weighting different sources of evidence in a Bayesian way rather than simply assigning different but fixed weight to observation and private information.

Neural Valuation of Environmental Resources

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Objectives: Valuation of environmental resources on economic benefit alone fails to capture much of the value that individuals place in them. In an effort to capture nonmarket factors in the valuation process, environmental economists have employed a number of willingness to pay survey methods. However, the accuracy of the survey value estimates has been thoroughly debated, as these estimates might also be colored by situational and attitudinal factors (such as the affective reactions to destructive land uses). We used a novel incentive-compatible task during functional magnetic resonance imaging (FMRI) acquisition to explore affective reactions during the valuation of environmental resources.

Methods: We specifically assessed neural activity during presentation of natural resources (i.e., iconic versus noniconic national parks), proposed land uses (i.e., conservative versus destructive), and varying amounts of requested donations, before subjects decided whether to donate from their endowment to preserve the depicted natural resources.

Results: In both behavioral and neuroimaging studies, subjects' choices to donate depended more on the destructiveness of proposed uses than the iconic (or archetypal) nature of the parks themselves. Consistent with an anticipatory affect account of decision-making, nucleus accumbens (NAcc) activity increased in response to more "iconic" or archetypal landscapes, while anterior insula activity increased in response to destructive proposed uses, and the combination of these considerations elicited activity in the medial prefrontal cortex (MPFC). Anterior insula activity also predicted increased donations to preserve parks threatened with destructive uses, while MPFC activity instead predicted decreased donations. Finally, individuals with pro-environmental attitudes showed the strongest anterior insula activation in response to proposed destructive park uses.

Conclusions: These collected findings suggest that anterior insula responses to destructive uses may play a more prominent role in environmental valuation than typically assumed in traditional survey methods. The results raise the possibility that neuroimaging methods might eventually complement more traditional methods of assessing the multiple factors that drive environmental valuation.

Expectations in the Ultimatum Game

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Introduction: Being treated fairly by others is an important social need. Experimentally, fairness can be studied using the Ultimatum Game in which the decision to reject a low, but non-zero, offer is seen as a way to punish the other player for an unacceptable division. The canonical explanation of such behavior is inequity aversion: people prefer equal outcomes over personal gains. However, there is abundant evidence that the decision to reject a low offer can be changed by both contextual factors and emotional state, which cannot be satisfactorily explained by the inequity aversion model. A recent alternative explanation proposes that the main driving force behind the decision to reject is that of deviation from expectations: the larger the difference between the actual offer and the expected offer, the more likely one is to reject the offer. We tested and extended this idea by providing participants with explicit information on what kind of offers to expect. Crucially, we independently manipulated both the mean and the variance of expected offers.

Methods: Each participant played as the responder in the Ultimatum Game and made a series of decisions to either accept or reject monetary offers. Participants were provided with information as to what kind of offers to expect in form of histograms, indicating what the current group of partners supposedly offered in a previous experiment. The critical manipulation was of both the mean and the variance of the histograms. Behavioral data were analyzed using a logistic mixed-model analysis. In addition, we fitted and compared different utility models, and participants underwent scanning using fMRI.

Results: As expected, we found that the decision to accept or reject a certain offer was dependent on the information provided. Importantly, we find that the mean and variance of expected offers differentially effected this decision. Specifically, changing the mean expected offer shifts the threshold for acceptance. In contrast, changing the variance alters how strictly this threshold is adhered to. A model comparison showed that the expectation model outperforms the inequity aversion model.

Conclusions: These results demonstrate the complex nature of social expectations, which might be better conceptualized as distributions instead of simple mean expected values, and how they influence considerations of fairness. Follow-up work is examining the neural bases of these expectations.

Do stake sizes matter in the Ultimatum Game? : An fMRI study

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Previous behavioral studies have shown contradicting results of the effects of stake sizes on proposing behavior in the Ultimatum Game. While Camerer (2003) suggests that proposers' behaviors do not alter with stake size, Anderson and colleagues (2011) found that proposing behaviors change when participants are explicitly instructed that the best strategy for responders is to accept any offer that is more than zero. However, the mechanism that underlies proposing behaviors remains unclear. When stakes rise in the ultimatum game, proposers face a risk-return tradeoff, in which making a lower offer increases the proposers' potential monetary gain but also increases the risk of rejection. A hypothesis is that proposing behaviors display two offsetting effects. That is, when stakes are higher, proposers want to keep a higher share of the offer yet know that proposing unfair offers risks the offers being rejected. Therefore, the two offsetting effects could represent the conflict that proposers may have when the stakes are high. For this reason, we investigated whether the response time and the neural activity during proposing behaviors on high stake trials could reveal the conflict that proposers may face. We recruited 45 participants to propose how to split the money with responders that varied in different stake sizes (NT$200 vs. NT$2000) and share sizes (giving 10%, 20%, 30%, or 40% of the money to the responder) in a binary choice task with fair and unfair offer while inside the MRI scanner. We found that these proposers usually made "fair" offers to the responders that were independent of the stake size. However, proposers' response times were longer as the stakes increased. In such cases, greater cortical activations were found in their anterior and posterior cingulate cortices (ACC and PCC), precunei, and medial frontal gyri. Moreover, the proposers had longer response times when choosing the fair offers in trials in which the unfair offers allotted higher shares to the responders. In such situations, proposers demonstrated greater activity in their ACC, supporting its role in high conflict situations (Botvinick et al., 1999). In sum, the effect of stake sizes on proposing behaviors was not observed when only choice behaviors are considered. However, the longer response times and pattern of neural activation in high stakes trials suggests that larger stake sizes produce greater conflict for proposers in the Ultimatum Game due to offsetting effects.

Gambling-related beliefs predict leave time in a Foraging Task

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Objective: Foraging behavior is an essential survival mechanism common to all organisms that search for food in environments with unevenly distributed resources. Optimal foraging theory is based on the hypothesis that animals search for rewards (i.e., food) in a way that maximizes rewards and minimizes costs, and experiments across species have shown that animals obey these predictions. However, little is known regarding how foraging theory relates to human decision making. Here, we investigated the usefulness of the marginal value theorem to explore the relationship between foraging decisions and gambling-related beliefs. Our "Foraging Task" measured the decision to stay in a depleting patch or leave for a richer one. Leaving the current patch resulted in an immediate travel-time delay of 5, 10, or 20 seconds. This task has not been previously used in psychiatric research, but foraging behavior may be relevant to problem gambling and impulsive decision making since task performance depends on sensitivity to rewards and delays. We hypothesized there would be a positive relationship between gambling-related beliefs and Foraging Task performance.

Methods: Participants with a range of gambling frequencies completed the Gambling-related Cognitions Scale (GRCS) and the Foraging Task. Higher scores on the GRCS represent more cognitive distortions, and positive and negative scores on the Foraging Task represent leaving the current patch later or earlier than optimal, respectively. Other questionnaires and tasks were also administered for comparison, including: the Barratt Impulsivity Scale, the Delay Aversion Questionnaire, the gambling-related subscale of the Risk Attitude Scale, the Balloon Analogue Risk Task, and the Loss Aversion Task. The primary variables of interest from the questionnaires and tasks were entered into a bivariate Pearson correlation analysis.

Results: We had anticipated questionnaire scores to positive correlate with the Foraging Task and the BART, and to negatively correlate with Loss Aversion. Unexpectedly, the analysis revealed a negative correlation between GRCS score and Foraging decisions (r = -.59, p < .001, n = 34). There were no other significant correlations between questionnaire scores and performance variables.

Conclusions: These results suggest that individuals who are characterized by stronger gambling-related cognitive distortions and positive expectations of winning leave a foraging patch early. Importantly, these data demonstrate that foraging models may be relevant to human reward-seeking behaviors, and could provide a new framework for understanding problem gambling.

Are consumers willing to pay more for happy hens?
Brain activations and behavioral choices after informational influence

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Objective: In 2008, California passed a proposition specifying confinement space for certain farm animals. Proposition (Prop) 2 is set to go into full effect January 2015 and has significant implications for egg production in California and possibly even interstate commerce. We examined the influence of promotional videos aired during the campaign on consumers' willingness-to-pay for eggs produced in a more open production system (cage-free, free range) and corresponding neurofunctional activations during decisions.

