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THE NEUROECONOMICS OF VOTING:

NEURAL EVIDENCE OF DIFFERENT SOURCES OF UTILITY IN VOTING

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Abstract

Which motives drive the decision of a voter to approve or reject a policy proposal? The Public Choice literature distinguishes between instrumental and expressive voting motives. We investigate the importance of these motives by analysing the patterns of neural activity in different voting situations. We conduct an fMRI-experiment which investigates neural activation at the moment of voting and use the altruism scale proposed by Tankersley et al. (2007) to differentiate between altruists and non-altruists. Non-altruists show neural activation patterns that are consistent with expressive voting motives. Among non-altruists, we also find activation patterns that point at egoistic instrumental motives. Both results are in line with the corresponding Public Choice literature. On the other hand, we find no evidence for expressive voting motives among altruists. Their neural activation pattern is generally much less conclusive with respect to the underlying motives.

Keywords

Voting behavior, expressive voting, instrumental voting, political decision making, charitable donation, neuroscience, neuroeconomics, neuropolitical, fMRI

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THE NEUROECONOMICS OF VOTING: NEURAL EVIDENCE OF DIFFERENT SOURCES OF UTILITY IN VOTING

1. Introduction

Traditionally, the theory of voter behavior assumed that voting decisions are driven by preferences over policy proposals. The vote serves as an instrument to change the voter's living environment in future (e.g., Downs, 1957). This so-called instrumental voting can be thought of as an investment under uncertainty: The voter bears the certain and immediate costs of voting and expects future utility gains from more favorable policies. He votes for his favorite policy proposal in order to increase the probability that it becomes accepted and pursued (e.g., Downs, 1957; Fiorina, 1976; Mueller, 1986). The essential shortcoming of the theory of instrumental voting is that it cannot explain the high voter turnout in real-life elections where the individual vote has a negligible chance of changing election outcomes (e.g., Downs, 1957; Tyran, 2004). To dissolve this "paradox of voting", it is necessary to assume some direct utility from the act of voting that does not relate to the policy outcomes expected in future. According to the theory of expressive voting, a voter goes to the booth because the act of expressing his approval to a certain candidate or policy proposal yields immediate utility. Voting thus is an act of consumption, much like cheering at a football game (e.g., Fiorina, 1976; Brennan and Hamlin, 1998). As long as an expressive voter does not expect to be pivotal, he votes for the proposal or candidate for which approving yields the highest immediate expressive utility. In those cases where he expects to be pivotal the instrumental utility outweighs the expressive utility. Given that the chance of being pivotal in real-world elections is negligible, expressive motives may – if existent in a large share of voters - drive the collective policy choices (Tullock, 1971). In this case, voting does no longer aggregate policy preferences. Instead, it promotes policies and candidates that make voters feel good when voting for them and impedes policies where the concomitant feeling is bad. Whenever expressive and instrumental motives collide, it is uncertain whether the policy chosen promotes the welfare even of the majority of voters who approved.¹ Moreover, it opens up another channel by which election polls can influence voting decisions: Policies where expressive and instrumental motives collide can be promoted or impeded by making expected outcomes seem less or more close.

So far, behavioral experiments provide only limited empirical support for a prominent role of expressive motives (e.g., Carter and Guerette, 1992; Fischer, 1996; Tyran, 2004; Feddersen et al., 2009; Kamenica and Egan, 2011; Shayo and Harel, 2012).² In this paper, we argue that the existing evidence from behavioral experiments does not necessarily mean that expressive motives are not as strong as predicted. The reason is that behavioral data – i.e. the observed decision to vote YES or NO – leaves us with a measure that is too crude to differentiate different voting motives. The observed voting decision supports the conclusion that – among two dif-

¹ Similarly, Feddersen and Pesendorfer (1996) show that strategic voting may undermine the majority vote's ability to aggregate private information as proposed in Condorcet's Jury Theorem. The main difference between this strand of literature and the one followed here is the purpose of collective decisions: In the case these authors have in mind, majority voting is a means of aggregating private information on an uncertain state of nature. In our paper, the aim is to aggregate individual policy preferences. In this context, the ethical voter central to the analysis of Feddersen and Pesendorfer votes instrumentally because his aim is improve policy outcomes (see also Battaglini et al, 2010). Given only two choices, strategic voting is irrelevant.

Most of these studies deliberately create treatments with different degree of pivotality changing the decision making environment (e.g. electorate size; for a review, see Shayo and Harel, 2012). Tyran (2004) is among the few who do not change the voting environment but elicit voters' expectations concerning the approval rate and infer the degree to which voters expect to be pivotal. In this paper, we Tyran's approach.

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ferent conflicting voting motives – a particular motive dominates. However, it does not tell us whether the other motive is relevant at all, nor does it inform us about the relative strengths of both motives. To gain deeper insight into the role of different voting motives, we apply neuroscientific methods. These provide us with a detailed account of brain activities involved in the voting process. By providing us with measures for neural correlates of the utility involved in the voting decisions, they allow for additional tests for the presence of expressive motives in voting. Over the last years, the application of neuroscientific methods in economics enhanced the knowledge about economic behavior and decision making. Up to now, the political sciences have paid little attention to these new methods (for some exceptions see Amodio et al. 2007, Chorvat 2007, Farmer et al. 2007, Harbaugh et al. 2007, Tingley 2006, Westen et al. 2007). To our knowledge, we provide the first study using functional magnetic resonance imaging (fMRI) to investigate voting behavior.³ We find neural activation patterns that are consistent with the theory of expressive voting among subjects classified as non-altruists. For those classified as altruists, we do not find neural correlates of an expressive utility from voting. Moreover, our results are inconclusive with respect to the ultimate factors that determine their instrumental utility when voting.

The paper proceeds as follows. After sketching the incentives involved in expressive and instrumental voting, section 2 derives the central hypotheses to be tested. Section 3 describes

³ The study by Rule et al. (2010) on the choice of political candidates in Japan and the US may be regarded as an exception. Yet it concentrates on judgements about personality and culture as drivers of choosing candidates for political offices. In addition, choices are hypothetical and the interaction of voters in the collective decision making framework is not captured by the procedures. Thus, we claim to provide the first fMRI-study on voters' interaction in voting decisions. We also focus on the choice of policies rather than candidates.

the experimental set-up of our study. The results are presented in section 4 and discussed in section 5. Section 6 concludes.

