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Supplementary Materials for

Social preferences or sacred values? Theory and evidence of deontological motivations

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1 Formal Statement of Assumptions and Theorem

These Supplementary Materials provide additional details and proofs for our results. For completeness, we also include all relevant information from the main text in these Supplementary Materials.

The standard consequentialist approach to choice under uncertainty (and central assumption for choice behavior regarding uncertainty) is first-order stochastic dominance (FOSD). A wide variety of models of choice under uncertainty satisfies FOSD and thus falls within this framework, among them most prominently, expected utility theory, its generalization by Machina [52], but also cumulative prospect theory ([53]) or rank-dependent utility theory ([54]). Stochastic dominance is a compelling criterion for decision-making quality and is generally accepted in decision theory ([65, 66, 67]).

In the following paragraph and the axioms up to FOSD, we closely follow the canonical framework as laid out in Kreps [55]. Let there be outcomes x. x can be a real valued vector. In the thought experiment, it would be $x = (x_1, x_2)$. Let the set of all x be finite and denote it by X. A probability measure on X is a function $p : X \to [0, 1]$ such that $\sum_{x \in X} p(x) = 1$. Let P be the set of all probability measures on X, and therefore, in the thought experiment, a subset of it, is the choice set of the decision-maker.

Axiom 1. *(Preference Order) Let $\succsim$ be a complete and transitive preference on P.*

Our first axiom ist standard, it says that preferences are a preference order. It implicitly includes consequentialism since the preference relation is on P, that is, over lotteries that are over consequences x.

Next we define first-order stochastic dominance (FOSD). Often, definitions of FOSD are suitable only for preference relations that are monotonic in the real numbers, for example see Levhari, Paroush, and Peleg [56]. These definitions define FOSD with respect to the ordering induced by the real numbers, assuming that prices are vectors. It is important to define FOSD with respect to ordering over outcomes rather than the outcomes themselves. FOSD over outcomes is inappropriate in the context of social preferences, which are often not monotonic due to envy or fairness concerns.

Definition. (FOSD) p first-order stochastically dominates q with respect to the ordering induced by $\succsim$, if for all x':

$\sum_{x:x'\succsim x} p(x) \leq \sum_{x:x'\succsim x} q(x)$.

Axiom. *(FOSD) If p FOSD q with respect to the ordering induced by $\succsim$, then $p \succsim q$.*

Formally, our theorem needs both strict FOSD and weak FOSD since the former does not imply the latter.

Definition. (Strict FOSD) p strictly first-order stochastically dominates q with respect to the ordering induced by $\succsim$ if p FOSD q with respect to that ordering, and there exists an x' such that:

$\sum_{x:x'\succsim x} p(x) < \sum_{x:x'\succsim x} q(x)$.

Axiom. *(Strict FOSD) If p strictly FOSD q with respect to the ordering induced by $\succsim$, then $p \succ q$.*

The following theorem implies that in our thought experiment, changing the probability of being consequential π does not change the decision. It is this prediction of the theory that we test and interpret a rejection of the prediction as evidence that people are not purely consequentialist.

Theorem 1. *If the DM satisfies the axioms Preference Order, FOSD, and Strict FOSD, and there exist $x, x', x'' \in X'$ and $\pi\epsilon(0;1]$ such that $\pi x + (1-\pi)x'' \succcurlyeq \pi x' + (1-\pi)x''$, then for all $\pi'\epsilon(0;1] : \pi' x + (1-\pi')x'' \succcurlyeq \pi' x' + (1-\pi')x''$.*

Proof. (i) $x \succsim x'$: Suppose not, then $x' \succ x$, and therefore $\pi x' + (1-\pi)x''$ strongly first-order stochastically dominates $\pi x + (1-\pi)x''$. Then by axiom Strict FOSD, $\pi x' + (1-\pi)x'' \succ \pi x + (1-\pi)x''$, a contradiction.

