Is choice-induced preference change due to pre- or post-decision cognitive dissonance resolution?

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Keywords: decision-making, cognitive dissonance, choice confidence, subjective value

Word counts: 3,645

ABSTRACT

For more than 60 years, it has been known that people report higher (lower) subjective values for items after having selected (rejected) them during a choice task. This phenomenon is coined “choice-induced preference change” or CIPC, and its established interpretation is that of “cognitive dissonance” theory. In brief, if people feel uneasy about their choice, they later convince themselves (albeit not always consciously) that the chosen (rejected) item was actually better (worse) than they had originally estimated. While this might make sense from a psychological standpoint, it is worrisome from broader cognitive or evolutionary perspectives. This is because such a cognitive mechanism would yield irrational biases that bring no clear adaptive fitness. In this work, we rather assume that CIPC is better explained by an effortful refinement of option value representations that occurs *during* (and not *after*) difficult choices. This makes CIPC the epiphenomenal outcome of a cognitive process that is instrumental to the decision. Critically, our hypothesis implies two novel predictions about how observed CIPC should relate to specific meta-cognitive processes, namely: reports of choice confidence and subjective certainty regarding pre-choice value judgments. We test these predictions in a behavioral experiment where participants rate the subjective value of food items both before and after choosing between equally valued items (we augmented this traditional design with reports of choice confidence and subjective certainty about value judgments). The results confirm our predictions and provide evidence against the standard post-choice cognitive dissonance reduction explanation. We then discuss the relevance of our work in the context of the existing debate regarding the functional role of cognitive dissonance.

INTRODUCTION

The causal relationship between choices and subjective values goes both ways. By definition, choices are overt expressions of subjective values, which is the basis of decision theory (Slovic, Fischhoff & Lichtenstein, 1977). However, one's choices also influence one's values, such that actions or items seen to acquire value simply because they have been chosen. Such "choice-induced preference change" (CIPC) has been repeatedly demonstrated via the so-called "free-choice paradigm" (Brehm, 1956). Here, people rate the pleasantness of (e.g., food) items both before and after choosing between pairs of equally pleasant items. Results show that the post-choice pleasantness ratings of chosen (rejected) options are typically higher (lower) than their pre-choice pleasantness ratings, which is typically taken as empirical evidence for the existence of a "cognitive dissonance" reduction mechanism, triggered by difficult choices (see Harmon-Jones & Harmon-Jones, 2007; Izuma & Murayama, 2013 for reviews). An established variant of this interpretation is that people rationalize their choice *ex post facto* as they think along the lines of, "I chose (rejected) this item, so I must have liked it better (worse) than the other one," and hence adjust their internal values accordingly (Bem, 1967). Over the past decade, neuroimaging studies have demonstrated that the act of choosing between similarly-valued options causes changes in the brain's encoding of subjective values (Izuma et al, 2010; Voigt et al, 2018). Cognitive dissonance reduction (and its variants) is now the popular explanation behind a broad variety of important irrational sociopsychological phenomena, ranging from, for example, post-vote political opinion changes (Beasley & Joslyn, 2001) to post-violence hostile attitude changes (Acharya, Blackwell & Sen, 2015).

This is not to say, however, that the empirical demonstration of cognitive dissonance reduction has remained unchallenged. The first issue is theoretical in essence. In brief, it is unclear why evolutionary pressure would have favored post-choice cognitive dissonance reduction mechanisms, given that it eventually induces irrational biases that have no apparent adaptive fitness (Perlovsky, 2013). In fact, there is an unresolved debate about whether decision making in any other animal species (including non-human primates) involves CIPC (Egan, Santos & Bloom, 2007; West et al, 2010). Second, the main experimental demonstration

of cognitive dissonance has also been challenged on statistical grounds. In 2010, Chen and Risen reported a methodological issue in the way CIPC had typically been measured and explained. The basic idea was that simple random variability in repeated value ratings may confound classical measures of CIPC in the context of the free-choice paradigm. The authors provided a detailed mathematical explanation for how such statistical confound may eventually cause an apparent CIPC (see Chen & Risen, 2010 for details), and introduced a clever control condition. Here, both first and second value ratings are provided before any choice is ever made, thus precluding choice from causally influencing reported subjective values. Results show that significant CIPC occurs regardless of whether the choice is made before or after the second rating. Although this supports the validity of Chen and Risen's statistical criticism, subsequent studies also demonstrated that the magnitude of CIPC is significantly greater when the choice is made before the second value rating (Salti et al, 2014; Coppin et al, 2013; Coppin et al, 2012; Sharot et al, 2012). Taken together, the current theoretical and empirical bases of CIPC do not yet provide a straightforward portrait of why and how choice may influence subjective values.