Methods: Forty-six participants (24 females), aged 18 to 55 years ($M = 29.65$ years; $SD = 9.49$ years), were enrolled and performed a food decision-making task during fMRI scanning. In each decision, two options of identical one-dozen cartons of eggs were presented simultaneously. Below each option were two attributes, one describing price, and one production method. Cage free and free-range eggs were more expensive, at varying degrees. Participants were randomized to one of three 30-second video groups: Pro Prop 2, Anti-Prop 2, and a Neutral babbling brook. Neurofunctional activity was measured as percent BOLD signal change between conditions. Functional MRI data were analyzed in Brain Voyager QX 2.4, using random effects, $p_{corrected} < .01$, with a cluster threshold of 14 voxels, as determined by Monte Carlo simulation.

Results: Choices did not significantly differ Pre- to Post-Video for the Anti-Proposition 2 video group or the Neutral video group. However, consumers who viewed the Pro-Prop 2 video significantly increased the proportion of decisions for the cage-free/free-range higher priced option [50% to 61% (t=2.66, p = 0.02)]. Based on a whole brain analysis, participants in the Pro-Prop 2 Video group (N = 16) demonstrated significantly greater activations post-video compared to pre-video in left insular cortex (-37, -2, -6) and right occipital cortex (8, -92, 6).

Discussion: Consumers who viewed the Pro-Proposition 2 video were more likely to be willing to pay a premium for cage free and free-range eggs. A corresponding increase in insula activity was seen with their change in behavioral choices post-video. Insular activation is implicated in increased negative affect. The Pro Prop 2 video included disturbing images of poorly treated farm animals, and this may have increased negative affect in consumers. Based on the outcome of the 2008 proposition, the Pro Prop 2 videos were effective in changing consumer opinion.

Automatic versus choice-dependent value representations in the human brain

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Objective: Recent theories of value-based decision making (VDM) propose a unified brain valuation system that represents subjective values (SV) both when these are choice-relevant and choice-irrelevant in non-VDM tasks (Lebreton et al 2009). Recent meta-analyses (Bartra et al 2013; Clithero & Rangel 2013) suggest that this system comprises the medial prefrontal cortex (mPFC), the posterior cingulate cortex (PCC) and the ventral striatum (VS); however, it is largely unknown whether the value representations in these different regions are redundant or rather play distinct functional roles. Here we dissociate two types of value representations in this network in terms of their functional response profile and involvement in value-based choice accuracy versus value-based attentional capture.

Methods: Twenty-six healthy participants underwent fMRI while alternating between blocks of purchasing (SV choice-relevant) or perceptual (SV choice-irrelevant) decisions. Both choice types were matched for visual stimulation, motor responses, and reaction times (RTs). The SV of each movie was quantified by willingness-to-pay ratings prior to fMRI. Regression analyses of accuracy data confirmed that SVs were indeed choice-relevant for purchasing decisions ($P = 0.0032$) and choice-irrelevant for perceptual decisions ($P = 0.77$). Value-based attentional capture was confirmed by a significant effect of choice-irrelevant SV on RT slowing during perceptual choices ($P = 0.0008$).

Results: The fMRI data revealed a clear functional dissociation between SV representations in the valuation system. The PCC was the only region that represented SV in both contexts (choice-relevant or choice-irrelevant). In contrast, mPFC and the VS only represented SV when it was choice-relevant and showed significantly higher correlations with choice-relevant as compared to choice-irrelevant SV representations, suggesting a value-gain mechanism. Crucially, the choice-relevant SV responses for both mPFC and VS related significantly to the accuracy of purchasing decisions, whereas the choice-irrelevant SV responses in PCC predicted the degree of value-based attentional capture during perceptual choices.

Conclusions: Our results demonstrate that distinct components of the brain's valuation system encode SV in context-dependent manners that serve different behavioral aims. SV representations in mPFC and VS are modulated by a gain-control mechanism to increase value-based choice accuracy, whereas SV representations in PCC are also present when SV is task-irrelevant to enable automatic value-driven attentional capture.

Neural dynamics of decision-making in a financial trading task

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Objective: Although economic models of decision-making often assume that choice behavior is rational, deviations from optimality have been repeatedly documented in financial trading. One of the most robust departures is the "disposition effect": individuals have a greater propensity to sell assets that have gone up in value, rather than down, since the time of purchase. Recent neuroimaging data suggests that this behavior is associated with differential activity in ventromedial prefrontal cortex (vmPFC) for the realization of capital gains (price – cost) compared to paper gains. However, less is known about when these responses emerge during decision-making, and how individuals overcome these biases to implement appropriate trading actions.

Methods: Using event-related potentials (ERP), we measured subjects' brain activity while they traded in an experimental stock market to obtain real monetary outcomes. On each trial, subjects were informed of the original cost and current price of one of three stocks (A, B, and C), and then made a decision whether to buy or sell that or another stock. The disposition effect was defined as the proportion of gains realized minus the proportion of losses realized across the course of the experiment; a positive number indicates a greater tendency to sell winning stocks. For each stock, optimality of choice on a given trial was defined mathematically based on the stock's expected return and the participant's decision to hold or sell.

Results: As predicted, the average disposition effect was significantly positive, despite the fact that this was financially suboptimal behavior. ERP signals correlated with capital gain were visible across the time course of the trial from as early as 150 ms after the onset of the decision screen, with highly significant activity emerging from approximately 400-650 ms. In line with previous data, this neural capital gain response was localized to regions including vmPFC, and its magnitude was significantly correlated with the propensity to sell winning stocks. In contrast, neural correlates of optimal choice occurred from 100-150 ms after stimulus onset over central and parietal sensors, and were localized to regions including anterior cingulate cortex (ACC).

Conclusions: These data illustrate how the temporal resolution of ERP can provide insight into the cognitive correlates of financial behavior. Consistent with prior neuroimaging data, our results support the role of neural value signals in the disposition effect, and further suggest the importance of cognitive monitoring to overcoming this bias.

Evidence of Suboptimal Inference as a Source of Choice Behavior Variability

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Objective: Choice behavior can be inconsistent, varying from trial to trial even with near-identical stimuli[1]. Often, inconsistent trials in experimental studies are rejected/excluded[2]. Variability is commonly attributed to errors caused by internal noise (i.e. noise in the nervous system[3]). A recent paper[4] proposed an alternative theory that variability could also arise from suboptimal inference rather than noise. It is, however, difficult to attribute the exact source of variability due to confounding. We designed two complementary tasks in an attempt to isolate the sources.

Methods: During each trial in Task 1 (i.e. No Spin), a subject was presented with two roulette wheels where a fraction of each wheel is colored orange. The subject was asked to choose the wheel that has the larger proportion of orange. Making the correct choice won a monetary prize. In Task 2 (i.e. Spin), a subject was presented with the same pair of wheels and was asked to choose the wheel that has the larger chance of winning. After choosing, the wheels were spun and the subject won a monetary prize if the chosen wheel stopped in the orange. A staircase procedure was used to vary one wheel while the other acted as the test condition. There were 20 test conditions, uniformly distributed between [0.025,0.975] with 30 trials per condition. 20 naïve subjects performed both tasks.

Results: We compared the total number of wise (i.e. correct) choices made by each subject for both tasks. While the total number of wise choices differs across subjects, all subjects made more wise choices in the No Spin task than the Spin task. The former has a median of 489/600 while the latter's median is markedly lower at 444/600.

Conclusions: Both tasks have the same optimal solution (i.e. the wheel with more orange). The No Spin task established a baseline for internal noise error while the Spin task measured the incremental error arising from suboptimal inference. The substantial difference in the results of both tasks supports the theory that suboptimal inference is a source of behavioral variability.
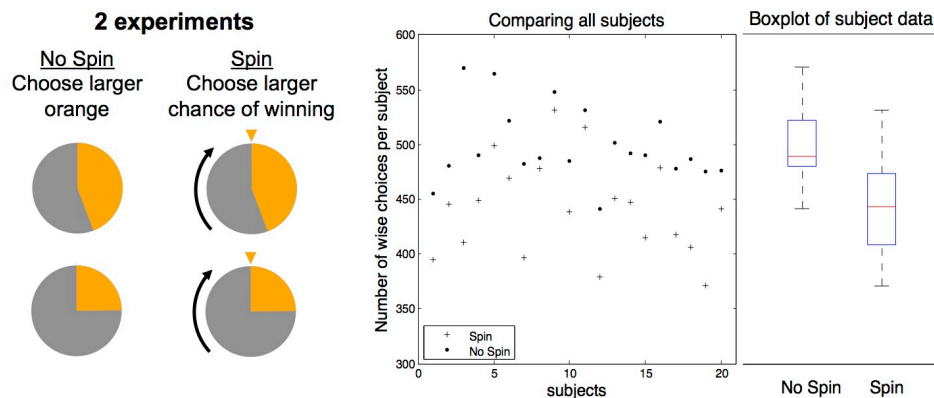
[1] Tversky, A. (1969). Intransitivity of preferences. *Psychological Review, 76*(1), 31-48.