2. Expected voting decisions and their neural correlates

2.1 Behavioral predictions and economic experiments

The set-up of most experimental studies on expressive voting resembles Tullock's thought experiment (e.g., Tullock, 1971). It is based on a ballot in which a large number of individuals vote on the following proposal: Tax everyone and donate the revenues to charity. Throughout this paper, voting refers to this type of redistributional policies; the proposal is to take money from the broad public and use it to help a clearly defined minority. This minority consists of individuals that - by a broad consensus in society - are considered to be in need. To identify the incentives that voters face when deciding on this proposal, consider the individual voter i. Let x_i denote the net utility he witnesses if the proposal is rejected (hereafter: instrumental utility). Individuals who draw a higher utility from the money being donated are hereafter called altruists. For them $x_i < 0$ while $x_i > 0$ for non-altruists who witness a higher utility when the money is available for private use. Let ε_i denote voter i's expressive utility from voting for the proposal. By voting in favour of donating the money, voter i complies with the predominant ethical standards in society and may think of himself as a generous person. Both aspects arguably yield utility (Mueller, 1986; Hillman, 2010). Thus, we follow Tullock (1971) and Tyran (2004) in assuming that the immediate expressive utility from voting in favor of donating the money is higher than from rejecting this proposal. We also assume that the instrumental utility dominates the expressive utility, (i.e. $0 \le \varepsilon_i < |x_i|$). The expected utility differential \widehat{UD}_i from voting YES is then given by (e.g., Tyran, 2004):

$$\begin{aligned} \widehat{UD}_i &= \widehat{U}_i(YES) - \widehat{U}_i(NO) \\ &= \widehat{r}_i \cdot (x_i + \varepsilon_i) + \widehat{p}_i \cdot \varepsilon_i + \widehat{s}_i \cdot \varepsilon_i \quad - \quad \widehat{r}_i \cdot x_i + \widehat{p}_i \cdot x_i \\ &= \varepsilon_i - \widehat{p}_i \cdot x_i \end{aligned}$$

A risk-neutral voter will vote YES if the utility differential is positive and NO if it is negative. Here, $\hat{p_i}$ denotes the probability at which voter i expects to be pivotal. The case where $\hat{p_i} > 0$ is hereafter called *close-decision case*. In most elections and ballots the approval rate among other voters is either sufficiently high to accept the proposal even if he votes against it or too low to accept the proposal even if he voted in favor of it. Hereafter, we denote the first case the *sure-donation case* and the second one the *sure-private-money case*. In both cases, $\hat{p_i} \approx 0$. The probability at which voter i expects the sure-donation (sure-private-money) case is denoted $\hat{r_i}$ ($\hat{s_i}$).

Depending on the instrumental and expressive utility (x_i resp. ε_i), we can differentiate four types of voters: i) altruists who have expressive motives ($x_i < 0$, $\varepsilon_i > 0$), ii) altruists without expressive motives ($x_i < 0$, $\varepsilon_i = 0$), iii) non-altruists who have expressive motives ($x_i > 0$, $\varepsilon_i > 0$), and iv) non-altruists without expressive motives ($x_i < 0$, $\varepsilon_i = 0$).⁴ Altruistic voters vote YES because the utility differential is positive regardless of whether he expects to be pivotal or not. Whether or not they have expressive voting motives is irrelevant for their decision as well. Similarly, a non-altruist who is not motivated by expressive motives votes NO regardless of whether he expects to be pivotal or not. The reason is that his utility differential ($\widehat{UD}_i = \widehat{p}_i x_i$) is always negative. However, the expected probability \widehat{p}_i of being pivotal is es-

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Non-altruists are not defined by the absence of other-regarding motives but by the dominance of selfish motives over altruistic motives in the case of pivotality.

sential for a non-altruist who is motivated by expressive motives because he faces a trade-off between expressive and instrumental motives. By voting YES, he has an immediate and certain gain in expressive utility ε_i . But this utility comes at the costs of giving away the chance to tip the scales against donation by voting NO. In other words, the sign of the utility differential \widehat{UD}_i depends on probability \widehat{p}_i . In the close-decision case where \widehat{p}_i is large, the instrumental motives dominate his decision (i.e., $|\widehat{p}_i x_i| > \varepsilon_i$) and he will vote NO. In the suredonation case where $\widehat{r}_i \approx 1$ and sure-private-money case where $\widehat{s}_i \approx 1$, the individual cannot expect to tip the scales (i.e., $|\widehat{p}_i \approx 0$). Therefore, the expressive motive becomes dominant, (i.e., $\widehat{UD}_i \approx \varepsilon_i > 0$) and thus voter i will vote YES.

Expressed in non-technical terms, the theory of expressive voting argues that non-altruistic voters get the good feeling of approving to a proposal to donate money. In most cases, this good feeling comes at zero material costs because the proposal is rejected or approved anyway. As the chance of being pivotal is negligible in virtually all voting decisions, non-altruists generally behave like altruists even though they really do not want to donate money. The true motivation of the non-altruists only shows in those rare cases when they expect to be pivotal and thus approving bears the danger of material costs. In this case, they prefer the money over the good feeling and vote against donation. Altruistic voters always vote YES regardless of whether they expect to be pivotal or not and regardless of whether they have altruistic motives or not. When it comes to testing for expressive motives, we cannot use behavioral data from altruists. Instead, all experimental tests for expressive motives in voting have to rely on observing the voting behavior of non-altruistic subjects in situations with and without pivotality.

Tyran (2004) performs an economic experiment to test for expressive motives in voting. Therein, every participant is given a voucher worth approximately \$ 6. The proposal is to donate the endowments of all participants to charity (instead of cashing the voucher in at the end of the experiment). Participants vote on this proposal five times with five different quora. A quorum defines the minimum approval rate necessary for the proposal to be accepted. At the end of the experiment, one voting round is chosen at random and its decision is executed. By letting candidates vote on the same proposal using different quora, Tyran (2004) keeps the instrumental utility x_i and the expressive utility of approving the proposal ε_i constant but induces changes in the expected probability $\hat{p_i}$ of being pivotal. He asks candidate for their estimated approval rates among fellow-voters for all five decisions. Based on these estimates, it is possible to identify whether voter i expects to take his vote in the sure-donation, sureprivate-money or close-decision case. A substantial share of participants either disapproved or approved for all quora even when the expected approval rate suggests that $\hat{p_i} \approx 0$. Among those 40 % who voted YES for some quora and switched to NO for others, only 25 % (10 % of all participants) showed a switching pattern consistent with the theory of expressive voting.