In line with recent neuroimaging studies (Jarcho, Berkman, & Lieberman, 2010; Colosio et al, 2017), we challenge the implicit assumption behind established explanations of CIPC, and purport that preferences changes occur *during* the decision, not after it. We take inspiration from behavioral economics studies of decision making showing that preferences are constructed in an *ad hoc* manner, depending on the decision context (Tversky & Thaler, 1990; Lichtenstein & Slovic, 2006; Warren, McGraw, & Van Boven, 2011). More precisely, when facing a difficult decision where initial subjective values for the options are similar, people are reluctant to make a choice that they are not confident about (De Martino et al, 2013). Therefore, they take the time and effort to reassess the values of the alternative options before committing to a particular choice (Shenhav, Botvinik & Cohen, 2013). The ensuing refinement of internal value representations eventually raises choice confidence enough to trigger the decision, which is why the decision is more consistent with post-choice reports of subjective values (hence the CIPC). Critically, this makes CIPC the epiphenomenal outcome of

a cognitive process that is instrumental to the decision, which resolves theoretical concerns. In addition, our working hypothesis makes two original predictions that deviate from standard post-choice cognitive dissonance reduction theory. First, the magnitude of CIPC should increase with decision difficulty. This is because CIPC derives from the mental effort involved in the decision process, which is expected to scale with decision difficulty. In what follows, we will consider two features of pre-choice reports of subjective values that determine decision difficulty, namely: the similarity of option values and the subjective uncertainty regarding value judgments. In particular, we predict that CIPC should increase with subjective uncertainty regarding pre-choice value judgment. This goes against standard post-choice cognitive dissonance reduction theory, because post-choice dissonance should be highest when pre-choice values are similar, with a high judgment certainty. Second, CIPC should positively correlate with choice confidence, even when controlling for the impact of decision difficulty. This is because, under our hypothesis, CIPC indirectly signals a successful improvement of choice confidence (due to mental effort spreading option values apart). This prediction is again critically different from classical dissonance reduction theory, which would posit that choices made with low confidence should trigger the strong aversive dissonance feelings that eventually lead to CIPC. Finally, we can rule out variants of Chen and Risen's statistical confound by showing that, if anything, evidence for both predictions should be weaker when the choice is made after the second value rating.

METHODS

In essence, our experimental design is borrowed from Chen and Risen's 2010. In brief, the so-called RCR (Rating, Choice, Rating) group of participants was asked to rate the value of a series of items both before and after making paired choices. In contrast, the RRC group of participants rated the items twice before making the paired choices. As we will see, comparisons between the RCR and the RRC group will serve to rule out variants of Chen and Risen's statistical confound. Now, when evaluating subjective values, participants also rated

their subjective certainty regarding their value judgment. In addition, they also reported how confident they were when making paired choices. This allowed us to assess the impact of both subjective uncertainty on value judgments and choice confidence reports on CIPC.

Participants

A total of 111 people participated in this study. The RCR group included 58 people (39 female; age: mean=27, stdev=6, min=19, max=46). One participant was excluded from the analysis for not performing the tasks properly (i.e., decisions were entirely inconsistent with both pre- and post-choice value ratings). The RRC group included 53 people (30 female; age: mean=34, stdev=12, min=18, max=55). Four participants were excluded from the analysis for not performing the tasks properly. All participants were native French speakers. Each participant was paid a flat rate of 12€ as compensation for one hour of time.

Materials

We wrote our experiment in Matlab, using the Psychophysics Toolbox extensions (Brainard, 1997). The experimental stimuli consisted of 108 digital images, each representing a distinct sweet snack item (including cookies, candies, and chocolates). Prior to the experiment, participants received written instructions about the sequence of tasks, including typical visual examples of rating and choice trials.