[2] Tversky, A., & Kahneman, D. (1992). Advances in prospect theory: cumulative representation of uncertainty. *Journal of Risk and Uncertainty, 5*, 297-323.

[3] Faisal, A. A., Selen, L. P., & Wolpert, D. M. (2008). Noise in the nervous system, *Nature Reviews Neuroscience, 9,* 292-303.

[4] Beck, J. M., Ma, W. J., Pitkow, X., Latham, P. E., & Pouget, A. (2012). Not noisy, just wrong: the role of suboptimal inference in behavioral variability. *Neuron, 74*(1), 30-39.

Ethics or empathy? Different appraisals activate distinct social cognitive brain regions during altruistic choice

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OBJECTIVE: Generosity (the willingness to sacrifice one's own resources in order to benefit others) is an important aspect of human social behavior. Yet its computational underpinnings remain poorly understood. How does the brain integrate competing concerns when making tradeoffs between outcomes for oneself and others? Do people act generously because they care about conforming to social norms that promote generosity (i.e. ethics), because they think about others' feelings (i.e. empathy), or both? How does the brain represent these different considerations during altruistic choices?

METHODS: We used fMRI to scan participants as they completed a modified version of the Dictator Game, making choices about different tradeoffs between monetary payoffs for the self and an anonymous partner. We analyzed the commonalities and differences in patterns of neural response as participants made choices under three different instructional conditions: 1) respond naturally, 2) consider the right thing to do (i.e. ethics), and 3) consider the partner's feelings (i.e. empathy).

RESULTS: Behaviorally, focusing on ethical and empathic reasons for choice both increased generosity, with empathy instructions inducing significantly greater generosity overall and reducing the amount of time participants took to choose generously. Neurally, reduced activation in regions associated with conflict and self-control suggested that instructions to focus on ethics or empathy made generous choices easier. However, neural responses during the ethics condition more closely resembled natural response than did responses during the empathy condition. Focusing on empathy increased activation overall in the temporoparietal junction (TPJ) and altered correlates of choice.

CONCLUSIONS: These findings suggest that altruistic behavior may result from a variety of different motives, supported by different social-cognitive brain regions. We observed comparatively subtle differences in neural response between the natural and ethics-focused conditions, combined with the more striking changes during empathy-focused choice. This suggests that uninstructed generosity during anonymous interactions may result more from ethical considerations of one's own actions than empathic consideration of others' feelings. However, they also suggest that empathic considerations may more effectively increase generosity.

Depression distorts valuation responses in anterior insula and caudate nucleus

Jan B. Engelmann, Gregory S. Bern, Boadie W. Dunlop

Objective: Distortions in decision-making are common among patients with major depressive disorder (MDD) and can lead to substantial negative life consequences. Little is known about how the neural computations underlying valuation of potential gains and losses are altered in patients with MDD compared to healthy control (HC) subjects. A component of decision-making with particular clinical significance for MDD patients is loss aversion, which is the tendency to overweight potential losses relative to similar-sized potential gains.

Methods: We combined fMRI with a choice task involving mixed gambles designed to assess behavioral and neural loss aversion in 21 MDD and 25 HC subjects. We conducted region-of-interest (ROI) analyses within brain areas known to be involved in valuation, including the caudate nucleus, anterior insula, and ventromedial prefrontal cortex. For each ROI, neural loss aversion was calculated by contrasting the slope for gains (parametric correlation between BOLD amplitude and gain amount) to that for losses (parametric correlation between BOLD amplitude and loss amount).

Results: Behavioral and neural results conjointly indicated that MDD subjects' choice appraisals were driven primarily by potential losses. Specifically: (1) choice latencies among HC subjects were slower with increasing stake sizes in the domain of *both* gains and losses, while MDD subjects exhibited slower choice latencies with increasing stakes only in the loss domain, but not in the gain domain; (2) ROI analyses investigating neural loss aversion in caudate nucleus and anterior insula indicated significantly greater positive slopes for gains relative to losses (gain > loss) in HC subjects, while choice-relevant brain signals showed significant reversals (loss > gain) in MDD subjects; and (3) trial-by-trial regression analyses investigating whether neural activity in our ROIs predicted decision-making demonstrated a link between choice-related signals in the caudate nucleus and decisions in HC subjects, which was completely absent in MDD subjects.

Conclusion: Taken together, our results indicate that MDD patients show an abnormal focus on losses during value-based decision-making, both behaviorally and neurally. This suggests that MDD patients are impaired in their ability to integrate potential gain and loss values. These results extend cognitive models of depression, which posit that depressed thinking is characterized by selective attention to and encoding of negative events, to the domain of economic decision-making.

Differential Neurofunctional Activity During Ethical, Food-Related Decision-Making

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Objective: We examined how consumers' ethical concern about a food's production method relates to how, neurofunctionally, they make decisions whether to purchase that food. We hypothesized ethical concern would correlate negatively with differential neurofunctional activity in dorsolateral prefrontal cortex (dlPFC) as participants made decisions concerning the food's production method, as opposed to its price.

Methods: Forty-six participants (24 females), aged 18 to 55 years (M = 29.65 years; SD = 9.49 years), were enrolled. After completing the Food Choice Questionnaire (FCQ), participants underwent two functional magnetic resonance imaging (fMRI) scans. During these, they performed a task in which they made 56 food-related decisions. In each decision, two options were presented, both one-dozen cartons of eggs. Below each option were two attributes, one describing price, and one production method. In each decision, either the prices differed (i.e., high or low, the "price" condition), or the production methods differed (i.e., caged or cage-free, the "method" condition), but not both. Ethical concern was measured as scores on the Ethical Concern subscale of the FCQ. Differential neurofunctional activity was measured as percent blood oxygenation level-dependent (BOLD) signal change between conditions.

Results: For 23 randomly selected participants, we conducted an exploratory whole-brain correlation between ethical concern and differential neurofunctional activity in the method > price contrast. Higher ethical concern correlated (p < .01, 14-voxel threshold) with lower differential neurofunctional activity in left dlPFC (-13, 61, 30). For the remaining 23 participants, we conducted a confirmatory region-of-interest (ROI) correlation between the same variables, using an 8-mm^3 volume to define an ROI in left dlPFC. Higher ethical concern again correlated (p < .05, 14-voxel threshold) with lower differential neurofunctional activity in left dlPFC.

Discussion: We observed significant negative correlations between ethical concern and differential neurofunctional activity in left dlPFC in the method > price contrast. This suggests consumers who report ethical concern as an important component of food-related decision-making may, when making such decisions, rely less upon neurofunctional activity in left dlPFC. Limitations include the use of only one food and the FCQ's failure to measure ethical concern regarding animal welfare specifically. Future studies may use additional foods, as well as a measure of animal welfare-related ethical concern.

Individual Differences in Discounting of Time, Probability, and Effort Across Monetary, Social, and Health Domains

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Objective: Some have suggested that a unitary value system in the brain might lead to high consistency of preferences across different types of discounting across domains. To investigate this we examined relations among temporal, physical effort, and probability discounting across monetary, social, and health domains.

Methods: Thirty-three healthy participants aged 22–80 completed nine runs of a hypothetical discounting task, which included three types of costs (time delays, probability, effort requirements) across three domains (monetary, social, health). For the time discounting tasks participants made choices between a smaller magnitude reward with a shorter time delay and a larger magnitude reward with a longer time delay. For the probability discounting tasks participants made choices between a smaller magnitude reward with a higher probability and a larger magnitude reward with a lower probability. For the effort discounting tasks participants made choices between a smaller magnitude reward with a lower level of physical effort required and a larger magnitude reward with a higher level of physical effort required. Within each of the tasks, we computed the percentage of choices in which the participant choose the lower cost reward (associated with shorter time delays, higher probability, or lower effort). Discounting parameters derived from computational models fit to the choice data (with hyperbolic functions for time, odds against, and effort) will also be computed. fMRI and PET data are also currently being collected.

Results: Time discounting was highly correlated across domains (money, social, health), all $r > .35$, all $p < .04$. The same was true for probability discounting, all $r > .46$, all $p < .007$, and effort discounting, all $r > .5$, all $p < .003$. However, there was very little consistency within each domain (monetary, social, health) for discounting of time, probability, and effort. For example, within the monetary domain, preferences for low effort options, high probability options, and short time delays were not correlated, all $|r| < .33$, $p > .06$.