2.2 Neuro-scientific methods and relevant experiments

While this share is lower than theory predicts, it is not clear what the result tells us about the importance of expressive motives: Do expressive motives exist only for a small fraction of subjects or are they relevant for most subjects yet dominated by instrumental motives? The essential shortcoming of behavioral data is that we can only infer the sign of the utility differential \widehat{UD}_i , but we cannot compare its magnitude $|\widehat{UD}_i|$ for different situations. Neuroeconomics allows for such comparisons. Therefore neuroscientific methods can help us to gain further insight into the process by which choices are generated. Neuroeconomics seeks to explain both behavior and its causes (Kable and Glimcher 2009). By providing measures for the intensity of the reward expected from a certain decision, neuroscientific methods enable

us to test for differences in magnitude $|\widehat{UD}_i|$ for situations where its sign is unchanged. Moreover, they allow for a comparison of reward levels of different voting decisions in the same situation. Therefore, neuroscientific methods can help us to gain more insight into the decision making process that leads the individual to vote YES or NO.

In this paper, we use functional magnetic resonance imaging (fMRI) in an experiment that is similar to the experiment by Tyran (2004). FMRI is a neuroimaging method which allows for a measurement of physiological changes while a subject performs an experimental task. These physiological changes are correlated with neural activity and can be linked to mental processes. The underlying idea is to compare the brain's condition during the exercise of a specific task with its condition during a control task or a second task. The resulting images show activations of the brain areas affiliated with the specific task and therefore provide information about differences in the underlying neural processes responsible for the overt act. FMRI permits discrimination of different causal processes even if they result in the same observable behavior. On the other hand, it reveals that the brain processes seemingly different stimuli in an analogous manner (e.g., Camerer et al. 2005; Izuma et al. 2010). The main research focus in neuroeconomics is on the neural mechanisms underlying decision making - investigating the expected utility model, decision making under risk and uncertainty, intertemporal choice etc. (see for an overview: Camerer et al. 2005; Loewenstein et al. 2008, Sanfey et al. 2006). Over the past years, numerous studies in this field increased our knowledge about the neural processes of decision making extensively. Given that voting decisions are based upon the same processes, we can use this knowledge to examine the neurobiology of instrumental and expressive motives in voting. Although the brain operates via networks, we learned about the contribution of different brain areas to different brain functions in the past years. We know that the brain does not code objective but subjective reward values and seems to convert values of different stimuli (e.g. primary and secondary reinforcers) to one "neural currency" (Izuma 2010 et al., Saxe et al. 2008, Kable and Glimcher 2009). The striatum plays a major role in this encoding of rewards. Consequently, this brain region is of special interest for our present study. The striatum is a subcortical region located in the interior regions of both cerebral hemispheres of the human brain. It can be divided into two subregions called caudate nucleus and putamen. Caudate and putamen are often related to as dorsal (upper) striatum (whereas the lower ventral striatum refers to the nucleus accumbens), both are associated with encoding the subjective value of goods and actions. The striatum reveals reward responses referring to forecasted or experienced value (Kable and Glimcher 2009). Former work showed that monetary gain but also monetary loss is processed in the striatum (Delgado 2007, Seymour et al. 2007). So this region seems to be highly important for the encoding of value representation that guides the choice among different options. Neuroeconomics commonly uses money as reinforcer to investigate decision-making, but there is a growing body of research suggesting that not only monetary but also social rewards are represented in the striatum (Saxe et al. 2008, Izuma et al. 2010, Fliessbach et al. 2007, Moll et al. 2006) and that different types of rewards are translated into a common neural currency (Kable and Glimcher 2009). For instance, Izuma and colleagues (2010) let subjects decide whether to donate an amount of money to charity or to keep the money for themselves. This decision is made in presence or absence of observers. The presence of observers increased donation rates and fMRI reveals the highest striatal activations i) when subjects donate in public and they expect high social rewards and ii) when subjects keep the money for themselves in absence of observersand thus expect monetary gain without social cost. Another study shows that striatal activity is also highest for monetary gain and noncostly donations when anonymity is guaranteed (Moll et al. 2006). The subjects in our voting experiment face a similar task - to donate money to charity or to keep it for private use. The essential difference between our experiment and those reported above is that our subjects make their decision collectively rather than individually.

Nevertheless, the above literature suggests that the striatum is the primary region of interest for our study.

Harbaugh et al. (2007) analyse the neural activity when individuals are forced to donate collectively. The subject in one treatment are taxed to finance donations to charity while the subject in the other treatment decide voluntarily and on an individual basis to donate an equivalent amount of money to charity or to keep it for private use. In their studies, altruists show reward-related striatal activity even when being forced to give the money to charity. The activation in the ventral striatum is higher when charitable giving is voluntary compared with mandatory transfers. This supports the notion of warm glow in charitable giving (Andreoni, 1989). Warm glow describes the extra utility derived from the act of giving money for charity. Just like expressive motives in voting, charitable giving is then seen as an act of consumption that is intended to increase the utility/reward of the donor. The question of whether others benefit from the donation is not of primary relevance. Contrary to that, altruistic motives see charitable giving as an investment where the utility/reward results from the consequences of being taxed. Thus, Harbaugh et al. (2007) show that investment-related motives (i.e. instrumental motives - altruistic or egoistic) and consumption-related motives (warm glow) are important in charitable giving. In our study, we analyse the importance of these two types of motives when individuals vote on charity. With respect to voluntary and forced donations analyzed by Harbaugh et al. (2007), voting lies in between these two extremes: Each voter makes an individual decision when approving or rejecting the proposal but the final decision is largely determined by the other voters.