Experimental Design

The experiment was divided into three sections, following the classic Free-Choice Paradigm protocol: Rating #1, Choice, Rating #2 (RCR group) or Rating #1, Rating #2, Choice (RRC group). Note that only in the RCR group do Rating #1 and Rating #2 correspond to pre-choice and post-choice ratings. Participants underwent a brief training session prior to the main testing phase of the experiment. There was no time limit for the overall experiment, nor for the different sections, nor for the individual trials. Within-trial event sequences are described below (see Figure 1).

Rating: Participants rated the stimulus items in terms of how much each item pleased them. The entire set of stimuli was presented to each participant, one at a time, in a random sequence (randomized across participants). At the onset of each trial, a fixation cross appeared at the center of the screen for 750ms. Next, a solitary image of a food item appeared at the center of the screen. Participants had to respond to the question, “Does this please you?” using a horizontal Likert scale (from “not at all” to “immensely”) to report their subjective valuation of the item. Participants then had to respond to the question, “Are you sure?” using a vertical Likert scale (from “not at all” to “immensely”) to indicate their level of subjective uncertainty regarding the preceding value judgment. At that time, the next trial began.

Choice: Participants chose between pairs of items in terms of which item they preferred. The entire set of stimuli was presented to each participant, one pair at a time, in a random sequence of pairs. Each item appeared in only one pair. The algorithm that created the choice pairs first sorted all items into 10 bins, then paired off (at least) half of the items within each bin, then paired off all remaining items across bins. This ensured that at least half of choices would be between items of similar subjective value (value rating difference < 1/10 of the full rating scale, as shown in previous studies to cause CIPC), but that a substantial portion would be associated with greater value differences.

At the onset of each trial, a fixation cross appeared at the center of the screen for 750ms. Next, two images of snack items appeared on the screen: one towards the left and one towards the right. Participants had to respond to the question, “What do you prefer?” using the left or right arrow key. Participants then had to respond to the question, “Are you sure about your choice?” using a vertical Likert scale to report their level of confidence in the preceding choice. At that time, the next trial began.