Conclusions: We found evidence for consistency of preferences within each cost type across domains. Individuals with a preference for short time delays showed this preference for monetary, social, and physical health-related rewards. The same was true for discounting of probability and physical effort. However, we also found evidence for some level specificity of preferences. Individuals with strong preferences for short time delays for money did not necessarily also have strong preferences for higher probabilities or lower levels of effort to obtain money.

Using Reaction Times to Estimate Economic Preferences

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Objective: We often would like to collect individual preference data on a number of different dimensions, but are limited by the amount of time and attention from our subjects. To address this concern, a recent line of research has focused on dynamically optimized experimentation for more efficient estimation of economic preference parameters. However, these more efficient procedures have so far ignored a second aspect of subjects' choices, namely their reaction times (RT). Here we sought to demonstrate that RT data could be used to generate point predictions of preference parameters, based on only a single decision.

Methods: We carried out an experiment in which subjects performed a series of binary lottery choices. The options on each trial were selected by the Dynamically Optimized Sequential Experimentation (DOSE) procedure developed by Wang, Filiba and Camerer. The DOSE procedure combines Bayesian updating with the Kullback-Liebler information measure in order to select the most informative question to ask, conditional on a subject's previous choices. Here we used 30 trials of the DOSE procedure to precisely estimate each subject's loss-aversion parameter. Then separately, we used a simple drift-diffusion-like model to predict each subject's loss-aversion parameter from just his/her RT on the first trial.

Results: By using RT data, we were able to estimate the difference between a subject's indifference point, and the indifference point implied by the options presented on the first trial. Using several different model specifications, we find consistently strong correlations between the single-trial, RT-predicted parameters, and the "true" parameters from the full DOSE procedure.

Conclusions: Previously, all that could be learned from a single binary decision was whether a subject was above or below the median parameter value in the population. Here we've shown that, by using RT data from just their first decision, it is possible to produce fairly accurate point predictions of loss-aversion. The results lend additional support for evidence accumulation models of economic decision-making and suggest ways to further improve the estimation of economic preference parameters.

Asymmetric effects of favorable and unfavorable information on decision-making under ambiguity

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Objective: In ambiguous situations, individuals make decisions based on incomplete knowledge. While economic theory suggests that people weight all available information equally in estimating value, previous findings show the existence of both optimistic biases (e.g. motivated reasoning) as well as pessimistic ones (e.g. negativity bias). Thus we examine how incremental information that is favorable or unfavorable to a desired outcome influences valuation of an ambiguous financial prospect.

Methods: Across multiple studies, participants indicated willingness-to-pay (WTP) for gambles where a poker chip was randomly drawn from a bag of 100 red and blue chips. For each gamble, participants read the following: "This bag contains at least X red chips and at least Y blue chips." Red chips resulted in a monetary payout; blue chips had no payout. Thus X represented the amount of favorable information while Y represented the amount of unfavorable information, and both could be varied independently ($X=\{0, 25, 50\}$; $Y=\{0, 25, 50\}$), generating 9 possible rounds. The impact of information type on WTP was estimated by regression analyses.
   In a final incentive compatible experiment, participants saw an expanded range of X and Y values, yielding 100 rounds total. For each round, in addition to indicating their WTP for a ticket to play, they were asked to indicate their estimate of the likelihood that a red vs. a blue chip would win, and their subjective certainty in the accuracy of their estimate.

Results and Conclusions: We demonstrate a robust asymmetric influence of favorable over unfavorable information in determining value under ambiguity. In the domain of gains, regression analyses demonstrated that the absolute magnitude of the impact of unfavorable information on WTP was 13% of the impact of favorable information (test for equality of regression coefficients p<.01.) This bias held when individuals could choose the winning chip color, in the domain of losses (unfavorable absolute magnitude=33% of favorable, p<.01), and when real monetary incentives were used.
   In our final study, we find this bias towards favorable information is driven by the interaction of multiple mechanisms. Specifically, we show that favorable information increases both the estimated likelihood of a desired outcome, and certainty in that estimate. In turn, both likelihood and certainty increase valuation (WTP). Unfavorable information, however, decreases the estimated likelihood of a winning outcome, but also increases felt certainty about this estimate. Thus in ambiguous contexts, the impact of unfavorable information on WTP is minimized by these elements acting in opposition.

***Note to the committee** – we understand that this abstract does not contain neural data (yet). We have already acquired fMRI data for the task, but were unable to analyze it in time for the abstract deadline. The work was designed to build on the ambiguity research done by Hsu et al. 2005, Huettel et al. 2006 and Levy et al. 2010 among others, and we hope our behavioral results may be considered given their potential interest to this community.*

The Accuracy of Value-based Choices Depends Causally on Fronto-Parietal Gamma-Band Synchronization

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Objective: Humans and animals routinely use different sources of information to choose the best course of action. For instance, during perceptual decisions, organisms discriminate choice options based on objective states of the environment (e.g., watermelons are heavier than cherries), whereas during value-based decisions, organisms make choices based on subjective preferences (e.g., cherries are tastier than watermelons). A recent EEG study showed that evidence accumulation for both types of decisions correlated with gamma activity over parietal regions, whereas a similar signal over a fronto-polar region was unique for value-based choices. Crucially, fronto-parietal synchronization of these signals predicted the accuracy of value-based choice, but not of perceptual decisions. It is currently unknown whether this correlation indicates a casual relationship or a mere epiphenomenon.

Methods: We employed a behavioural paradigm where perceptual and value-based choices were based on identical stimuli and motor responses while human participants (n=27) underwent transcranial alternating current stimulation (tACS). We used a specific tACS protocol designed to modulate synchronization of brain activity in a topological- and frequency-specific manner. This protocol was employed here to exogenously decouple fronto-parietal gamma-band synchronization during perceptual or value-based choices, allowing us to test for causal effects of neural desynchronization on value-based choice precision.

Results: Compared to a sham condition, subjects made more incorrect decisions during the exogenously-induced fronto-parietal desynchronization with tACS ($P_{MCMC} < 0.02$). Importantly, this effect was specific to value-based choices, as perceptual decisions were not affected by the stimulation ($P_{MCMC} > 0.35$).

Conclusions: Our results provide evidence that value-based choice accuracy depends causally on fronto-parietal coupling of brain activity in the gamma-band. Crucially, this relationship is specific for value-based choices, as our tACS intervention did not affect perceptual choices based on the same stimuli. Our results suggest that pathological disruption of fronto-parietal synchronisation may result in inaccuracies of preference-based choices, as commonly observed in various clinical disorders (e.g., addiction, OCD, or obesity).

Socioeconomic Status and Learning from Financial Information

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Objective: Growing up in stressful environments, such as those characterized by poverty, has been shown to have significant effects on brain development and behavior later in life. We tested the hypothesis that individuals who come from low socioeconomic status (SES) environments are particularly sensitive to negative information regarding economic outcomes and will learn differently from the same information than individuals with more privileged backgrounds.

Methods: Two hundred and three adult subjects, ages 19-23, recruited at a top university in Romania, participated in the study. Participants performed an investment choice task *(1)* where they had to select during 96 trials one of two assets: a risky stock about which there was uncertainty whether or not it paid dividends from a good or a bad distribution, and a safe bond with known payoffs. Subjective beliefs regarding the quality of the stock were elicited in an incentive-compatible manner, and compared to objective Bayesian beliefs, to measure how well participants learned. Questionnaires were used to assess participants' SES, numeracy, financial literacy, and demographic characteristics.

Results: We find that the ability to form accurate beliefs regarding the payoff distributions of financial investments is worse among lower SES individuals, even after controlling for participants' financial literacy, numeracy, education, age, or gender. The beliefs of low SES individuals are overly pessimistic, relative to Bayesian beliefs, in contexts where payoffs are negative and stakes are bigger. These context effects on learning ability are not present among high SES participants. Furthermore, the improvement in learning ability over time is slower for low SES individuals.

Conclusions: Our results suggest that people's socioeconomic status shapes in predictable ways how they perceive and use information when making financial decisions. By modifying brain development and function, prior experiences can change future economic decisions and thus may have a significant influence on social mobility.

References:
1. C. M. Kuhnen, *Journal of Finance* (forthcoming).

Why be nice? Pro-social behavior in rats and its neural basis

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Abtract

Pro-social behavior is the tendency increase the well-being of other individuals. Complex pro-social behaviors, such as cooperation and altruism, are part of human daily interactions and are often essential to group achievements. Despite recent advances, however, it remains unclear whether rodents also show pro-social behavior. To address this issue, we trained rats in a Pro-social Choice Task (PCT) where animals had to decide between a selfish alternative, yielding a reward only to them, or a pro-social alternative, resulting in a reward for both them and a partner. We contrast the rats' behavior to their choices in a non-social control condition where the partner was replaced by an inanimate rat puppet while keeping reward contingencies identical. We find that rats had a higher propensity to make pro-social choices when paired with a real rat than with an inanimate partner. The tendency to make pro-social choices was modulated by the difference in weight between the actor and the partner.