2.3 Hypotheses

Based on the model and the evidence from previous experiments, we can derive a number of testable hypotheses to help us learn more about the voting decision. Given that this is to some extent an explorative study, we test for expressive motives as well as for the largely undisputed instrumental motives.⁵ The tests are based on comparisons of neural activation patterns for different constellations, depending on the subject's expectation concerning their fellow voter's behavior and on whether they vote YES or NO. Most tests are performed separately for altruists and non-altruists. There are 12 different constellations that can be compared in tests. Each constellation is denoted by three-letter abbreviation (see figure 1). The first letter states whether the subject is an altruist (A) or a non-altruist (N). The second letter captures the subject's expectation with respect to the behavior of his fellow-subjects. It differentiates between sure-donation (D), sure-private-money (P), and close-decision case (C). The third letter in the abbreviation is takes Y (N) when the subject voted YES (NO). For example, APY captures a constellation in which an <u>A</u>ltruist sees himself in a situation in which he expects to keep the money for <u>P</u>rivate use and votes <u>Y</u>ES. Whenever we do not differentiate between altruists and non-altruists, the first symbol in the abbreviation is a wildcard (*).

--- Insert figure 1 ---

1) Hypotheses concerning instrumental motives

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We first derive a number of hypotheses to test for instrumental voting motives. The expected instrumental utility from voting YES respectively NO differs between sure-donation case (

We also test for possible bandwagon motives (e.g. Hong and Konrad, 1998; Tyran, 2004) by contrasting the neural activities for *DY to the activities for *PY, both at the quorum of 50 percent. If bandwagon motives are present, the reward-related activation is expected to be higher in the *PY than in *DY constellations. However, we find no such pattern.

 $x_i + \varepsilon_i$ respectively x_i) and sure-private-money-case ($0 + \varepsilon_i$ respectively 0). For non-altruists ($x_i > 0$), keeping the money is more rewarding than donating the money and thus the utility from voting YES is always higher under the sure-private-money case than under the sure-donation case ($x_i + \varepsilon_i > \varepsilon_i$). Thus, we arrive at our first hypothesis H1⁶: Higher reward-related neural activity in the striatum for NPY than for NDY. The opposite applies to altruists who want the proposal to be pursued (i.e., $x_i < 0$). Therefore, H2 states: Higher reward-related striatal activity for ADY than for APY. In the sure-private-money case, the altruist expects the majority to reject the proposal he approves. Evidence from earlier neuroscientific studies (e.g., Abler et al. 2005, Siegrist et al. 2005) suggest that he may exhibit neural activation in areas which are related to "frustration" is present in APY but not in ADY. It is important to note that the three hypotheses on instrumental voting motives apply regardless of whether or not subjects are motivated by expressive motives.

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The same course of reasoning supports the mirror-inverted pendant to H1: Higher reward-related neural activity for NPN than for NDN. However, the small number of observations where subjects voted NO in the sure-donation case made it impossible for us to test this hypothesis. For the same reason, we cannot provide tests for a mirror-inverted pendant to H2 and H3. In addition, decisions of the category C (close decision) were not observed frequently. For this reason, we cannot test for differences in neural activations that result from increased uncertainty when $\hat{p_i} > 0$ and thus the individual voter is not sure about the outcome. For the same reason, we cannot test for possible activations due to warm glow as suggested by Harbaugh et al. (2007). We would expect activations in the associated regions to be higher for *CY than for *DY because only in *CY does the individual voter have the chance to give voluntarily.

2) Hypotheses concerning expressive motives

When it comes to expressive motives, we have to compare neural activity patterns in situation where an individual votes YES with patterns occurring when the individual votes NO. We recall that the expected utility from voting YES respectively NO is given by $x_i + \varepsilon_i$ respectively x_i for the sure-donation case and $0 + \varepsilon_i$ respectively 0 for the sure-private-money case. The utility differential between voting YES and voting NO is thus given by $\widehat{UD}_i = \varepsilon_i > 0$ for both sure-donation and sure-private-money case. It is important to note that this result applies to altruists and non-altruists alike. Thus, we arrive at our final yet most important hypothesis H4: Higher reward-related activation in the striatum for *PY than for *PN.

3. Methods

3.1 Subjects

The experiment involves 30 healthy male subjects without any history of neurological or psychiatric disease. Due to insufficient task comprehension or technical problems during the fMRI-session, six subjects have to be excluded so that 24 subjects are finally analyzed (Age: 26 ± 3 , range 19 - 37 years).⁷ All subjects are right-handed according to the Edinburgh Handedness Scale. All subjects give written informed consent and the study is approved by the ethics committee of the University of Bonn.

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Two of the six subjects revealed an insufficient performance in the pre-scanning task comprehension questionnaire. Despite further verbal task explanation before entering the scanner, we could not be sure of a sufficient comprehension of the different quora, though this was essential for the study. Four subjects were excluded due to incomplete scanning data – the scanning sessions of two subjects were cut short because of technical problems, the data corresponding to two further subjects was logged incompletely, again because of technical malfunction.

3.2 Task

Before entering the fMRI scanner, the subjects are instructed about the experiment. Each participant is told that he participated in a group experiment on voter behavior where the total number of voters is 30. Our set-up of our experiment follows Tyran (2004) in its essential features⁸ and thus resembles Tullock's thought experiment as presented in section 2.1. In every round of the experiment, the subjects are confronted with the following decision: Each participant is granted $X \in$ and is then asked to vote on the proposal to donate the money to a certain charitable organisation. In every trial the proposal is presented naming the organisation, the quorum (Q) and the stake (X). If more than Q % of the participants vote YES, the proposal is accepted and thus the X \in of all participants are donated. Else, all subjects keep the X \in . Given this information, each participant has to approve or reject the proposal by pressing respective buttons on the MRI-response-grips. The next trial begins after the response entry (no time-limit) and a black screen (4-6 seconds) (Fig. 2). After subjects have read the written instructions and all questions have been resolved, we check task comprehension via questionnaire. In the MRI, each participant starts with practicing-trials without image acquisition.

--- Insert figure 2 ---

The experiment runs over 315 rounds in one session with three different values of Q (10 %, 50 %, 80 %) and three different values for X (5 \in , 10 \in , 20 \in). Each combination of Q and X is randomly presented with seven different charitable organisations (German Red Cross, SOS

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There are, however, a number of differences between our set-up and Tyran's. We use only the first of two treatments of his study and use only 3 (10, 50, 80) rather than 5 quora (1, 254, 50, 75, 99). For technical reasons, we also elicited voters expectations only after the decisions were made.