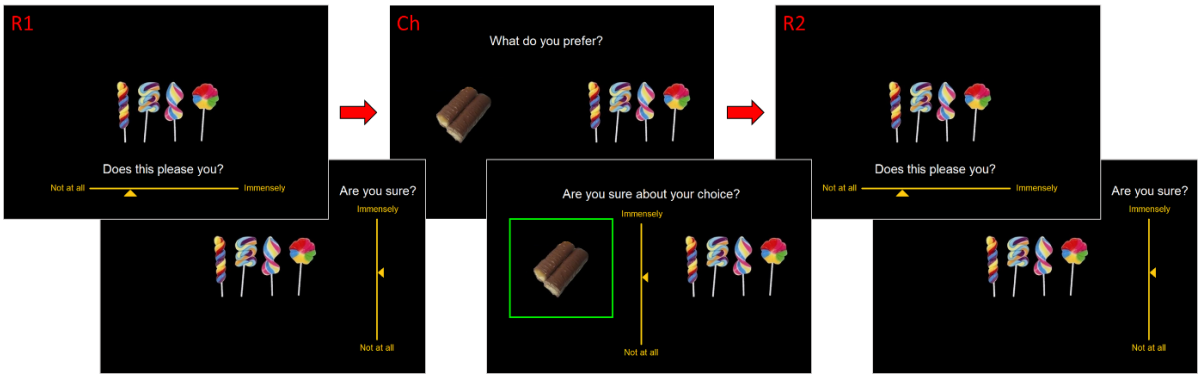

Figure 1: Experiment Tasks: Rating #1, Choice, Rating #2

RESULTS

Before testing our hypothesis (against both statistical confounds and standard post-choice cognitive dissonance reduction theory), we performed a number of simple data quality checks. First, we assessed the test-retest reliability of both value judgments and their associated certainty reports. For each participant, we thus measured the correlation between ratings #1 and #2 (across items). We found that both ratings were significantly reproducible (value ratings: correlation = 0.879, 95% CI [0.862, 0.896], $p<0.001$; certainty ratings: correlation = 0.493, 95% CI [0.427, 0.559], $p<0.001$). Second, we asked whether choices were consistent with value ratings #1. For each participant, we thus performed a logistic regression of paired choices against the difference in value ratings. We found that the balanced prediction accuracy was beyond chance level (group mean = 0.697, 95% CI [0.678, 0.715], $p<0.001$). Third, we checked that choice confidence increases both with the absolute value difference between paired items, and with the mean certainty reports about value judgments (of the paired items). For each participant, we thus performed a multiple linear regression of choice confidence against absolute value difference and mean judgment certainty (ratings #1). A random effect analysis shows that both have a significant effect at the group level ($R^2 = 0.230$, 95% CI [0.193, 0.267]; absolute value difference: GLM beta = 9.487, 95% CI [8.217, ∞], $p<0.001$; mean judgment certainty: GLM beta = 3.19, 95% CI [2.059, ∞], $p<0.001$). Fourth, we

asked whether we could reproduce previous findings that CIPC is higher in the RCR group than in the RRC group. For each participant, we thus measured the magnitude of CIPC in terms of the so-called "spreading of alternatives" (SoA), calculated as the mean difference in value rating gains between chosen and unchosen items (SoA = $[\text{rating\#2-rating\#1}]_{\text{chosen}}$ - $[\text{rating\#2-rating\#1}]_{\text{unchosen}}$). As expected, we found that SoA is significant in both groups (RCR group: SoA = 4.879, 95% CI [3.898, 5.861], $p<0.001$; RRC group: SoA = 2.643, 95% CI [1.991, 3.295], $p<0.001$). In addition, SoA is significantly higher in the RCR group than in the RRC group (SoA difference = 2.24, 95% CI [1.204, ∞], $p<0.001$) (see Figure 2).

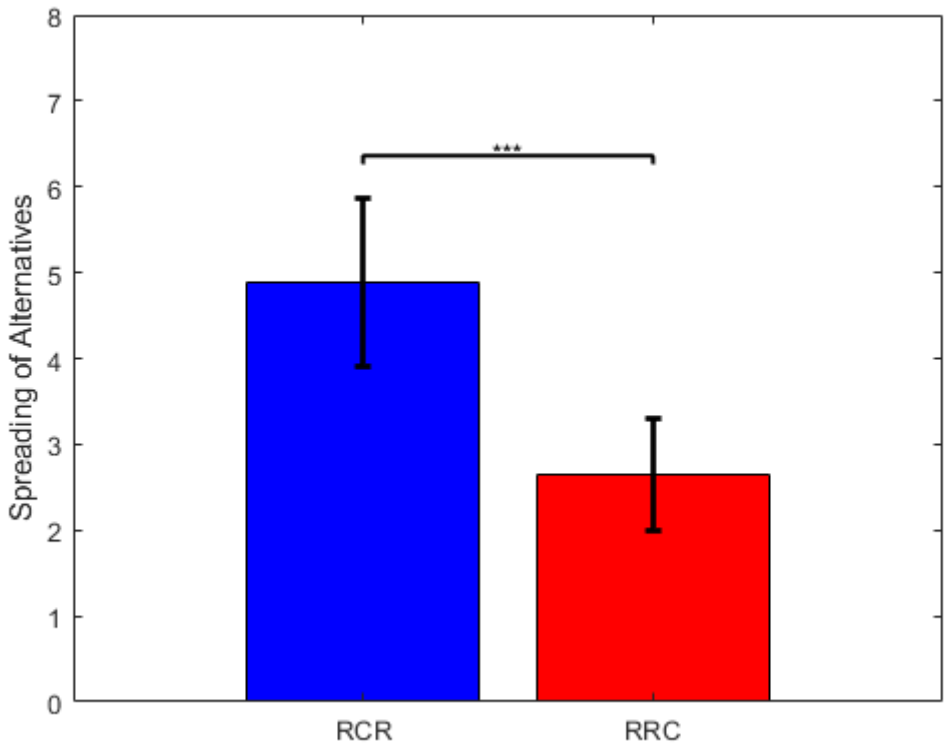

Figure 2: Mean and 95% CI for spreading of alternatives in the RCR and RRC groups