(ii) Since $x \succsim x'$, $\pi' x + (1-\pi')x''$, first-order stochastically dominates $\pi' x' + (1-\pi')x''$. Thus by axiom FOSD, $\pi' x + (1-\pi')x'' \succ \pi' x' + (1-\pi')x''$. □

The theorem has a corollary for the case of expected utility:

Corollary. *If the decision-maker satisfies axiom Preference Order and maximizes expected utility and there exist $x, x', x'' \in X'$ and $\pi \epsilon (0;1]$ such that $\pi x + (1-\pi)x'' \succcurlyeq \pi x' + (1-\pi)x''$, then for all $\pi' \epsilon (0;1]$: $\pi' x + (1-\pi')x'' \succcurlyeq \pi' x' + (1-\pi')x''$.*

The corollary holds since expected utility's independence axiom implies the axioms of FOSD and Strict FOSD. Note that in the thought experiment and experimental setup, d affects the recipient only via the payoff x_2^C. Thus, the theorem applies even to situations where the DM cares about not only the recipient's outcome but also about the recipient's opinion or feelings about the DM or her decision d. Thus, for consequentialist preferences, even allowing such consequences as others' opinions, the DM's optimal split does not depend on the probability of the DM's split being implemented.

Formally, our theorem needs both strict FOSD and weak FOSD since the former does not imply the latter. The axiom of Strict FOSD does not imply the axiom of FOSD. An example can be derived from Machina [68] with preferences that satisfy Preference Order and Strict FOSD but violate FOSD. Are there assumptions besides strict FOSD so we don't need both strict and weak FOSD? Yes, if a preference satisfies Preference Order, Strict FOSD, Continuity, and Rich Domain then it satisfies FOSD. Continuity alone is not sufficient for the axiom of Strict FOSD to imply the axiom of FOSD.

Definition. $\succsim$ is continuous if for all $p, q, r \in P$ the sets $\{\alpha \in [0,1] : \alpha p + (1-\alpha)q \succsim r\}$ and $\{\alpha \in [0,1] : r \succsim \alpha p + (1-\alpha)q\}$ are closed in [0,1].

Now consider someone who would like to be fair, but between two unfair lotteries she prefers the one that is more fair. Formally, for all $\pi, \pi' \in [0;1]$: $\pi \cdot (1-\pi) \geq \pi' \cdot (1-\pi')$ if and only if $(x; \pi, y; 1-\pi) \succsim (x; \pi', y; 1-\pi')$. The axiom of Strict FOSD is trivially satisfied since there is no lottery that strictly first-order stochastically dominates another lottery. Axiom of continuity is satisfied. However, axiom of FOSD is violated: $(x; \frac{2}{3}, y; \frac{1}{3})$ weakly first order-stochastically dominates $(x; \frac{1}{2}, y; \frac{1}{2})$, but $(x; \frac{1}{2}, y; \frac{1}{2}) \succ (x; \frac{2}{3}, y; \frac{1}{3})$.

Axiom. *(Continuity)* $\succsim$ *is continuous.*

Axiom. *(Rich domain) There are two outcomes* $x, y \in X$ *such that* $x \succ y$*.*

Proposition. *If a preference satisfies Preference Order, Strict FOSD, Continuity, and Rich Domain then it satisfies FOSD.*

Proof. Suppose p weakly first-order stochastically dominates q. We need to show that $p \succsim q$. Suppose not, that is $q \succ p$.

Since X is finite there exits an $\overline{x}$, $\underline{x}$ such that for all x: $\overline{x} \succsim x$, and an $x \succsim \underline{x}$. By the axiom of Rich Domain, $\overline{x} \succ \underline{x}$.

At least one of the following three cases is satisfied: (i) $\overline{x} \succ q$, (ii) $p \succ \underline{x}$ or (iii) $q \succsim \overline{x} \succ \underline{x} \succsim p$.

(i) Since p weakly first-order stochastically dominates q, and $\overline{x} \succ q$, for any $\alpha > 0$ the lottery $\alpha\overline{x}+(1-\alpha)p$ strictly first-order stochastically dominates q. But then $\{\alpha : \alpha\overline{x}+(1-\alpha)p \succsim q\} = (0, 1]$, a violation of continuity.