Children's Villages, Médecins sans Frontières, Welthungerhilfe, UNO Flüchtlingshilfe, Deutscher Kinderschutzbund, Terre des hommes), with five repetitions each. The seven organisations are utilized to provide some variety in the stimuli in order to prevent boredom. We conduct pre-tests with similar groups of participants and find these seven organisations to be equally well-known and similar with respect to reputation and other characteristics. Not differentiating between the seven organisations, the experiment contains 105 voting decisions per X and Q and 315 voting decisions in total. This number of repeated trials permits analysis for each value of X and Q. Without repetition the signal-to-noise ratio would be too low to detect significant task related differences in neural activity. The participants do not know the values of Q and X and the names of the relevant organisations beforehand. Throughout the experiment, the participants are not informed about the aggregate voting behavior of preceding rounds.

To ensure validity, the subjects are informed that their decisions will have real consequences because after the completion of the group experiment one round is chosen at random (the same round for all participants) and the decisions made in this round is executed. In a post-experimental questionnaire, we elicit the participants' perception of the different charitable organizations using a 5-point-scale ("I know this organization", "I attach importance to this organization's work", "With this organization, I'm sure the deserving poor receive the donated money", "This organization has a good reputation", "This organization has to be supported"). We elicit the strength of the subjects altruistic motives using the Personal Altruistic Level (PAL) proposed by Tankersley, Stowe and Huettel (2007).⁹ We then ask the partici-

⁹ Based on the Self-Report Altruism Scale (SRAS), the PAL is more applicable to a sample of young adults from a university surrounding. Tankersley and colleagues report a high correlation between PAL and

pants for all values Q, for $X = 5 \in$ and $X = 20 \in$ and for all organizations (separately), whether they expect a clear majority for or against the proposal and whether they expected the decision to be a close one (*"For organization XY ... Do you expect a clear majority to approve the proposal Q/X?" and "There is no clear majority for or against the proposal?"*). We use this information to elicit whether subjects expect to vote in a sure-donation, sure-privatemoney or close-election case. Thus, we do not use false feedback or other forms of deception to artificially create these cases but stick with the standards of experimental economics – as we do in the other aspects of the experiment. Finally, each participant received an allowance of 10 \in per hour.

3.3 fMRI data acquisition

Scanning is performed on a 1.5 Tesla (T) Avanto Scanner (Siemens, Erlangen, Germany) using a standard 8 channel head coil. Scan parameters are: number of slices: 33; slice thickness: 3 mm; matrix size: 64 x 64; field of view: 192 mm; interleaved slice acquisition; echo time (TE): 50 ms; repetition time (TR): 2.91 s. The task is presented via video goggles (Nordic NeuroLab, Bergen, Norway) using Presentation© software (NeuroBehavioral Systems Inc.).

3.4 fMRI data analysis

FMRI data analysis is done using Statistical Parametric Mapping 5 (SPM5, www.fil.ion.ucl.ac.uk/spm/). Preprocessing includes realignment with slice timing, unwarping, normalisation to an EPI-template and smoothing with an 8 mm Gaussian kernel. The hemodynamic response to each event (each voting decision) is modelled by a canonical hemodynamic response function and the temporal derivative.

SRAS. Because our questionnaire already demands a great deal of concentration, we therefore decided to use only the PAL (instead of the SRAS) for keeping the total amount of questions as low as possible.

For the non-parametric first-level analysis, 18 vectors are constructed (YES-/NO-vote for each X and each Q), using the stimulus onsets of the proposal. Parameter images for the respective contrasts of interest are generated for each subject and are then subjected to two different second-level random effects analyses. Predefined linear combinations of the group contrast images are at first tested with two-sample t-tests. In another second-level random effects analysis for the sure-private-money case, we use a full-factorial design with the factors "type" (two levels: altruist/non-altruist) and "vote" (two levels: yes/no). Statistical threshold is in both second-level analyses set at a p-value of .001 voxelwise (uncorrected for multiple comparisons) with a cluster size threshold of ten voxels.

4. Results

We use a post-experimental questionnaire to differentiate between altruists and non-altruists (see table 2). Any participant who scores an above median score (≥ 30) on the altruism-score (towards strangers) proposed by Tankersley et al. (2007) is hereafter classified an altruist, all other participants are classified non-altruists. Thereby, we arrive at 13 altruists and 11 non-altruists. No subject consistently approve or reject the proposal in 100% of the trials but altruists show significantly higher approval rates than non-altruists for all three stakes (Bernoullitest, p = 0.05). The approval rate across all 24 participants is consistently declining with higher stakes and is higher for Q = 10 than for Q = 80 (Bernoullitest, p = 0.05). The same pattern is observed in the sub-samples of altruists and non-altruists.

--- Insert table 1 ---

We elicit subjects' expectations concerning the voting behavior of their fellow-subjects for the stakes $5 \in$ and $20 \in$ and all quora in the post-experimental questionnaire. Based on the answers, we classify whether subjects expected to be in a sure-donation, sure-private-money or close-decision case when deciding about a certain stake X at a given quorum Q. This classification is conducted separately for every subject and every X-Q-combination. Expectations varied substantially across subjects. Among altruists and non-altruists, the expected approval rate for a quorum of 10 % is higher than for a quorum of 80 % (see Table 2). In addition, expected approval rates decline in stakes.

1) Instrumental motives

These preliminaries settled, we turn to the neuroscientific analysis and start with the tests on instrumental voting motives. As hypothesized, non-altruists show significantly higher activation in the striatum (left putamen) when approving the proposal in the sure-private-money case in contrast to approving in the sure-donation case (H1: NPY > NDY, two-sample t-test, p < 0,001 unc, k>10) (Fig. 3).

--- Insert figure 3 ---

For altruists, two-sample-t-tests confirm higher activation in the left striatum (caudate and putamen) when approving in the sure-donation case in contrast to approving in the sure-private-money case (Fig. 4a). This result supports H2 (ADY>APY, p < 0,001 unc, k>10). We also find additional activation in the right parahippocampus (Fig. 4b), left anterior rostral MFC (Fig. 4c) and right pSTC (Fig. 4d). The opposite contrast (H3: APY>ADY, p<0,001 unc.; k>10) exhibits activation in the left insula (Fig. 5a) as well as left caudate nucleus (Fig. 5b) and middle prefrontal cortex (Fig. 5c).