To further explore the neural basis of pro-social behavior in rats, we performed lesions of the lateral orbitofrontal cortex (lOFC). We compared pre- *vs* post-lesion pro-social behavior to a sham control group performances. Preliminary data suggests that the lOFC might be necessary to discriminate between social and non-social contexts, but not for the execution of pro-social behavior per se.

Predictable optimism: Using Urban Big Data to Understand Day-to-Day Fluctuations in New Yorkers' Lottery Gambling

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Objective: Optimism bias—the maintenance of unrealistic beliefs that positive events are likely to occur in the future—is often considered a stable trait. However, a decision-maker's level of optimism may also change over time based on situational or contextual factors (e.g., Johnson & Tversky, 1983). Here we take an "Urban Big Data" approach to investigate how New York City (NYC) residents' lottery ticket gambling fluctuates in accordance with positive and negative outcomes outside of their control. As lotteries promise very low odds of winning large sums of money, lottery ticket purchases are a useful proxy for unrealistic optimism. We reasoned that outcomes of local sports teams' games were meaningful external events that may determine fluctuations in optimism, and moreover, yield nearly year-round data to examine our question.

Methods: We obtained daily lottery sales data for all New York State lottery games for all 173 ZIP codes in NYC, as well as each sports outcome (win/loss) for each NYC-based professional baseball, basketball, hockey, and football team for the years 2011 and 2012. Critically, we only considered daily, non-jackpot lotteries, as their payoffs do not fluctuate, which guarantees that the lotteries' expected values remains constant over time. We tabulated socioeconomic status (SES) and adult populations for each ZIP code from the US Census. Mixed-effects regressions were used to predict each neighborhood's daily per-capita composite lottery sales from the previous day's sports results (both the aggregate probability of winning and winning streaks) as well as a number of nuisance variables controlling for cyclicality.

Results: Our regressions indicated that sports successes by NYC teams, but not Chicago teams (e.g., all wins versus all losses the day before) positively and significantly predict daily per-capita lottery gambling. Lengths of winning streaks by NYC (but not Chicago) teams also significantly predicted NY lottery purchases, suggesting that hot-hand like effects may transfer between different domains. These predictive effects were present at both the city and the neighborhood levels and were not moderated by SES. SES negatively predicted per-capita lottery sales, corroborating earlier (albeit survey-based) observations that low-income individuals spend disproportionally larger amounts of their income on lottery gambling.

Conclusions: Our results suggest that positive external events can (in part) explain the fluctuations' in NYC residents' patterns of lottery gambling behavior, consistent with contextual and situational factors exerting effects on optimistic expectations.

References:
Johnson, E. J., & Tversky, A. (1983). Affect, generalization, and the perception of risk. *Journal of Personality and Social Psychology*, *45*(1), 20–31.

Aspects of Imagining the Future and Discounting Behavior

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Objective: Recent work has shown that individuals who discount delayed rewards to a lesser degree tend to exhibit greater BOLD activity in ventromedial prefrontal cortex (vmPFC) when imagining the future. Interpreting this relationship, however, hinges on knowing what aspects of imagined events modulate vmPFC activity. Here we test how the vividness, valence and temporal distance of an imagined event modulates BOLD activity.

Methods: Sixteen people participated in the study. Each participant was scanned using fMRI while imagining scenarios manipulated for vividness, valence, and temporal distance. Subjects rated each scenario for how vividly they could imagine it and how positive the scenario was. Following the scanning session, participants completed a behavioral discounting task that required them to choose between a smaller monetary reward available immediately or a larger monetary reward available after a delay. We analyzed our neuroimaging data using the general linear model; during the imagination period, we included separate regressors for the comparison of scenarios that were high versus low in vividness, high versus low in valence, and high versus low in temporal distance. A region-of-interest analysis was also conducted using a vmPFC mask obtained from a previous meta-analysis. Behaviorally, each individual's discount rate was estimated using a hyperbolic discounting model.

Results: At the whole brain level, we found increased BOLD activity in the precuneus, hippocampus, and striatum for more vivid scenarios compared to less vivid scenarios. We also found increased BOLD activity in the vmPFC and ventral striatum for positive scenarios compared to negative scenarios. No significant modulations were found for scenarios in the near future compared to those in the far future. ROI results revealed that, in addition to valence, vividness also significantly modulated vmPFC activity. Additionally, individuals who exhibited a greater effect of vividness on vmPFC activity tended to have lower discount rates.

Conclusions: These results show that the vividness of an imagined future event – not just its valence – can modulate BOLD activity in vmPFC, and that the size of this effect predicts discount rates. These results suggest a relationship between vividly imagining the future and discounting, and suggest that the vividness of future thought might be a cognitive process to be targeted in interventions aimed at changing discounting behavior.

Neural Representation of Contingent Valuation

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Objective: Contingent Valuation (CV) is a survey-based method used by policymakers and market researchers to gauge the demand for non-market goods. These are goods that are not bought and sold in a traditional market setting, such as environmental proposals. Although pervasive in its use, the method is fraught with criticism due to its reliance on hypothetical questions and scenarios (e.g., how much would you pay for 5% cleaner air?). CV is frequently used in evaluating large-scale public projects, in estimating the economic consequences of environmental regulations, and in litigation over natural resource damages. Despite ongoing debate over the validity of the CV procedure for environmental goods (whether it accurately describes citizens' willingness to pay), it remains the most prevalent tool for eliciting these preferences. We test the hypothesis that neural signals in the same areas that predict traditional valuations also predict preferences measured by CV methodology.

Methods: We present behavioral data and scanner data from 30 human subjects. Using functional magnetic resonance imaging (fMRI), we measured the blood oxygenation level-dependent (BOLD) response while subjects passively viewed an assortment of goods (the same goods that are later measured behaviorally) while thinking about the items' value in a dollar amount.

Behaviorally, we examined a total of four valuation procedures. These include two popular incentive-compatible methods: the Becker–DeGroot–Marschak (BDM) method and a choice experiment. Importantly, we also examined two procedures that are not incentive-compatible: CV and subjective ratings on a visual analogue scale (VAS). Each method was implemented with a separate class of goods: snack foods (BDM), consumer goods (choice), environmental proposals (CV) and daily activities (VAS).

Results: Our examinations of these three classes of goods replicated previous findings. A random-effects parametric regression using behavioral preference ranks as regressors yielded correlations in ventromedial prefrontal cortex, ventral striatum, or both for each non-CV preference elicitation ($p < 0.05$, FDR uncorrected). In contrast, preferences between environmental proposals (as measured by CV) yielded no meaningful correlations in any region of the brain at comparable statistical thresholds.

Conclusions: Our procedure replicates known valuation correlations for three classes of goods. In contrast, the environmental public goods valued with the CV procedure did not yield neural correlates at comparable statistical thresholds. The results show that the preferences regarding environmental public goods elicited by the CV procedure differ from traditional valuations.

Referential Symmetry in the Encoding of Subjective Value

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Objective: Neural encoded subjective value should scale to match the relevant range of outcomes (Padua-Schioppa and Assad 2008); an effect verified by Tobler et al (2005). If so; it follows that rescaling of overall value must be properly reflected in a multiattribute (part-value) integration rule. Our objective was to derive such a rule from neurobiological principles.

Methods: This work is theoretical. Mathematical deduction was used to explore the logical consequences of three assumptions about neural operations. These assumptions are compatible with well-known neural constraints; i.e., " … neural activity is physically constrained to minimal and maximal levels …" (Louie and De Martino 2014) and "A fundamental difficulty in representing the value of rewards (and many other stimuli) is that the number of possible values has no limits. By contrast, the representational capacity of the brain is limited by its finite number of neurons and the limited number of possible spike outputs of each neuron." (Tobler et al 2005).

Results: Our three conditions – positivity, detectability, and boundedness – lead to a specific functional form to represent the value integration process. This form yields three main results: first that diminishing sensitivity is a natural by-product of the integration rule we deduced. Second, the rule is a sufficient condition for loss aversion. And third, the rule naturally generates non-compensatory value integration.