(ii) Since p weakly first-order stochastically dominates q, and $p \succ \underline{x}$, for any $\alpha > 0$, p strictly first-order stochastically dominates $\alpha\underline{x} + (1-\alpha)q$. But then $\{\alpha : p \succsim \alpha\underline{x} + (1-\alpha)q\} = (0, 1]$, a violation of continuity.

(iii) First we show that all elements z in the support of q satisfy $z \sim \overline{x}$. First note that by definition of $\overline{x}$, all elements in the support satisfy $\overline{x} \succsim z$. Suppose there is at least one element z such that $\overline{x} \succ z$, then $\overline{x}$ strictly first-order stochastically dominates q, which by axiom Strict FOSD implies $\overline{x} \succ q$, a contradiction. Thus, for all elements z in the support of q we have $z \sim \overline{x}$.

Second, we show that all elements z in the support of p satisfy $z \sim \underline{x}$. First note that by definition of $\underline{x}$, all elements in the support satisfy $z \succsim \underline{x}$. Suppose there is at least one element z such that $z \succ \underline{x}$, then p strictly first-order stochastically dominates $\underline{x}$, which by axiom SFOSD implies $p \succ \underline{x}$, a contradiction. Thus for all elements z in the support of p we have $z \sim \underline{x}$.

Since all elements in the support of q are indifferent to $\overline{x}$, all elements in the support of p are indifferent to $\underline{x}$, and $\overline{x}$ is strictly preferred to $\underline{x}$, q strictly first order stochastically dominates p. But that is a contradiction to p weakly first order stochastically dominating q. $\square$

Further note that if the cardinality of the outcome space is 2, then independence is as weak an axiom as first-order stochastic dominance.

Axiom. *(Independence)* $\succsim$ *satisfies independence if for all lotteries* p, q, r *in* $P: p \succcurlyeq q \Leftrightarrow \alpha p + (1-\alpha)r \succcurlyeq \alpha q + (1-\alpha)r$.

Proposition. *Consider* X *with 2 elements. If* $\succsim$ *on P(X) satisfies Preference Order, Strict FOSD and FOSD, then it satisfies Independence.*

Proof. Without loss of generality let $X = \{x, y\}$ and $x \succcurlyeq y$. Denote $k = \alpha p + (1-\alpha)r$ and $l = \alpha q + (1-\alpha)r$.

(i) $x \sim y$

Then l weakly first-order stochastically dominates k, and vice versa. Thus by FOSD $l \succcurlyeq k$ and $k \succcurlyeq l$, thus $k \sim l$.

(ii) $x \succ y$

(ii.i) p and q are identical: Then $k = l$ and trivially $k \sim l$.

(ii.ii) $p \sim q$ but not identical: Then one must strictly first-order stochastically dominate the other, which by Strict FOSD contradicts indifference.

(ii.iii) $p \succ q$: By the lemma below, this implies $p(x) > q(x)$, and thus $p(y) < q(y)$, then k strictly first-order stochastically dominates l:

For y: $\sum\limits_{y \succsim z} k(z) = k(y) = \alpha p(y) + (1-\alpha)r(y) < \alpha q(y) + (1-\alpha)r(y) = l(y) = \sum\limits_{y \succsim z} l(z)$.

For x: $\sum\limits_{x \succsim z} k(z) = 1 = \sum\limits_{x \succsim z} l(z)$.

Thus by Strict FOSD $l \succ k$. □

Lemma. *Consider* $X = \{x, y\}$ *and* $x \succ y$. *If* $\succsim$ *on P(X) satisfies Preference Order and Strict FOSD, then* $p \succ q$ *if and only if* $p(x) > q(x)$.

Proof. 1.) $p \succ q$ implies $p(x) > q(x)$.

Proof by Contradiction: Suppose $p(x) \leq q(x)$.

i) $p(x) = q(x)$: This implies that $p = q$, and thus trivially by completeness $p \sim q$, a contradiction.

ii) $p(x) < q(x)$: Since $x \succ y$ this means that q strictly first order stochastically dominates p, and thus by Strict FOSD $q \succ p$, a contradiction.