--- Insert figure 4 ---

--- Insert figure 5 ---

However, the observed striatal activation in the two opposing contrasts (ADY>APY and APY>ADY) originates in different processes. Plots of the contrast estimates reveal the influ-

ence of each factor of interest on the activation within the left putamen and left caudate (F-Test for *AY, p<0,001 (FDR), k>10). As Fig. 6a and 6b show, the striatal activity in contrast ADY>APY results from a negative signal change in the left putamen as well as in left caudate, so these regions are less activated in both cases. Because the negative signal changes are higher in the private-money case, the contrasts show stronger signals in the sure-donation case (Fig. 4a), although the effect size is negative in both cases. Contrary to that, the detected caudate activation in the contrast APY>ADY follows from a positive signal change in both cases. As Figure 6b shows, the signal change in the sure-private-money case is much higher than in the sure-donation case, therefore we observe a higher activation in the left caudate nucleus for sure-private-money than sure-donation in the contrast APY>ADY (Fig. 5a).

--- Insert figure 6 ---

2) Expressive motives

Next, we turn to our main hypothesis and the search for neural activation patterns that point at the presence of expressive voting motives. As these motives may apply to both altruists and non-altruists alike, we do not initially distinguish between altruists and non-altruists here. Instead, we contrast approvals and rejections of all subjects in the sure-private-money case (H4: *PY>*PN, p<0,001 unc.; k>10) and find no significant activation. With lowering the level of significance to p<0,005 unc.; k>10, two-sample t-tests confirm (among others) higher activation in the left caudate and left putamen when approving in contrast to rejecting the proposal in the sure-private-money case (Fig. 7). In a next step, we are interested to find out how much altruists and non-altruists each contribute to the observed neural activity in *PY > *PN. We therefore conduct an analysis with a full-factorial-design for the sure-private-money case with the factors "type" (altruist/non-altruist) and "vote" (yes/no). We conduct a conjunction analysis (p<0.005) for the contrasts APY>APN and NPY>NPN and observe no voxels activated in both contrasts. We mask the contrast *PY > *PN inclusively with the contrast APY >

NPY. This approach shows all voxel which are significant at .005 unc. with k>10 across all subjects and at .05 unc. for altruists. None of the activations "survives" this masking. We then inclusively mask the contrast *PY > *PN with the contrast NPY > NPN on the same significance level and find all activations described for *PY > *PN. Thus, the observed neural activity in *PY > *PN seems to be solely elicited by non-altruists and not by altruists. We then plot the contrast estimates for each region and found further support for this conclusion. For the left caudate, APY elicits a small and NPY a large positive signal change, whereas APN shows no effect and NPN a negative signal change (Fig. 8). We also conducted a separate test for non-altruists which yields (among others) significant striatal activation (NPY > NPN, two-sample t-test, p < 0,005 unc, k>10). Plots of the contrast estimates reveal a positive signal change in the striatum for approvals and a negative signal change for rejections of the proposal (Fig. 9). For altruists, the same test reveals no significant activation (APY > APN, two-sample t-test, p > 0,005 unc, k>10).

--- Insert figure 7 and 8 ------ Insert table 3 ------ Insert figure 9 ---

5. Discussion

The purpose of this study is to achieve a better understanding of the motives in voting by using the neuroscientific method of fMRI. We want to learn more about rewarding aspects of the act of voting by investigating the activity of reward-related brain areas, especially the striatum.¹⁰ We explored differences in the striatal activation between altruists and non-

¹⁰ The complete list of brain activation is available by the authors upon request.

altruists but our special focus rests on the importance of expressive motives in voting. We start by discussing the evidence on instrumental voting motives. Here, we expected altruists and non-altruists to show distinctly different reward-related activation when confronted with the prospect to have to donate money (sure-donation case) as well as when expecting to keep the money for private use (sure-private-money case).

1) instrumental motives, non-altruistic voters

We hypothesized that a non-altruistic voter exhibits higher striatal activation when voting YES in the sure-private-money case than in the sure-donation case (H1: NPY>NDY). He approves the proposal in both cases presumably to attain the expressive utility (because $\varepsilon_i > \hat{p}_i x_i$) knowing that – with a very high probability, that his monetary payoff do not depend on his decision (i.e., $\hat{p}_i \approx 0$). The fMRI-results show that keeping the money in the sure-private money case (NPY) reveals an increased activity in the left putamen, whereas giving to charity in the sure-donation case (NDY) shows a decreased activity in the same region. Thus, the non-altruist shows the hypothesized neural activation consistent with materialistic and egoistic preferences.

2) instrumental motives, altruistic voters

An altruistic voter wants the proposal to be pursued when he approves it because it is in his instrumental interest. However, the donation is only pursued if the overall approval rate is sufficiently high. Thus, we hypothesized that the altruist shows higher reward-related activation when voting YES in the sure-donation case than in the sure-private-money case (H3: APY vs. ADY). The observed activation in the left striatum (caudate and putamen) supports this hypothesis at first sight, because these regions are known to represent monetary and social reward. But for ADY as well as for APY the left putamen and caudate are deactivated, only the deactivation for APY is much higher, so contrasting both cases, the striatal activity is

less negative for ADY. This pattern does not fit the logic underlying hypothesis H2. Given this result, we focus on the other activated regions (left arMFC, right parahippocampus and right pSTC) in the contrast ADY vs. APY for a possible explanation. The additionally activated anterior rostral MFC (arMFC) is supposed to play a major role in social cognition (for an overview: Amodio and Frith 2006). It is found to be associated with considering others' mental states and intentions, including reflections about what we want others to think about ourself. But it is also referred to thinking about the self and processing of what feels like the right thing to do in a moral dilemma (Amodio and Frith 2006). We also find a higher activity of the right pSTC which is associated with self-reported altruism (Tankersley et al. 2007) and willingness to give (Hare et al. 2010). Considering these additional activations, we might observe in this contrast (ADY > APY) not a clear reward processing but thinking about what is the right thing to do against the background of the own altruistic standards and the standards of others.