In what follows, and unless stated otherwise, we focus on the RCR group of participants. Recall that, under our hypothesis, effort allocation during the decision process is expected to refine internal value representations up until a target level of confidence is met and the decider

commits to a choice. To begin with, we thus asked whether certainty about value judgments improved after the choice had been made. For each participant, we thus estimated the mean difference between post-choice and pre-choice certainty reports (across all items). A random effect analysis then shows that post-choice certainty reports are significantly higher than pre-choice certainty reports (certainty increase = 4.46, 95% CI [2.320, 6.608], $p<0.001$) (see Figure 3). This finding supports our claim but does not provide evidence for or against classical post-choice cognitive dissonance reduction theory. We then asked whether post-choice ratings better predict choice (and choice confidence) than pre-choice ratings. First, we performed another logistic regression of paired choices, this time against the difference in post-choice value ratings (ratings #2). The ensuing choice prediction accuracy is higher than with pre-choice value ratings (accuracy = 0.792, 95% CI [0.774, 0.810], accuracy gain = 0.095, 95% CI [0.073, 0.118], $p<0.001$). Second, we regressed choice confidence, this time against post-choice absolute value difference and mean judgment certainty. The ensuing amount of explained variance in choice confidence reports is higher than with pre-choice ratings (R^2 = 0.254, 95% CI [0.215, 0.293], R^2 gain = 0.024, 95% CI [0.003, 0.046], $p=0.016$). When testing for the significance of differences in pre-choice and post-choice regression parameters, we found that this gain in explanatory power is more likely to be due to value ratings (GLM beta difference = 0.581, 95% CI [0.032, ∞], $p=0.044$) than to certainty reports (GLM beta difference = 0.274, 95% CI [-0.397, ∞], $p=0.25$). These results are important, because they validate basic requirements of our pre-choice CIPC hypothesis. However, they are equally compatible with both pre-choice and post-choice CIPC mechanisms. Next, we focus on testing the two specific predictions regarding the relationship between CIPC and meta-cognitive processes, which discriminate mechanisms of pre-choice value refinements from post-choice cognitive dissonance reduction.

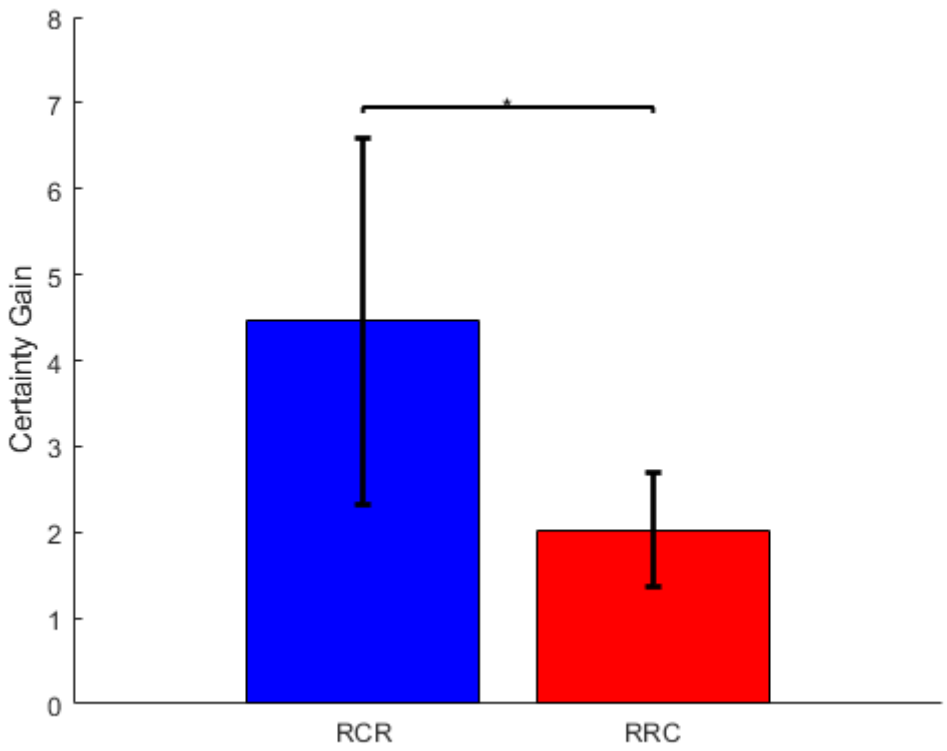

Figure 3: Mean and 95% CI for value certainty gain (post- minus pre-choice) in the RCR and RRC groups