2.) $p(x) > q(x)$ implies $p \succ q$: This follows from Strict FOSD. □

Note that there are examples where Independence is violated but FOSD is not. Cumulative prospect theory is one such example where the Allais paradox is allowed (thus violating Independence) but FOSD is satisfied.

Next, we illustrate consequentialist-deontological preferences where the optimal decision changes as the probability of being consequentialist changes. Let $u(x_1, d) = f(x_1) + b(d)$. Then, $U(x_1, d) = \pi(f(x_1^C) + b(d)) + (1-\pi)(f(x_1^N) + b(d))$ and $V(d) = \pi f(\omega - d) + (1-\pi) f(\omega - \kappa) + b(d)$. The first order condition is: $\frac{\partial V(d)}{\partial d} = -\pi f_1(\omega - d) + b_1(d) = 0$. For d^* to be a maximum, the second order condition yields: $\frac{\partial^2 V(d)}{\partial d^2} = \pi f_{11}(\omega - d) + b_{11}(d) < 0$. Applying the implicit function theorem to the first order condition yields: $\frac{\partial d^*}{\partial \pi} = \frac{f_1(\omega - d^*)}{\pi f_{11}(\omega - d^*) + b_{11}(d^*)} < 0$, since utility is increasing in its own outcomes and the denominator which is the second derivative of the indirect objective function is negative.

Note that the recipient's payoff is a function of the DM's payoffs, but as long as other-regarding concerns are concave then the sum of utility from DM's own payoffs and utility from others' payoffs is still concave and the above result holds. Decisions do not have to be continuous to obtain this result. If decisions are discrete, then the behavior of a mixed consequentialist-deontological person is jumpy (i.e., it weakly increases as her decision becomes less consequential).

2 Lab Instructions

Figure 1: Lab Implementation

Fig. S1. Lab Implementation. Subjects put their irrevocable decisions anonymously in sealed envelopes, and their envelope is shredded with some probability with a public randomization device. Photo Credit: Martin Schonger, ETH Zurich.