We further hypothesized that the altruist should exhibit neural activation in areas which are related to "frustration" in the sure-private-money case in contrast to the sure-donation case, because he expects the majority to reject the proposal which he wants to see pursued (H3). Contrasting APY > ADY, we find stronger activation in the dorsal striatum (caudate nucleus), left insula and middle prefrontal cortex. We find the hypothesized activation in the left anterior insula. The anterior insula is part of the pain processing system and also associated with unfairness in social interactions, frustration and a feeling of discomfort (Abler et al. 2005, Meyer-Lindenberg 2008). Meyer-Lindenberg even links the anterior insula signal to "gut feeling". But the insula is also associated with the processing of reward magnitude and showed a higher activity for a higher reward magnitude in former studies (Smith et al. 2009). The next activated region - the caudate nucleus - has been associated with social processes like trust (Baumgartner et al. 2008). King-Casas et al. (2005) suppose the caudate nucleus to compute

"information about the fairness of a social partner's decision". But just like the insula, the caudate nucleus, too, is also involved in anticipation and reception of reward (Valentin and O'Doherty 2009, Dreher et al. 2009, Pizzagalli et al. 2009). The third activation in this contrast is in a middle prefrontal region (mPFC), that is correlated with expected reward value and variance (Tobler et al. (2007). Hence, on the one hand all three regions (insula, caudate and mPFC) may indicate a more reward-related activity for APY than for ADY. On the other hand, insula and caudate can also be related to unfairness. While the non-altruist reveals clear reward-related processes when he votes YES but expects not having to give the money away, the altruist may feel uncomfortable: Not to pursue the proposal may appear unfair to him, causing an uncomfortable "gut feeling". This interpretation supports the bottom line of hypothesis H3 with respect to the altruists motivation when voting YES in the sure-private-money case.

In a first upshot, we observe distinct differences between altruists and non-altruists in their neural representation of instrumental motives. While the non-altruist reveals a clear reward-related brain activity in the sure-private-money case (H1), the neural activation pattern of al-truists is less clear. Donating the money in the sure-donation case (ADY) elicit activity in regions known to be involved in social cognition, like processes about agency, altruism, will-ingness to give and consideration about the right thing to do (arMFC and pSTC). Donating the money in the sure-private-money case (APY) activates reward-related brain regions but as well regions which are associated with a feeling of discomfort and unfairness. If the altruist really wants the proposal to be pursued – as an investment and consumption alike – reward-related activity should have been more prominent in ADY. We therefore cannot find clear support for H2.

3) expressive motives, altruistic and non-altruistic voters

Our final yet most important hypothesis aims at testing for expressive motives in voting. Assuming that these motives are present, we expect all voters – no matter if they are altruists or non-altruists – to perceive approvals in the sure-private-money case as more rewarding than rejections in this case (H4: *PY>*PN). The observed activation in the dorsal striatum (left caudate nucleus and left putamen) supports this hypothesis at first sight. However, further analyses revealed that the observed neural activity is nearly completely attributable to nonaltruists. Altruistic voters do not reveal this activation pattern. This finding is consistent with all other results of this experiment. Only the non-altruist reveals a distinct reward-related neural activity namely when he approves the proposal in the sure-private-money case (NPY). The plots of the contrast estimates for the left caudate (Fig. 8) support this. Non-altruists reveal a stronger positive signal-change than altruists when they approve the proposal in the sureprivate-money case. Rejecting the proposal elicits a negative signal-change for non-altruists and nearly no signal-change for altruists. Thus, the immediate expressive utility from the act of voting seems to be less distinctive for altruists.

Despite its interesting first results, our study has a number of limitations. First, the number of subjects in each group is rather small, which might account for partly less conclusive results and the need for lowering the level of significance to p<0.005, respectively. Second, we are unable to analyse voting behavior in close-decision cases because they are not sufficiently frequent to allow for a meaningful statistical analysis. The extreme rarity of close decisions is typical for majority voting and therefore limits behavioral experiments as well as field studies on expressive behavior alike. It can be avoided if the experimenters applies treatments in which they explicitly confront subjects with situations in which their decision is likely (or even certain) to tip the scales and other treatments where they are (almost certainly) not pivotal. However, these treatments cannot be framed as voting decisions in sizeable groups but have to be presented as voting decisions in a group of three to five subjects. Therefore, sub-

jects are likely to perceive these treatments with large and small groups to differ in more than just the probability of being pivotal. Nevertheless, it may be interesting to observe the neural patterns of subject in such treatments.

In order to keep the task in the fMRI simple, we do not elicit subjects' expectations with respect to their fellow-voters' behavior at the point in time when they make their decision but only after the experiment. This bears the danger that the answers in the post-experimental questionnaire may deviate from the expectations that subjects entertained when performing the task in the fMRI. However, our results do not rely on the comparison of close and nonclose decisions. In our opinion, it seems unlikely that a voter expects a proposal to pass comfortably expost while he expected a clear rejection while in the scanner. Thus, the time-lag between voting decisions and answers on expected behavior of fellow-subjects is unlikely to jeopardize our findings. Finally, we do not generate a sufficient number of cases in which non-altruists reject the proposals and therefore we are unable to test the mirror-inverted versions of our hypotheses (e.g., H1': Higher reward-related neural activities for NPN than for NDN). This is the prize of using charitable organizations that produced a high emotional involvement among subjects. However, we have deliberately chosen these organizations to make sure that expressive motives - if existent at all - are likely to have an impact on subjects' behavior. In a future experiment, it may be interesting to use higher stakes and/or less involving organizations and thereby produce a sufficient mix of rejections and approvals.

6. Conclusion

In this paper, we provide a first fMRI-study on voting behavior. We follow Tyran (2004) in our experimental set-up and our primary focus on expressive motives. Furthermore, we use the altruism-score proposed by Tankersley et al. (2007) to differentiate between altruists and non-altruists and investigate differences in striatal activation between them in the context of voting. Our results are in line with former experiments on social decision-making and charitable giving (Moll et al. 2006, Izuma et al. 2010, Harbaugh et al. 2007) but also shed further light on the motivational basis of voting decisions.