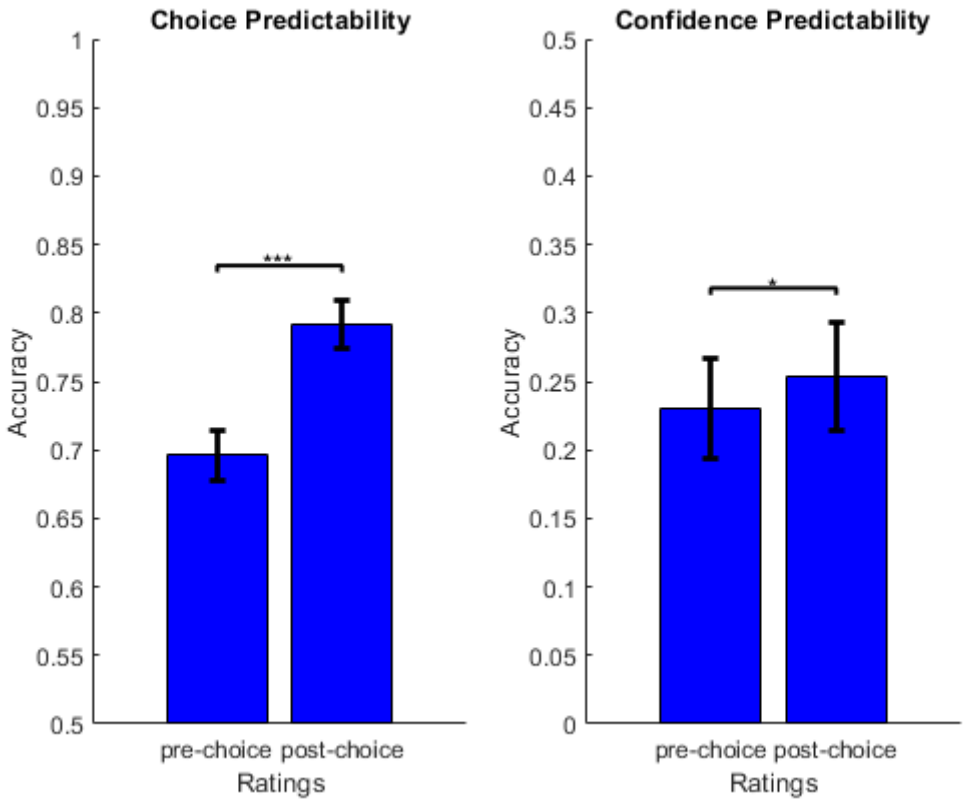

Figure 4: Mean and 95% CI for choice predictability (left) and choice confidence predictability (right), based on pre- vs post-choice ratings

We now assess the statistical relationships between CIPC and both choice difficulty and choice confidence. For each participant, we performed a multiple linear regression of SoA onto absolute difference in pre-choice value ratings, mean pre-choice judgment certainty reports, and choice confidence (see Figure 5). As expected, a random effect analysis on the ensuing parameter estimates shows that SoA significantly decreases with the absolute difference in pre-choice value ratings (GLM beta = -0.293, 95% CI [-∞, -0.262], $p<0.001$). More importantly, we found that SoA significantly decreases with pre-choice judgment certainty (GLM beta = -0.061, 95% CI [-∞, -0.03], $p=0.0012$) and increases with choice confidence (GLM beta = 0.197, 95% CI [0.166, ∞], $p<0.001$). The latter findings support our hypothesis, and are incompatible with classical post-choice cognitive dissonance reduction theory.