These general results provide new explanations for specific phenomena of interest to neuro and behavioral scientists, including: the attraction effect, the compromise effect, similarity effects, and other context dependent behaviors that run counter to classic utility theory. The theory also uncovers an interesting tension between decision simplification via non-compensatory (heuristic-like) rules and the compromise effect as moderated by the overall value of choice options under consideration.

Conclusions: The proposed theory generates novel behavioral hypotheses and yields a functional rule that may be a contender for the divisive normalization process outlined by Glimcher. "A growing body of evidence ... suggests that the representation of decision variables in the choice areas is neither a ratio-of-choice-variables as originally proposed for value-based models nor a difference-of-choice variables as originally proposed for perceptual-based models. Instead it appears that these networks employ a divisively normalized representation that can accommodate both ratio-like and difference-like behavior."

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Perceptual priors decoded using the drift-diffusion model predict beliefs in an investment task

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A major goal of Neuroeconomics is to understand how humans form expectations in uncertain environments and make decisions based on their past experience. This goal is extremely broad, encompassing expectation formation in both high-level economic decision-making (EDM) and lower level perceptual decision-making (PDM). For example, how does an investor form beliefs about future stock market returns? How does a driver predict when a stoplight will change color? While these examples illustrate distinct problems, it is unknown whether the brain deploys distinct processes to form beliefs in these two domains.

One hypothesis is that the brain relies on separate psychological mechanisms to govern belief formation in PDM and EDM. An alternative hypothesis is that the brain uses a common underlying belief-formation mechanism. If the latter hypothesis holds, then a single computational model should accurately describe belief formation across EDM and PDM tasks.

Here, we test this prediction by recruiting N=38 subjects to participate in an experiment consisting of two separate tasks. In a perceptual decision-making task (PDT), the subject is incentivized to quickly classify a visual stimulus. In the economic decision-making task (EDT), the subject is incentivized to provide an explicit prediction of the probability that a stock will go up in price.

In order to precisely recover a subject's prior belief in the PDT, we provide a novel analytical technique that decodes prior probabilities (beliefs) from reaction times. In particular, we estimate a drift diffusion model for each subject, and use the fitted structural parameters to solve for prior probabilities. We report three main results: 1) Prior beliefs in the PDT correlate with prior beliefs in the EDT (r=0.90, p<0.005) 2) Subjects who have more volatile beliefs in the PDT also have more volatile beliefs in the EDT (r=0.46, p=0.003) 3) A single computational model with one free parameter, the Dynamic Belief Model (Yu and Cohen 2009), that is fit to the PDT data can explain a significant amount of variation in the EDT data.

These results support the hypothesis that the brain relies on a common psychological mechanism to govern belief formation in economic and perceptual decision-making tasks. This suggests that the large body of work on belief formation in economic decision-making might also apply to problems in perceptual decision-making, and vice versa.

The effect of incentives on cooperation

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Objective: To encourage cooperation in social dilemma situations, authorities frequently reward cooperators or punish non-cooperators. Although both rewards and punishments have been shown to be equally effective, it is unclear by which mechanisms they promote cooperative behavior. For instance, incentives may promote cooperation because they enhance norm compliance, because they increase strategic reasoning or because they boost satisfaction derived from doing good. By measuring the neural processes underlying cooperation in the Public Goods Game we examined whether rewards and punishments function in a similar way, or whether they promote cooperation differently. Additionally, we compared the effect of social and monetary incentives.

Methods: Participants played 5 versions of a Public Goods Game (PGG) while undergoing fMRI. In addition to a standard PGG in which no incentives were used, participants played 2 versions of a monetary PGG and 2 versions of a social PGG. In the monetary PGGs, participants could either receive a small financial bonus for investment in the public-good, or a financial fine for free-riding. In the social PGGs, participants' names could either be placed on a cooperator or a non-cooperator list that ranked participants based on their investments in the public good and was publically disseminated afterwards.

Results: Participants cooperated more in the incentivized games than in the standard PGG, with cooperation rates highest in the monetary conditions. The effect of incentives was associated with enhanced activity in the striatum, DLPFC, DMPFC, insula, and VMPFC. No behavioral differences were found between rewards and punishments. However, neural activity in the punishment conditions differed from activity in the reward conditions, with stronger activations for punishments than rewards in brain regions previously implicated in social norm compliance.

Conclusions: These findings show that rewards and punishment have similar impacts in cooperative behavior, however the mechanisms underlying this cooperation are different at the neural level. This result not only increases our fundamental understanding of the effect of incentives, but provides useful practical insights as to how policy interventions could be structured as well.

Weber's Law is reversed for value-based choice

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Objective: Weber's law is one of the most fundamental laws in the behavioural sciences, stating that animals – including humans – compare stimuli based on proportional rather than absolute differences in stimulus magnitude. This law is thought to reflect a universal principle of brain function that has evolved to enable adaptive behaviour across many different contexts. Critically, current theories suggest that Weber's law also applies to choices based on subjective preferences and may account for puzzling distortions of economic choice. Here, we used behavioural measurements, computational modelling, and functional magnetic resonance imaging (fMRI) to directly compare how stimulus magnitude influences perceptual versus value-based decisions.

Methods: We employed fMRI in 31 participants during a behavioural paradigm where perceptual and value-based choices were based on identical stimuli and motor responses, so that decisions reflected selective accumulation of just one type of evidence. To characterize the mechanisms by which stimulus magnitude influences perceptual and value-based choices, we implemented a computational dynamical model that parsimoniously estimates the effects of different levels of stimulus evidence and magnitude on participant- and condition-specific choice accuracies and reaction times.

Results: We found that Weber's Law held for perceptual choices, as higher combined stimulus magnitude led to less accurate choices. For value-based choices, in contrast, higher combined stimulus magnitude resulted in higher accuracy without slowing reaction times. Our computational model formalizes this finding, which clearly reveals opposite influences of magnitude in perceptual and value-based decisions. Applying our model to other data sets (n=110 subjects) confirmed that these differential weighting-magnitude effects generalize across different cultural contexts and experimental settings. Model-based fMRI analyses revealed a positive influence of magnitude on value evidence in the ventro-medial prefrontal cortex and a negative magnitude modulation of perceptual evidence in the inferior parietal cortex.

Conclusions: Our investigation suggests that previously proposed universal processing principles (e.g. divisive normalization) have to take into account fundamental differences between perceptual and value-based choices. Our finding has strong implications for theories assuming that distortions of economic decisions and the evolution of risk preferences originate from Weber's law.

Trust, Competition and Cooperation in Autism Spectrum Disorder

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Objective: Impaired social interactions and repetitive behavior are key features of autism spectrum disorder (ASD). In the present study we compared social decision-making in subjects with and without ASD. Subjects performed five social decision-making games in order to assess trust, fairness, cooperation & competition behavior and social value orientation.

Methods: 19 adults with autism spectrum disorder and 17 controls, matched for age and education, participated in the study. Each subject performed five social decision-making tasks. In the trust game, subjects could maximize their gain by sharing some of their money with another person. In the punishment game, subjects played two versions of the Dictator's Dilemma. In the dictator condition they could share an amount of 0-100 points with another person. In the punishment condition, the opponent was able to punish the subject if he/she was not satisfied with the amount of points received. In the cooperation game, subjects played with a small group of 3 people. Each of them could (anonymously) select an amount of 5, 7.5 or 10 Swiss francs. The goal of the game was to achieve a high group minimum. In the competition game, subjects performed a dexterity task. Before performing the task, they were asked whether they wanted to compete (winner takes it all) or cooperation (sharing the joint achieved amount of points) with a randomly selected person. Lastly, subjects performed a social value orientation task where they were playing for themselves and for another person.

Results: There was no overall difference between healthy controls an ASD subjects in investment in the trust game. However, healthy controls increased their investment over number of trials whereas ASD subjects did not. A similar pattern was found for the punishment game. Furthermore, ASD subjects revealed a decreased investment in the dictator condition of the punishment game. There were no mean differences in competition behavior and social value orientation.

Conclusions: The results provide evidence for differences between ASD subjects and healthy controls in social decision-making. Subjects with ASD showed a more consistent behavior than healthy controls in the trust game and the dictator dilemma. The present findings provide evidence for impaired social learning in ASD.

Common Sense in Choices: Effects of Modality on Value

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Objective: In order to make decisions, the human brain must be able to quantify everything around it, and represent it in terms of value. Previous findings suggest that the striatum and ventromedial prefrontal cortex (vmPFC) comprise a *common currency* network, representing value regardless of type. In the present work, we examined whether the sensory domain in which the information is perceived affects value representation. Additionally, we aimed to identify modulation of value on sensory information processing.