Figure 2: Sample Screenshot of Lab Experiment

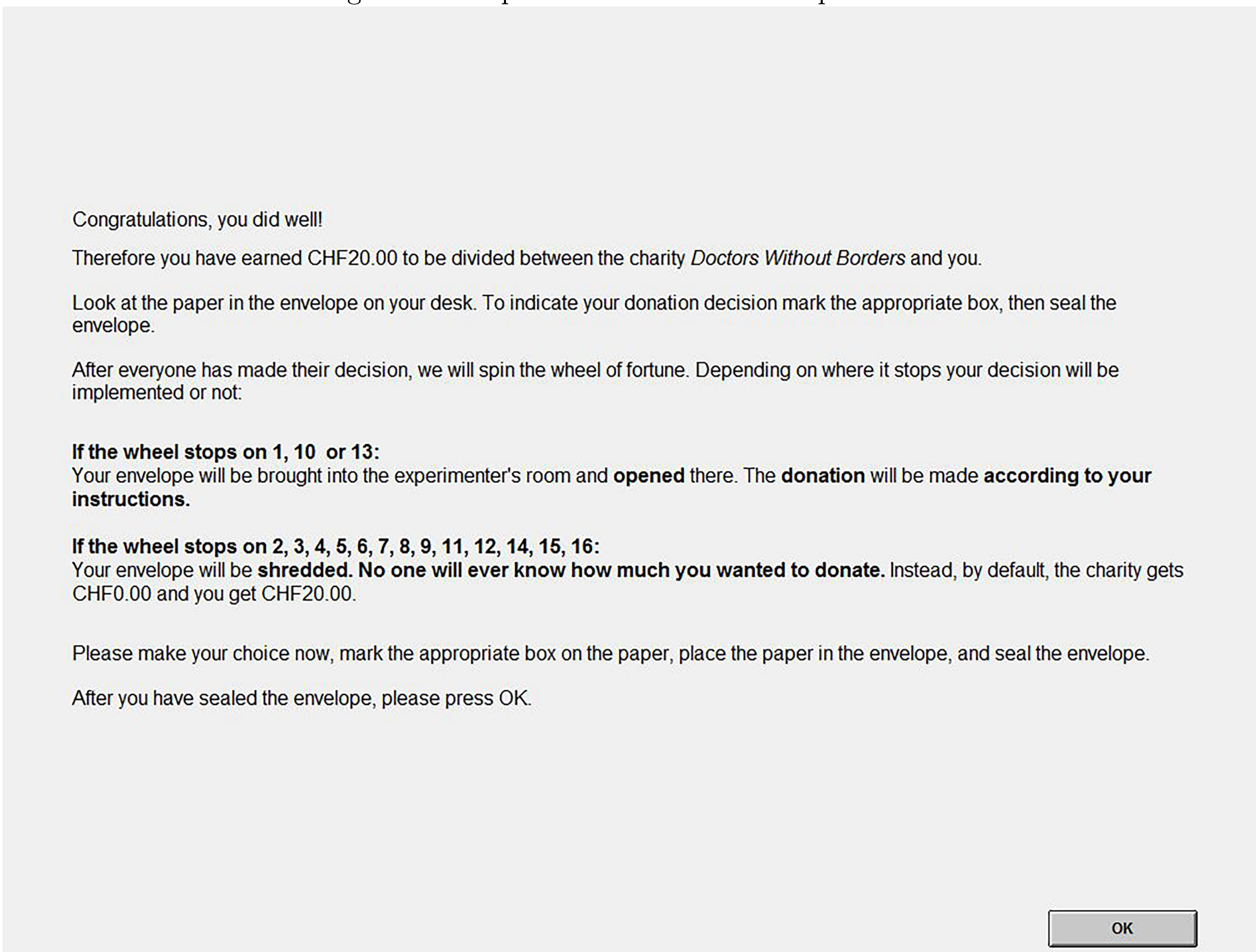

Fig. S2. Sample Screenshot of Lab Experiment. Shredding Experiment Instructions Donation Screen for Subject with $\pi = 3/16$ and $\kappa = 0$.

Figure 3: Donation Decision Placed in Sealed Envelope

Donation decision of subject number: 2

If you see the congratulations screen**:**

Of the CHF20 I want to donate

0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**

CHF to Doctors Without Borders.

If you have made too many mistakes**:**

Please check this box:

☐

After marking exactly one box, please put this sheet in the envelope and seal it.

→ Then click OK on the screen so the experiment can proceed!

Fig. S3. Donation Decision Placed in Sealed Envelope. Paper-based survey response form for subjects in the lab experiment.

3 MTurk Instructions

Figure 4: Schematic of MTurk Experiment (Experiment 1)