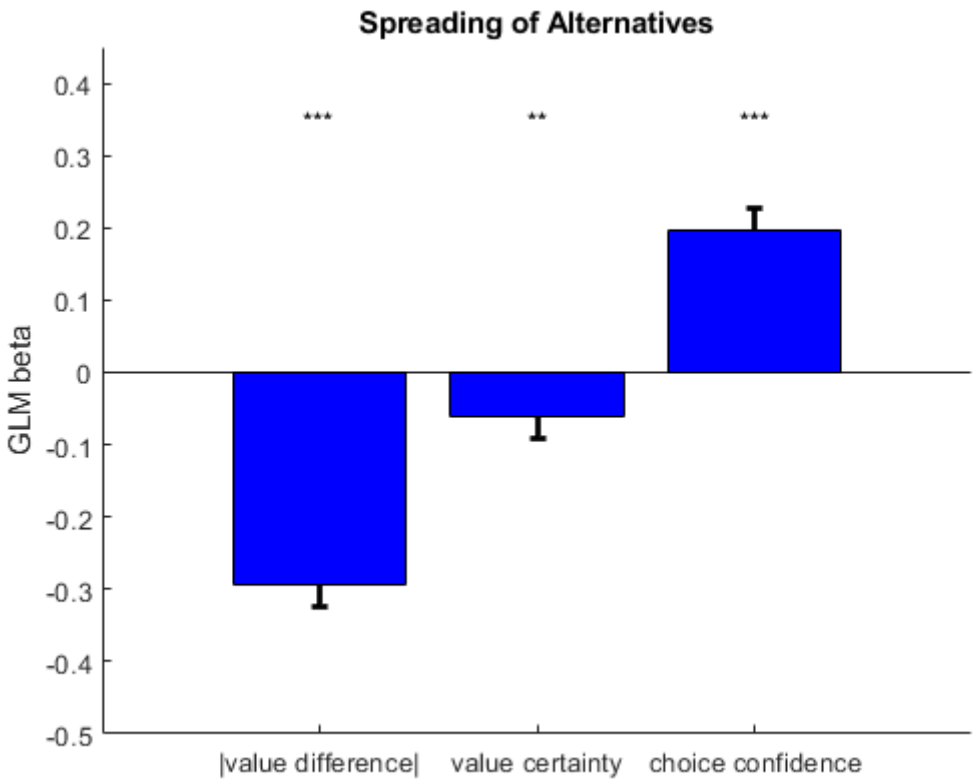

Figure 5: Mean and 95% CI for GLM beta weights of absolute value difference, average value certainty (within a choice pair), choice confidence on spreading of alternatives

Finally, we aimed at ruling out statistical confounds. This can be done by showing that if the above statistical relationships exist in the RRC group, they should be significantly weaker than in the RCR group. We thus performed the above analyses on data acquired in participants from the RRC group, which we compared to the RCR group of participants using standard random effect analyses. First, we found that the gain in subjective certainty regarding value judgments (from rating #1 to rating #2) is higher in the RCR group than in the RRC group (certainty gain difference = 2.44, 95% CI [0.201, ∞], p=0.036). In particular, this shows that the certainty gain in the RCR group is not due to a mere exposure and/or familiarity effect. Second, the gain in choice prediction accuracy (from rating #1 to rating #2) is significantly higher in the RCR group

than in the RRC group (accuracy gain difference = 0.033, 95% CI [0.007, ∞], p=0.019). Third, and most importantly, both the impact of absolute pre-choice value difference (GLM beta diff = -0.066, 95% CI [-∞, -0.015], p=0.016) and mean judgment certainty reports (GLM beta diff = -0.052, 95% CI [-∞, -0.007], p=0.030) on SoA are significantly higher in the RCR than in the RRC group. Note that some comparisons between the two groups turned out not to be significant (gain in confidence prediction accuracy: p=0.55, impact of choice confidence on SoA: p=0.14). Nevertheless, taken together, these findings are unlikely under a chance model of random variations in value ratings.