Methods: Twenty nine healthy adults participated in the behavioral study. We have designed a novel decision making task, in which we presented to subjects either a visual or an auditory binary choice situation. In each choice situation subjects had to choose between a certain amount of 10 NIS and a lottery of some amount of money (ranging from 10 to 75 NIS) and a probability to win it (15%-80%). Using standard tools from economics we examined whether subjects' risk preference would be affected by the sensory modality in which we presented the choices. Following the behavioral session, eight subjects were scanned using functional Magnetic Resonance Imaging (fMRI) while preforming the same task. We searched for brain areas that represented subjective value for each sensory modality and brain areas that represented subjective value irrespective of the sensory modality.

Results: behavioral data shows no difference in subjects' risk preference between auditory and visual presentation. Neuroimaging data reveal that BOLD signal in the vmPFC is correlated with subjective value, irrespective of modality, strengthening the notion of a common neural value network. Additionally, auditory and visual cortices' activation correlates with subjective value in a modality-specific manner.

Conclusions: These results suggest that the final common pathway for valuation and choice is not affected by the sensory modality in which information is perceived. Taken together with the modality-specific sensitivity to value in sensory areas, the present work sheds light on the interplay between sensory and value processing.

Cognitive processes underlying forward induction and the role of intelligence

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Objective: The general principle of Forward Induction (FI) as game theoretic solution concept is that a player may be able to infer information about the intended action of the counterpart by considering the actions taken in earlier stages of a game. Choice behavior alone is not sufficient to identity FI thinking: our objective is to predict players' behavior in games in which FI applies by analyzing the visual information acquisition (VIA) pattern they adopted in a single class of games, and test whether, and for which subjects, the predictions of FI are supported.

Methods: We recorded eye movements of 105 participants playing 96 matrix and multistage games with different equilibrium structures: 1) *Battle of the Sexes*, (two pure strategy equilibria). 2) *Prisoner's Dilemma* games (both players have a dominant strategy). 3) *Dominant Solvable* games (the counterpart has a dominant strategy). 4) *Stag Hunt* games, with two equilibria in pure strategies and both players could choose between a safe low-return choice and a high risk high-return one.
We performed mixture models cluster analysis to group participants into types according to the prevailing payoff comparisons they made in a single class of games. We finally used the clusters to predict participants' choices in the other classes of games.

Results: Cluster analysis identified 4 VIA patterns, according to which we infer the decision rule adopted by each cluster: players in cluster 1 (*own focused players*) focused on their own payoffs. Players in cluster 2 (*distributed attention players*) exhibited an extensive VIA pattern including information of earlier stages of the games. Players in clusters 3 and 4 (*last-stage focused players*) exhibited a balanced mixture of all types of comparisons but omitted to acquire information about earlier stages of the games. Such categorizations predicted the participants' choices throughout all games. *Own focused players* best respond against the uniform probability belief over the opponent's actions. *Distributed attention players* were able to apply FI in games with multiple equilibria. *Last-stage focused players* were able to detect equilibrium in games with unique equilibria but not to apply FI.

Conclusions: One can identify players who apply FI by examining the way they visually analyze the games: considering the outside option repeatedly is necessary and sufficient for FI thinking. A substantial fraction of players is strategically sophisticated but ignores information in past moves. Our results indicate that individuals have a way of approaching and analyzing strategic interactions, which is constant across games and strictly related to their ability to reason strategically.

Anticipating uncertain lottery outcomes

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Objective: Previous studies have shown that decision-makers are often influenced by anticipatory emotions. As such, humans typically evaluate their emotions with reference to predicted outcomes. In this study we keep the outcome values of a set of lotteries constant, but change both the type and source of the associated uncertainty. Specifically, we test if risk as compared to ambiguity, a social versus a non-social source, and their interaction, affects the anticipation of outcomes.

Methods: Twenty adults participated in the study while undergoing fMRI, and made decisions in two types of lottery setup. Participants could indicate how many tokens to transfer to either a computerized lottery device (non-social condition) or to a human receiver who had decided in a single shot decision in an earlier session to either keep or transfer back half of any amount of tokens received (social condition). In both contexts participants could condition their transfer when probabilistic information was provided (risk) or not (ambiguity). Firstly, participants made all their decisions without any outcome information provided. In a second stage all actual outcomes were randomly presented, together with the previously chosen transfer amount. Neuroimaging data was analyzed by looking at the BOLD response when participants reviewed the choice setup along with their chosen amount of transfer.

Results: Irrespective of the type or source of uncertainty we find that beliefs regarding the probability of an investment being returned affects anticipatory outcomes. The higher the participants' beliefs, the more activation in the anterior cingulate cortex, the insula, and the superior temporal gyrus. In all experimental conditions higher beliefs resulted in higher transferred amounts. Only in the social context do we find activation in middle orbital frontal gyrus when adding participants' chosen level of transfer as a parametric modulator to the GLM model.

Conclusions: Our results indicate that individuals' beliefs concerning the probability of an investment being returned influences the anticipation of outcomes. The higher participants' beliefs, the more they transfer in uncertain lotteries. At the same time, these individuals are more vulnerable to lose their investment when expectations have been wrongly assessed. As activation in the ACC and insula positively correlates with more optimistic beliefs, these participants are more likely to be sensitive to anticipatory emotions.

Unrelated Fear Reduces Financial Risk Taking

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Objective: Fear may play an important role in financial decision-making. Previous research suggests that fear of an aversive event that cannot be escaped might reduce the willingness to take risks, contrary to the predictions of existing economic theories. So far, however, only weak evidence has been obtained, based on self-reports. In the current study we use the well-established paradigm of fear conditioning to test the hypothesis that Pavlovian fear learning, that is unrelated to the economic event, reduces financial risk taking.

Methods: Thirty-seven healthy participants underwent a fear-conditioning paradigm in which one of two visual stimuli (i.e., fractals) was paired with a Shock, whereas the other stimulus was paired with a touch (CSShock vs. CSTouch). Thereafter, participants made a series of gambles. Each gamble consisted of a Sure option (i.e., a guaranteed gain of €10) and a Risky option (e.g., a 50% chance on a gain of €20 and a 50% chance on no gain (€0)). Half of the gambles (Shock Gambles) was presented with the CSShock, the stimulus that signaled threat, whereas the other half (Touch Gambles) was presented with the CSTouch, the stimulus that signaled no threat.

Results: Fear learning was evident from the differential expression of fear (CSShock > CSTouch) at both the cognitive level (US-expectancy and liking ratings) and the physiological level (skin conductance responding and pupil dilation). However, the CS did not differentially arouse participants during the Shock Gambles as compared to the Touch Gambles. In line with this finding, but contrary to our expectations, fear learning did not affect financial decision-making. That is, percentage Sure (and Risk) choices did not differ on Shock versus Touch Gambles. However, additional analyses revealed that on trials immediately after the delivery of the actual Shock, participants were less willing to take risks on the Shock Gambles as compared to the Touch Gambles, showing that in that case they reacted differentially to the CS. Moreover, these effects of fear learning were absent on the Gambles immediately after the delivery of a Touch.

Conclusions:
These results suggests that fear (i.e., potential delivery of a Shock) only reduces risk taking during financial decision-making when participants were just exposed to the actual adverse event (i.e., the actual delivery of the Shock but not the Touch). From these findings it can be concluded that the expectation of an adverse event that cannot be avoided, like a global risk, needs sufficient awareness to reduce financial risk taking.

Dissociating the neural correlates of prediction error signals, predicted and outcome value

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Objective: In many decision-making tasks individuals need to compute several distinct value signals: predicted values (PVs) that measure the value of upcoming outcomes, outcome values (OVs) that measure the actual value of the decision outcomes, and prediction errors (PEs) which measure the deviation between the previous two and are used to guide learning. Dissociating the neural basis of these signals is difficult because in most tasks they are highly correlated. As a result, they are confounded in most existing studies. This has led to conflicting findings about the role of different prefrontal and striatal areas in the encoding of these signals. The goal of this research is to dissociate them using a novel fMRI task that can address these short comings of previous studies.

Methods: 23 subjects (15 females, M_{age}=20.87) participated in the study. During the experiment, subjects sampled 3 different water-based liquid rewards of different flavors. In half of the trials, subjects received the reward for sure, in the other half of the trials subjects received the reward with a probability of 50%. Before sampling, a cue predicted the reward flavor and the probability of reward delivery. During sampling, subjects also received information about a random payoff of -2,-1, 0, 1, or 2 EUR to de-correlate prediction error from outcome value signals. Subjects went through a total of 120 trials (i.e. 40 for each flavor).