Summarizing the first results generated by our study, we find different patterns of rewardrelated activity for altruistic and non-altruistic voters. For the non-altruistic voter, we observe striatal activity when voting YES in the sure-private-money case. Keeping the money is rewarding for the non-altruist. This result shows the importance of investment-related, instrumental motives in voting. Though not surprising as such, the result indicates the validity of our set-up. But for the non-altruistic voter, we furthermore find approving the proposal in the sure-private-money case to be more rewarding than a rejection. This result is noteworthy because it provides support for the existence of expressive motives among non-altruists. This interpretation further strengthens the notion of expressive voting according to which votes – if not pivotal - do not refer to the policy outcome but to the immediate utility from the act of voting. For altruists, we observe a neural activation pattern that can be associated with investment- as well as consumption-related motives: In the sure-private-money case, altruists show an activation either indicating towards unfairness because the money will not be given to charity or indicating towards reward perception with an uncomfortable "gut feeling". Approving the proposal in the sure-donation case activates brain regions associated with altruism, willingness to give and thinking about the right thing to do. At the same time, we do not observe expressive motives in non-altruistic voters.

Like Harbough (2007) found for charitable giving and taxation, we find that both investmentrelated (instrumental: altruism or egoism) and consumption-related (expressive) motives play a role in voting decisions. Previous studies using traditional economic methods had to rely on behavioral observations and found only limited support for expressive motives. Using neuroscientific methods, we provide evidence for a neural correlate of expressive utility. At this point, our conclusions are still partly interpretative and need further investigation in follow-up experiments.

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Qj	X = 5 €	X = 10 €	X = 20 €					
	All participants $(n = 24)$							
10 %	68.0	53.8	47.2 31.7					
50 %	70.2	48.3						
80 %	60.4	38.7	28.92					
	Altruists $(n = 13)$							
10 %	75.2	67.0	56.7 44.0					
50 %	81.8	66.8						
80 %	73.0	53.2	41.1					
	Non-altruists $(n = 11)$							
10 %	60.2	39.5	36.8					
50 %	56.6	26.5	17.1					
80 %	45.5 21.6 13.0							

 Table 1: Average approval rates [%]

Table 2: Share of participants that expected a clear majority [%]

Qj	$X = 5 \in X = 20 \in$						
	Altruists $(n = 13)$						
10 %	72.3	83.1					
50 %	72.3	33.7					
80 %	56.0	35.1					
	Non-altruists $(n = 11)$						
10 %	48.4	40.3					
50 %	34.1	5.20					
80 %	29.7	19.5					

			MNI-				
	Brain region	coordinates			z-score*		
		X	у	Z			
<i>Non-parametric analysis:</i> $p < 0,001$ (uncorrected for multiple comparisons, extent threshold of 10 voxels).							
Non-altruists: NPY > NDY	Putamen (L)	-21	18	-3	4,0		
Altruists:	Caudate (L)	-18	18	9	3,76		
ADY > APY	Putamen (L)	-21	18	9	4,07		
	Parahippocampus (R)	18	-12	-21	5,98		
	Anterior rostral MFC (L)	-12	60	9	3,35		
	pSTC (R)	54	-60	24	3,59		
Altruists:	Insula (L)	-42	18	3	4,52		
APY > ADY	Caudate (L)	-9	3	6	4,53		
	Middle prefrontal cortex	33	48	21	3,92		
Non-parametric analysis: p < 0,005 (uncorrected for multiple comparisons, extent threshold of 10 voxels).							
All voters:	Caudate (L)	-24	-18	21	3,98		
*PY > *PN	Putamen (L)		18	-3	3,16		

Table	3:	MNI-co	ordinates	and	statistic	values	for	the	signi	ficant	activations
Labie	••	11111 00	orannacos	unu	blatiblie	raraco	101	unc	JUSIN	noun	activations.

*z = Z-score for the peak activation voxel.

Figure 1: Constellations and corresponding abbreviations



Figure 2: Task

The experiment runs over 315 rounds. In each round, the proposal is presented naming the relevant organisation, quorum and stake of this ballot. Participants are allowed as much time to respond as desired. Responses are made by pressing one of two buttons on the response grips corresponding to the location of the options (yes / no) on the screen. The location of the options interchange randomly from trial to trial to prevent correlation between keypress and answer. The button press is followed by a black screen for 4-6 s (jittered) before the next trial begins.



Figure 3: NPY>NDY: Non-altruists exhibit higher activation in left striatum when approving the proposal in the sure-private-money case in contrast to the sure-donation case (p<0.001 uncorrected; k>10).



Figure 4: ADY > APY: Altruists show higher activation in (a) left striatum (putamen), (b) right parahippocampus, c) left anterior rostral medial frontal cortex (arMFC) and d) right posterior superior temporal cortex (pSTC) when approving the proposal in the sure-donation case in contrast to the sure-private-money case (p<0.001 uncorrected.; k> 10).



Figure 5: APY > ADY: Altruists exhibit activation (a) in the left insula, (b) in the dorsal striatum (left caudate nucleus) and c) in the middle prefrontal cortex when they approve the proposal in the sure private-money case (p<0.001 uncorrected.; k>10).



Figure 6: ADY > **APY:** The bars represent the signal change in (a) left putamen [MNI: -21, 18, 9] and (b) left caudate [MNI: -18, 19, 9] for altruists approving the proposal in the sure-donation case (left bars) and sure-private-money case (right bars). Fig. 6c) shows the signal change in the left caudate [MNI: -9, 3, 6] in the opposite contrast APY > ADY.



Figure 7: *PY > *DY: Without distinguishing between altruists and non-altruists, activation for approvals in the sure-private-money case is observed in (a) left caudate and (b) left putamen (p<0.005 uncorrected.; k > 10).



Figure 8: *PY > *PN: Plots of contrast estimates in the peak voxel of the left caudate (full-factorial p<0.005, k>10 voxel, MNI: -24, -18, 21). The difference in signal change is largest for NPY > NPN.



Figure 9: NPY > NPN: Plots of the contrast estimates for non-altruists reveal a positive signal change in the left putamen [MNI: -21, 18, -3] when voting YES (left bar) and a negative signal change when voting NO (right bar). In both cases, the voters know that they can keep the money for themselves.