DISCUSSION

In this work, we have presented empirical evidence that challenges standard interpretations of CIPC, in particular: post-choice cognitive dissonance reduction theory (and its self-perception variants). However, we would like to highlight that we do not dispute the concept of cognitive dissonance itself, nor even the idea that cognitive dissonance is the root cause of CIPC. In fact, our view only differs from standard post-choice cognitive dissonance reduction theory in one single aspect, namely: the temporal dynamics of the dissonance reduction. According to standard post-choice cognitive dissonance reduction theory, choices made with low confidence trigger strong aversive dissonance feelings that are resolved by retrospectively matching internal value representations to the choice. We would rather say that no choice commitment is made until internal value representation refinements allow choice confidence to reach a satisfying (non-aversive) level. This idea is a simple extension of the so-called Action-based model of cognitive dissonance (Harmon-Jones, Harmon-Jones, & Levy, 2015; Harmon-Jones, Amodio, & Harmon-Jones, 2009), and of recent attempts to formalize cognitive dissonance in terms of neurocognitive theories of predictive processing in the action-perception loop (Kaaronen, 2018). That cognitive dissonance reduction occurs during the decision process (and not after) is critical however, because it is now endowed with a clear functional purpose (namely: improving decision accuracy).

Our results apparently contradict the recent finding that CIPC only occurs for choices where the agent is later able to recall which option was chosen and which was rejected (Salti et al, 2014). Indeed, a possible explanation of this result is that post-choice option re-evaluation requires the memory trace of relevant choices. This interpretation is compatible with the observation that, when re-evaluating items after the choice, activity in the hippocampus discriminates between remembered and non-remembered choices (Chammat et al, 2017). However, we contend that this theory remains unsupported until empirical evidence is found for memory traces of information that is critical for post-choice CIPC (namely: whether an option was chosen or rejected, what was the option's pre-choice value, and which option was the alternative during the relevant choice). In addition, the relationship between CIPC and memory might be confounded by choice difficulty. In brief, the more difficult a decision is, the more mental effort it will eventually trigger, the more likely the agent is to remember his/her choice. Alternatively, post-choice reports of internal values may rely on slightly unstable episodic memory traces of intra-choice CIPC. The latter scenario is actually compatible with the fact that activity in the left dorsolateral prefrontal cortex (during choice) predicts the magnitude of CIPC only when the choices are remembered (Voigt et al 2018), and also with the intra-choice CIPC interpretation of the causal impact of post-choice activity perturbations (see below). In any case, either or both of these scenarios would explain why intra-choice CIPC might exhibit an apparent (non-causal) relationship with choice memory. Finally, note that the causal implication of memory is inconsistent with the assessment of amnesic patients, who exhibit normal CIPC despite severe deficits in choice memory (Liebermann et al, 2001).

Even though the cognitive architecture that underlies intra-choice cognitive dissonance reduction is yet to be disclosed, recent neuroimaging findings shed light on the question of whether CIPC occurs during or after the decision. On the one hand, a few brain stimulation studies suggest that perturbing brain activity *after the choice* (in particular: in the left dorsolateral and/or posterior medial frontal cortices) disrupts the observed CIPC (Mengarelli et al, 2013; Izuma et al, 2015). Although compatible with post-choice CIPC, such causal effects can be due to the post-choice disturbance of value representations that resulted from intra-

choice CIPC. On the other hand, many recent studies show that brain activity measured *at the moment of choice* is predictive of the magnitude of CIPC (Colosio et al, 2017; Jarcho, Berkman, & Lieberman, 2010; Kitayama et al, 2013; van Veen et al, 2009, Voigt et al 2008). Unsurprisingly, key regions of the brain's valuation and cognitive control systems are involved, including: the right inferior frontal gyrus, the anterior cingulate cortex, the ventral striatum and the anterior insula. This clearly supports the notion that option re-evaluation occurs at the time of the decision.

CONCLUSION

Taken together, our results lend support to the hypothesis that choice-induced preference change is caused by an intra-choice refinement of option value representations that is motivated by difficult decisions, and undermine the established theory of post-choice cognitive dissonance resolution. We also demonstrate the relevance of meta-cognitive processes (cf. reports of choice confidence and certainty about value judgments) to choice-induced preference change. This contributes to moving forward the state of the 60-year-old research on the reciprocal influence between choice and subjective value.

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