Results: We applied modeled-based fmri using parametric modulators for PV, OV and PE signals and found that neural activity in the parahippocampal gyrus (t=5.24) the inferior frontal gyrus (t=6.62) and anterior cingulate cortex (t=-3.34) correlates with predicted values, whereas prediction error signals were found in the ventral Striatum (t=-4.51). Outcome values were encoded in several taste related brain areas such as the primary taste cortex (i.e. insula, t=3.915) and a more caudal region of the mOFC (t=5.24). Interestingly in a first exploratory PPI-analysis, IFG (BA46) was positively connected with OFC (t=4.28) for predicted values, whereas e.g. the mOFC was negatively connected with the insula (t=-3.81) for outcome values.

Conclusions: Consistent with previous findings, we found that predicted values are encoded in the IFG (BA46) (Hare et al. 2008). Also consistent with previous findings we found correlates of prediction error signals in the ventral striatum (Hare et al. 2008). Further analysis are planned to understand differences in connectivity of these value-based decision making signals.

Dynamic constraints on the distribution of stochastic choice:

Drift Diffusion implies Random Utility

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Objective: We demonstrate that the Random Utility Model (McFadden, 2001) is a reduced form of a class of bounded accumulation models found in neuroscience, of which the drift diffusion model (Ratcliff, 1978) is a special case. The derivation constrains the distribution of random utility, resulting in serious implications for testing behavioural models and predicting choice behavior. An example of bias in the estimation of risk aversion is noted.

Abstract: Stochastic choice behaviour is an established empirical phenomena and the Random Utility Model has become the standard framework for modelling it in applied economic settings. However, it has been well-documented that the distribution of random utility has important implications for both testing behavioural theories and predicting behaviour, often overshadowing the underlying theory itself. We demonstrate that the random utility model can be derived from a predominant class of decision-making in neuroscience, Bounded Accumulation models, which emphasize the dynamic nature of a decision. These models have empirical support in both neural and behavioural datasets, and provide a tight relation between response times and stochastic choice behaviour. Of this class of models, the drift diffusion model (Ratcliff, 1978) can be considered a normative solution and is the most well-known example.

The goal of this paper is to mathematically link these two literatures and demonstrate that the random utility model can be derived from a bounded accumulation decision process. In particular, we specify how the distribution of random utility is influenced by the dynamics of the stochastic accumulation process. We demonstrate that specifics of the accumulation process currently being debated in the psychology and neuroscience literature influence the mean, variance, skew, tails, and correlation of the stochastic elements of random utility. The econometric implications of these results are then explored. For instance, the derivation yields a relation between observables in a dataset, the decision time, and the variance of random utility that can be easily controlled for with standard econometric tools. However, some results suggest more serious complications. We find that if choices are generated using the random utility distribution suggested here, estimates of common structural parameters, such as the coefficient of relative risk aversion, can be biased in a well-known experimental dataset (Holt and Laury, 2002).

Holt, C. A., and S. K. Laury (2002): "Risk aversion and incentive effects," The American Economic Review, 92(5).

McFadden, D. (2001): "Economic choices," The American Economic Review, 91(3), 351–378.

Ratcliff, R. (1978): "A theory of memory retrieval," Psychological Review, 85(2), 59–108.

Attention in Perceptual Decision-Making

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Objective: When faced with a value-based decision, humans tend to fixate on the items presented to them in order to compare their values and make the best possible choice. Previous work using food items has shown that patterns of fixations have an important role in this type of decision process. In particular, choices and reaction times in binary value-based decisions can be quantitatively described by a modified version of the drift decision model (called the aDDM), in which the value comparison process depends on the pattern of fixations among the two items, and in which relative visual attention has a sizable effect on choices. Here we investigate whether the same mechanism applies to perceptual decision making.

Methods: Our experiment consists of a simple binary perceptual choice task. On each block of trials, subjects are first trained to recognize a target, which is a bar oriented at a certain angle. Then, on each subsequent trial, they are shown two different bars on the screen, and must decide which of the bars has an orientation closest to the target. During trials we recorded both choices and reaction times, and used an eye-tracking device in order to obtain the subjects' patterns of fixations. We collected data from 25 different subjects (10 female; mean age = 23.2 years, SD = 4.38) and each one of them completed a total of 1,344 individual trials.

Results: Our preliminary data analysis shows several choice biases that are predicted by the aDDM. First, our data shows a last-fixation bias, meaning that subjects are more likely to choose the last item that was fixated in that particular trial. Second, subjects are also more likely to choose items that have been fixated for a longer period of time during the trial. Finally, the first item fixated in a trial does not influence that trial's final choice. Additional investigation with this data will allow us to estimate the parameters of the model at both individual and group levels, then use the estimated parameters to predict choices and reaction times.

Conclusions: Our results will generalize the validity of the aDDM to perceptual decisions, providing additional evidence of this model's capability to explain the role of attention in a wide range of decision situations.

A Friend in Need: The Effects of Stress on Social Discounting and Generosity

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Objective: Acute stress is assumed to be associated with a tend-and-befriend response, a putative coping mechanism where people behave generously towards others to seek and provide mutual protection. However, it would be maladaptive to befriend everyone alike during stressful times. Instead, we hypothesized that it is more advantageous to build and conserve social relationships with only a delimited number of socially close, but not distant individuals. We set out to investigate how stress affects social discounting, i.e., how generosity changes under stress as a function of social distance between interaction partners. We predicted that acute stress would deflect the social discount function, reflecting an increase in generosity towards socially close and decrease in generosity towards socially distant individuals compared to a non-stressed control group. Additionally, we predicted that endocrinological regulatory mechanisms in the aftermath of stress would result in a deflection of the social discount function in the opposite direction compared to under acute stress.

Methods: Seventy-eight adult male subjects participated in the study. Each subject went through either a group version of the Trier Social Stress Test or a control condition after which they carried out a social discounting task either 0 (early) or 70 (late) minutes after stress offset. In this task, subjects had to indicate how much of a given amount of money they would give up to individuals at specific social distances. Generosity was determined individually for each participant by calculating the percentage of money shared at each social distance. We modelled social discounting using hyperbolic discount functions, and compared the best-fitting discount parameters across stress and control conditions.

Results: We found that the social discount function in the early stress group had a higher offset compared to the control group, suggesting that stressed subjects were more generous toward socially close, but not distant others. Furthermore we found significant correlations between overall generosity and salivary cortisol levels as well as changes in salivary alpha amylase.

Conclusions: These results suggest that acute stress affects social discounting by making people more generous towards socially close, but not socially distant individuals. These results are in line with the tend-and-befriend hypothesis stating that individuals tend to form delineated social support networks in times of stress.

Bounded emotion, the psychophysics of affect and scope:
Collapse of affect in donation and non-donation judgment tasks

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Research on giving to individuals has found that people tend to give more to one child than to many children (Singularity effect; Kogut & Ritov, 2005; Slovic, 2007). A main psychological mechanism proposed to account for this finding is compassion collapse suggesting that as the number of victims increase people loose their feelings of empathy, sympathy and compassion (Slovic, 2007). Earlier studies (Västfjäll et al. 2014, Kogut & Ritov, 2005) have indeed shown that ratings of affect tend to covary with, and mediate, the singularity effect.

Aims. In this paper we present a series of studies aiming to investigate if compassion collapse is a general affective judgment phenomena. Bases on classical psychophysical theories of sensation, we propose and test a novel mechanism that could account for loss of feeling as magnitude increase – emotional masking. Emotional masking suggest that our emotional experiences are bounded by physical principles resembling those of basic sensation and perception. We also test an alternative mechanism for emotion collapse –motivated down-regulation of emotion (Cameron & Payne, 2011).

Method. We use a paradigm where participants either view 1, 3, or 9 affect-inducing pictures taken from the International Affective Picture System (Bradley & Lang, 1999) and then rate the intensity of their currently experienced emotion. Based on emotion theories we predicted that people would experience the strongest and most intense emotions to a single picture and as the number of pictures increased emotion intensity would drop. We conducted 2 web surveys using representative US samples (over 500 participants) where we varied total duration/stimulus duration, picture valence, and presentation form (sequential/simultaneous).

Results and conclusions. Across all studies we find strong support for affect collapse – the intensity of affect is strongest for a single affect-inducing stimulus and decrease as the number of stimuli increase. These findings suggest that our inability to feel for the many is an inherent property of our affective system and that this system share properties with our perceptual system. This has implications not only for life-saving but for any type of judgment of value and suggest that classical value functions (such as Prospect Theory) may not be appropriate for valuations of some affect-inducing options.