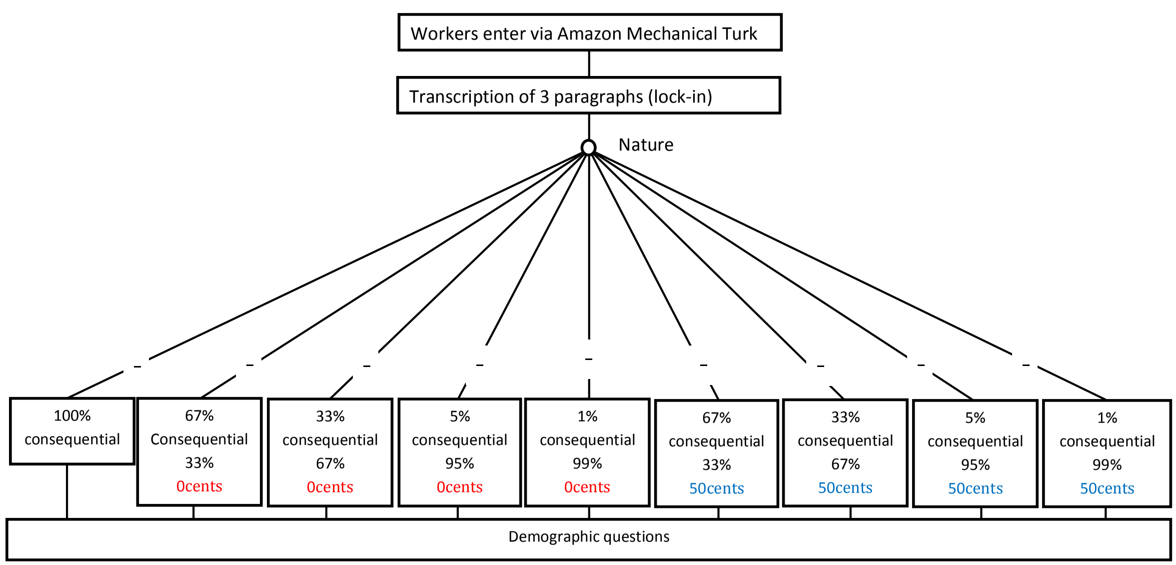

Fig. S4. Schematic of MTurk Experiment (Experiment 1). Treatment arms for first MTurk experiment.

Figure 5: Schematic of MTurk Experiment (Experiment 2)

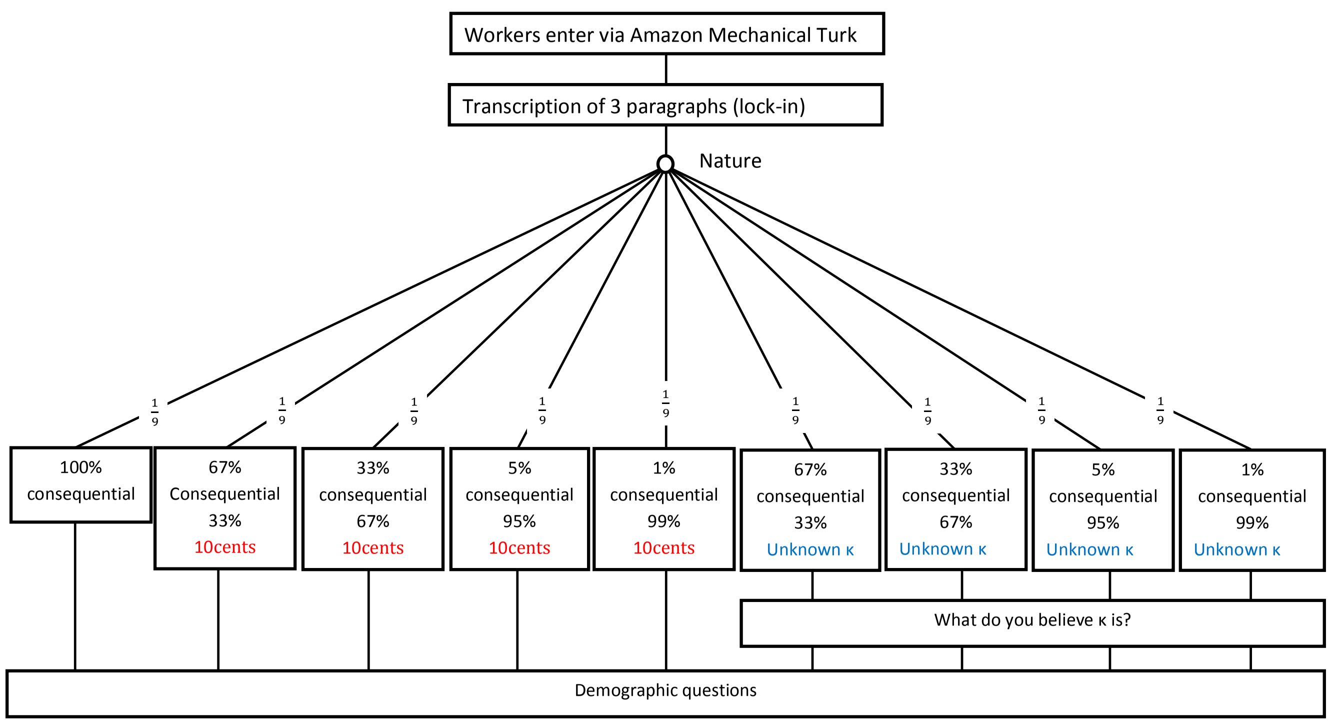

Fig. S5. Schematic of MTurk Experiment (Experiment 2). Treatment arms for second MTurk experiment.

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